The essential and most important injury of strangulation is cerebral hypoxia. This means that there is not enough oxygen delivered to the brain to maintain the functioning of the brain. Strangulation causes cerebral hypoxia in two ways: reduction of blood flow going to the brain and restriction of air going to the lungs. There are several types and methods of strangulation, but they all result in cerebral hypoxia. Because the brain is a vital organ highly dependent on a constant supply of oxygen, cerebral hypoxia due to strangulation represents a critical injury to a vital organ. In order to investigate strangulation assaults properly, it is important to understand cerebral hypoxic and how it is caused in strangulation, the neck structures involved in strangulation, the signs and symptoms of strangulation, and the best way to document strangulation injuries. These are all described in the following pages.

**Asphyxia and cerebral hypoxia**

The term “asphyxia” is frequently used to describe strangulation. While this term is acceptable for general purposes, it is unfortunately nonspecific and not especially helpful in understanding strangulation injuries. By itself “asphyxia” means “pulselessness” and thus describes anyone without a heartbeat. A more generous interpretation of asphyxia is “lack of oxygen delivered to the vital organs”. Again, this interpretation does not specify the essential injury of strangulation. Therefore, for a thorough understanding of strangulation it is important to use a more specific term. This more specific and preferable term is “cerebral hypoxia”.

Cerebral hypoxia is a preferable term because it specifies the site of injury – the brain. It also specifies the nature of the injury – injury due to lack of oxygen. As the brain has many functions and anatomic structures, cerebral hypoxia results in several levels of injury. Cerebral hypoxia manifests injury in two ways: loss of function and damage of anatomic structures. Loss of function occurs first and is potentially reversible or temporary, and damage of anatomic structures occurs later and is irreversible and permanent.

As with asphyxia, cerebral hypoxia may be due to a number of conditions. In general, the way something is produced is called the mechanism. In strangulation, the mechanism of cerebral hypoxia involves compression of neck structures – the blood vessels in the neck and the airway. Thus, there are two mechanisms in strangulation: vascular compression (referring to the blood vessels) and airway compression. The victim experiences different effects from each of these two mechanisms. These will be described below. Also as described below, there are many different forms of strangulation. Most forms involve a mixture of the two mechanisms producing cerebral hypoxia. Some forms involve more vascular compression and some involve
more airway compression. In order to understand the effects experienced by the victim of a particular strangulation assault, it is necessary to understand something about the anatomy of the neck.

**Neck structures involved in strangulation**

The neck structures affected in strangulation are the blood vessels and the airways. In the different types of strangulation, the blood vessels and the airway are each affected to a greater or lesser extent. For this reason it is useful to speak of vascular compression, in which there is compression predominantly of blood vessels – the carotid arteries and the jugular veins – and airway compression, in which there is compression predominantly of the airway – the larynx and trachea. Anatomically there are two carotid arteries, one on each side of the neck. They carry oxygen rich blood under high pressure from the heart to the head and brain. There are also two jugular veins, one on each side of the neck running alongside the carotid arteries. The jugular veins carry oxygen depleted blood under low pressure from the head and brain, returning the blood to the lungs. The airway, consisting of the larynx above and the trachea below, travel in the front of the neck. The larynx can be felt as the “voice box” or “Adam’s apple” and the trachea is felt as a series of bumps, which represent the tracheal rings that hold this part of the airway open. Both the larynx and the tracheal rings are composed of cartilage, which is a stiff gristly substance that is somewhat flexible, more so than bone, and can be compressed or bent to a certain extent before it fractures.

In addition to the relative positions in the neck of the blood vessels and airway, there are differences in the amount of force required to compress the different structures. The jugular veins are most easily compressed; as little as 7 pounds of pressure are sufficient. The carotid arteries require about 15 pounds of pressure, and the airway requires about 30 pounds of pressure to compress. The specific numbers are not important and are difficult to translate these pressures into specific forces occurring in real-life situations. The important point to understand is that the blood vessels, especially the jugular veins, take relatively little pressure to compress but are protected by their location on the sides of the neck, while the airway takes greater pressure to compress but is situated in a way that makes it easily accessible to direct pressure.

**Mechanism of strangulation**

Compression of the three different structures (carotid arteries, jugular veins and airway) produces cerebral hypoxia by different mechanisms. In carotid artery compression, the arterial blood flow is restricted, and cerebral hypoxia develops very quickly. With compression of the jugular veins only, cerebral hypoxia develops more gradually as the carotid arteries continue to deliver oxygen-rich blood to the brain. Over time, however, because the blood cannot get out of the head, the blood pressure inside the head increases until the blood pressure of the carotid arteries is insufficient to deliver any more blood. In this situation, the head is literally filled up
with blood – this is called venous congestion. With venous congestion the cerebral circulation becomes stagnant and cerebral hypoxia ensues.

With airway compression alone, respiration is restricted and the lungs fail to deliver oxygen to the blood. Although there is still circulation of blood to the brain, the oxygen content of the blood in the carotid arteries gradually diminishes and as it does, cerebral hypoxia develops.

Because it takes the least pressure to compress the jugular veins, venous congestion is a common occurrence in strangulation, even when the carotids arteries and airway are only partially obstructed. This is an important point because venous congestion leads to the formation of petechiae, which are pinpoint collections of bleeding and a major sign of strangulation, described further below.

**Effects of cerebral hypoxia in strangulation**

The earliest manifestation of cerebral hypoxia is loss of consciousness. Before losing consciousness completely, there may be confusion, disorientation, and lack of muscular coordination. Visual changes are common as the visual fields narrow and become dark. There may be flashes of light or flickering stars. Loss of consciousness may occur in as little as 10 seconds of cerebral hypoxia. After consciousness is lost, the victim is completely incapacitated and vulnerable to continued assault. If oxygen is restored immediately to the brain, the victim will probably regain consciousness, although confusion and disorientation are likely to persist at least for a short while. There may be loss of memory (amnesia) of the events. If cerebral hypoxia persists, deeper levels of brain function develop. At some point, brainstem function is impaired, and breathing stops. At this point, even if oxygen is restored to the brain, spontaneous breathing may not return. With these deeper levels of cerebral hypoxia, the neurons, or nerve cells, in the brain are irreversibly injured and die. After cell death, neurons are never replaced, and the functions they support are lost forever. Even with resuscitation and oxygen administration, after prolonged cerebral hypoxia the victim is likely to suffer permanent brain damage, which may range from loss of cognitive functions and motor control to brain death. The degree of permanent injury depends on the length of time that cerebral hypoxia persists. As mentioned earlier, consciousness is lost after as little as 10 seconds, and if oxygen is restored the victim is most likely to regain consciousness without any permanent damage. However, when severe cerebral hypoxia persists for longer than 4 minutes, the brain is irreversible damaged and brain death is likely to develop, regardless of whether oxygen and cardiopulmonary resuscitation are administered.

There are differences also in the effects experienced by the victim depending on whether the strangulation is predominantly vascular or airway. With predominantly vascular compression of the carotid arteries, such as occurs with the so-called carotid sleeper hold, unconsciousness develops relatively quickly, with little to no pain or panic experienced by the victim. In contrast, in predominantly airway compression, such as occurs in a choke hold with the forearm pressed
strongly against the airway, unconsciousness develops relatively slowly, and the victim experiences considerable pain and the panic of air hunger.

**Types of strangulation**

Traditionally there are two types of strangulation: ligature and manual. Ligature strangulation refers to neck compression produced by an object that can be used for tying, such as a rope, cord, belt, shoelace, wire or electrical cable. In manual strangulation the hands are used to compress the neck. In addition to these two types, there are additional neck holds, such as the lateral vascular neck restraint (LVNR) sometimes used by law enforcement and otherwise known as the carotid sleeper hold. “Burking” refers to a multi-modality technique of producing asphyxia, originating from the historical Thomas Burk, who was convicted of murdering several young women, whose bodies he sold to the London medical school in the 1800’s. He finally confessed to seducing these young women with liquor and then killing them by sitting on the chest, pinching the nose and covering the mouth with one hand while compressing the neck with the other.

In producing asphyxia in strangulation, the important factor is the extent of compression of the various neck structures. The properly applied LVNR directs pressure onto the sides of the neck while putting little pressure on the airway. This is why this method is highly efficient in incapacitating an individual quickly and painlessly. However, this same maneuver, if not applied correctly, can become a very inefficient and painful straight arm bar hold as the front of the neck slips from the crook of the elbow and becomes compressed by the mid-forearm. In a similar way, depending on how the hands are positioned, manual strangulation can compress either the sides of the neck, resulting in vascular compression, or the front of the neck, resulting in airway compression. Furthermore, ligature strangulation can result in predominantly airway compression, if the ligature is passed in front of the neck and pulled from behind, or a mixture of airway and vascular compression, if the ligature completely wraps around the neck and is tightened uniformly, such as in some practices of garroting. In general, most types of strangulation are a mixture of vascular and airway compression unless the pressure is precisely and anatomically directed. For this reason, in order to evaluate the experience of the victim, it is necessary to know the exact details of how the strangulation occurred.

**Signs of strangulation**

The signs of strangulation can be understood as nonspecific signs and specific signs. Nonspecific signs or marks indicate only that there was some sort of force applied to the neck, which may or may not be in the form of strangulation. These nonspecific marks include erythema (redness), swelling, abrasions, and contusions. In these marks there is no pattern that would indicate how the force was applied. The force may be from a blow or slap, a bite or sucking action ("hickey"). Specific signs of strangulation are marks that have a pattern reflecting a particular object or action. For example, in ligature strangulation there is typically a
linear band on the neck, usually on the front and sides of the neck. The orientation of the band is horizontal or angles upward depending on how the ligature was applied to the neck. In manual strangulation, fingernail marks are characteristic. These are fine, curvilinear abrasions that are often described as semilunar or semicircular, made by the fingernails of the assailant digging into the skin of the neck of the victim. The fingernail marks may be single or multiple depending on how the neck was grasped. They may be very small, fairly subtle, and easily overlooked. In addition to the semilunar fingernail marks, there may be fingernail scrapes made as the assailant’s fingernails drag across the victim’s neck skin, producing a series of parallel abrasions or a single, broad, linear abrasion.

It is important to avoid over-interpreting marks on the neck, remembering that a strangulation assault is a dynamic event with the marks reflecting actions of the victim as well as the assailant, resulting in changing positions of the object(s) against the neck. In general, the marks on the neck are greater with a vigorous struggle, such as would occur in a prolonged and painful strangulation assault in which airway compression was predominant. In such a case it is likely that a ligature mark would be broader than the ligature itself, as the struggle of the victim would cause the ligature to slip up and down the surface of the neck. Furthermore, a narrow, hard ligature (e.g., a piano wire) or one with relatively sharp edges (e.g., a leather belt) would likely produce more distinct marks than a broad, soft ligature (e.g. a sheet or a terry cloth belt). In fact, it is possible, using a broad, soft ligature, to kill a person by ligature strangulation without leaving any marks. Similarly, in manual strangulation, if the victim struggles vigorously, causing the assailant’s hands to slip and reposition, there would be expected to be more marks, both specific and nonspecific, than if the victim did not resist or was incapacitated quickly. In a carotid sleeper hold it is quite possible to incapacitate a person quickly without leaving any marks on the neck. Of course, once a person is incapacitated, that victim is completely vulnerable to continued assault by any means, including continued neck compression. Finally, when interpreting marks on the neck, it is important to consider jewelry, such as a chain necklace, or other items, like a medallion, that may have been worn about the neck. If this is the cases, these items can be pressed into the neck skin and produce a furrow that may be incorrectly interpreted as a ligature furrow. It is possible, of course, that a necklace or piece of clothing could have been used as a ligature. To test this possibility, it would be important to compare the pattern and strength of the item with the ligature furrow and the force required to produce the strangulation.

In addition to the primary signs of strangulation around the neck, there are secondary signs due to the venous congestion produced by compression of the jugular veins. Because of the venous congestion, the face above the level of compression becomes swollen and purple, or cyanotic. This congestion is transient and disappears when the neck compression is relieved. The most important secondary sign of strangulation is the appearance of petechiae. Petechiae (singular, petechia; plural, petechiae) are pin-point sized spots of bleeding (hemorrhage) seen on the surface of the eyes, under the eyelids, oral mucosa, and facial skin. They are a direct result of
the venous congestion, as the pressure increases within tiny blood vessels (the post-capillary venules) causing them to rupture and spill their blood into the surrounding tissue. Petechiae are most commonly seen in strangulation where the tissue surrounding these tiny blood vessels is fairly thin. The most likely place to see petechiae is on the surface of the eyes, where the tiny blood vessels travel in the conjunctiva, the thin membrane that covers the surface of the eyes as well as the inner surfaces of the eyelids. If the victim survives the strangulation, the petechiae coalesce into larger hemorrhages, called subconjunctival hemorrhages, that typically appear as diffuse hemorrhages over the sclerae, the “whites” of the eye. Petechiae in the facial skin are most likely to appear around the eyes, where they are called periorbital petechiae. In the mouth, petechiae may be present on the surfaces of gums or sides of the mouth. Here, they are called oral mucosal petechiae.

Petechiae and conjunctival hemorrhages are important signs of strangulation. However, the absence of petechiae does not mean that strangulation did not occur. It is possible to render an individual unconscious without producing petechiae. The most important factors responsible for producing petechiae are the length of time of neck compression and the degree of venous congestion during that time. Because these factors cannot be measured directly in assessing any particular incident of strangulation, there is no simple correlation between the severity of strangulation and the presence of petechiae. Nevertheless, it is generally true that the presence of petechiae reflects the severity of strangulation.

**Documenting strangulation injuries**

In all cases of strangulation seen at the hospital or by emergency medical providers, the diagnostic medical examination necessarily takes priority over the forensic examination. Only after the patient has been cleared medically should there be a focus on collecting forensic evidence. Of course, because medical records are likely to become forensic evidence, the medical examination should be documented thoroughly. When evaluating an individual for strangulation injuries it is important to document both the signs and the symptoms of strangulation. The signs of strangulation include the primary signs mentioned above, and include the nonspecific and specific injuries and wounds of the neck. In a thorough examination, these injuries are recorded by descriptions, diagrams and high quality photographs that include measurements of any injuries. Photographs should be taken of all four surfaces of the neck – front, both sides, and the back –whether or not injuries are present. If there are injuries visible, photographs must include a ruler next to but not covering the injury. Multiple photographs with and without a ruler and from different angles are necessary to fully document any injury. As it is likely that a digital camera is used, adequate quality of documentation is assured by immediately reviewing each picture for focus and lighting. Trying to get too close to the subject is a common mistake and results in a useless, out-of-focus photograph. Glare from the camera flash oftentimes obscures an injury, so it is very useful to take multiple photographs at different angles of the same surface or to try photographing the surface also with the flash turned off.
The eyes must be examined carefully for petechiae and conjunctival hemorrhages. The individual being examined can help by pulling the eyelids open and looking up, down, left and right. Special attention needs to be directed to examination of the under eyelids. This can be done by asking the individual to gently pull the lower eyelids down in order to see the pink membranes lining the inner aspect of the eyelids. The face, especially around the eyes and also behind the ears, should be examined closely under a strong light. It is necessary to take photographs using a macro or close-up lens and good lighting. For a good examination, the presence of petechiae must be documented as well as the location they are present. Furthermore, a complete examination documents the absence of petechiae in order to show that they were looked for and how thoroughly the examination was performed.

As it is likely that there will be additional injuries or signs of assault, it is important to examine other parts of the body and record any injuries identified. Again, thorough documentation includes descriptions, diagrams, and photographs. Documentation of potential bite marks requires expert photography. Strangulation assault is highly associated with sexual assault; therefore, a sexual assault examination may be required. Conversely, an individual reporting sexual assault should be questioned and examined for the possibility of strangulation.

**Documenting symptoms of strangulation**

In recording the symptoms of strangulation, it is necessary to distinguish symptoms experienced at the time of assault from those experienced after the assault, including at the time of examination. This is important for both medical and forensic purposes. Persistent pain in the neck may indicate an anatomic injury that could compromise the airway or the blood flow in the neck. Again, medical attention takes priority over forensic examination. After the patient describes the general sequence of events occurring during the assault, specific questions should be directed at the details of strangulation. It is useful to construct a time line in order to understand the sequence of events as the assault may have occurred over a period of time in several stages. The victim may have been unconscious, may have poor memory, or may be unwilling to recollect the events. Thus it requires time, patience, and trust in order to extract the details. The important details include the number of times the victim was strangled, over what time period, and by what means. Were the hands, a ligature, or a neck hold used? Exactly how were the hands, ligatures, or other objects positioned on the neck? What type of pain was experienced and where was it? It is useful to have the victim point to demonstrate how the neck was compressed and point to the places of greatest pain during the assault. Did the strangulation interfere with breathing? Did the face feel full or hot? Did the victim become unconscious and what was that experience like and how long did it last? How did the victim know how long the experience lasted? Were there visual changes – stars, flashes of light, darkness, or narrowing of the visual fields? Was the victim able to speak, cry, or yell while the neck was being compressed? Did the victim become incontinent of urine or feces? Besides the strangulation, were there other components of assault – beating, slapping, or biting? Where were these directed? Was there sexual assault? Were the victim and/or assailant using drugs or alcohol?
After the strangulation, was there persistent pain? How long did it last and exactly where was it? Again, it is useful to have the victim point or demonstrate where the pain was. Was there difficulty swallowing, coughing, gagging, vomiting and how long did these symptoms persist? Did the victim experience hoarseness or difficulty speaking? For this purpose it is useful to see if there is a 911 recorded call from the victim. If the pain persists at the time of examination, is there a certain point on the neck that is tender, and can it be related to an anatomic structure? Did the victim notice any hemorrhages in the eyes? If there was a medical evaluation, do the records correspond to the victim’s statement recorded from other sources? Are there any x-rays or laboratory studies, for example, blood alcohol or urine toxicology screens? Are injuries of the neck and other regions documented? Was there a sexual assault examination? Was the victim hospitalized? Were treatment or follow up medical care required for injuries? Did the victim experience persistent emotional symptoms or require psychological treatment? If possible, it is informative to repeat the evaluation of the victim over a period of time. Physical injuries progress over time, and deeper injuries become more apparent. Furthermore, hoarseness or pain that persists for several days indicates an anatomic injury such a hematoma or a laryngeal fracture.

Medical testimony in strangulation injuries

Medical testimony in strangulation assaults serves to educate the jury so that they can better understand the mechanisms of the injury and thus be able to determine whether the assault interfered with breathing or restricted blood flow to the brain. Medical testimony is also helpful in guiding the jury in assessing whether the documented physical injuries and symptoms are consistent with strangulation. Unfortunately, most strangulation assaults are poorly documented medically, and there are almost never any residual signs that strangulation ever occurred. After strangulation, the victim is either dead or completely healthy, at least physically. In essence, the jury must decide whether or not the victim truly experienced a potentially life-threatening assault. This decision often rests with the jury believing whether the victim’s story is credible and consistent with other evidence. Because strangulation injuries are more subtle than those of other types of assault, ideally the medical testimony should be educational for the jury to deliver a fair decision.