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Review Article

Pathological and Physiological Principles of Instantaneous vs. Sudden Death

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Abstract

The body of United States Marine Corp officer was discovered by his wife in the backyard of their home lying on a 12-gauge shotgun. Investigators identified an intraoral wound suggesting suicide, but still processed the death scene as a homicide. An autopsy was performed the following day. The death certificate issued that same day called the death a suicide. The purpose of this paper is to distinguish between instantaneous death and sudden death, as well as to emphasize the initial death certificate issued in an unwitnessed violent death is a preliminary document and should not be finalized until there is a comprehensive evaluation of all the evidence. In this case, the correct conclusion of the officer's death required an understanding of those principles that define when death is instantaneous or sudden. If the initial trauma to the officer was only by the intraoral shotgun discharge, then death would have been instantaneous and thus a suicide. However, the autopsy results as well as the crime scene, autopsy skull x-rays and autopsy photographs indicate otherwise. The intraoral shotgun blast destroyed the entire brainstem, yet there was one-half liter of aspirated blood in his right lung and a lesser amount in the left lung. The body of evidence shows the initial trauma was a fatal blow to the right occipital skull which caused a depressed fracture with at least one bone fragment penetrating the brain. The autopsy revealed his death was sudden, not instantaneous. Consequently, this distinction indicates the manner of death was homicide. Furthermore, the autopsy findings establish the officer had already expired when the intraoral shotgun discharge occurred. This was done to stage a suicide and was likely an attempt to hide the evidence of the depressed occipital skull fracture.

Keywords: Forensic science; Instantaneous death; Sudden death; Brainstem; depressed Skull fracture; Aspiration; Decerebrate posture; Decorticate posture

Introduction

On January 22, 1991, the wife of United States Marine Corps officer found her husband lying dead in the backyard of their home on the Marine Corps Air Station at El Toro, California. He was lying on his right side, dressed in a white terrycloth bathrobe, which covered a tee-shirt and pajama bottom just as she had left him less than an hour previously to attend a meeting off-base. The officer's double barrel 12-gauge shotgun was in front of him and under his legs and feet (Figure 1).

Figure 1: The body of the officer in the backyard of his quarters on the Marine Corps Air Station El Toro, California, USA; a patio chair is on top of the body and a 12-gauge shotgun under his legs.

The officer's wife rushed to him, dropped to her knees and cradled his head in her lap. She later reported feeling a large swelling behind his right ear. Blood which covered his face was smeared onto her dress. The officer was generally devoid of any other bloodstains (Figure 1) except on his left forearm, left hand and blood spatter right hand [1]. Two small blood stains measuring less than five inches in diameter were observed in the grass about 8 to 10 inches in front of the victim's mouth [1]. The only other blood on the ground was under the victim's right shoulder with an origin from the victim's right ear, nose and mouth. No blood was present on the ground below or above these three areas [1].

The Naval Investigative Service (NIS) conducted the death scene investigation and determined the victim had sustained an intraoral shotgun wound and there was no exit wound. The decedent's body was sent to the local county coroner's facility for post mortem examination. There was extensive photographic documentation of both the death scene and the autopsy. In addition, skull x-rays were taken by the medical examiner, but apparently not examined prior to issuing the death certificate for there was no mention of the presence of an extensive depressed occipital skull fracture in the autopsy report [2].

The death certificate [3], dated January 23, 1991, stated that death was "immediate." This was defined on the certificate as "the interval between onset and death." The "onset" was defined as the "Gunshot Wound, head."The "Manner of Death" was recorded as "suicide."

If the death certificate was accurate, then the following had to have occurred: The victim committed suicide by sitting in a lawn chair while holding a 12-gauge shotgun in his mouth with his left hand. He pushed the trigger of the shotgun with a finger or thumb of his right hand. The position of the body suggests that in this scenario, while he was sitting in the lawn chair, the stock of the shotgun had to be on the ground adjacent to the lateral side of his right leg (Figure 2A).

Figure 2: A- Reenactment of the suicide scenario with the victim sitting in a chair and inserting the shotgun into his mouth; the muzzle is gripped by the left hand while the right hand is at the trigger. The shotgun was found under the right leg (Figure 1).This would place the shotgun in the reenactment on the outside of the right leg. In this scenario, gas escape from the mouth would spray the thighs (arrows) with blood and tissue on the front of the bathrobe and/or the thighs of the pajama bottom. The white dashed line on the lower right leg outlines the probable area of gunshot residue deposition if there were breech and trigger housing gas leakage by the shotgun. B- Reenactment of the homicide scenario where the officer's upper body is pushed down in an apparent ambush and received an extremely powerful club blow to his right occipital. C- Reenactment of part of the homicide scenario where the shotgun is inserted into the mouth of the victim and discharged; there was no exit wound. In order for the muzzle to remain in the mouth when the shotgun is fired, the stock of the shotgun would have to be supported. Evidence for a rapid exit (recoil) of the muzzle of the shotgun in this scenario is the rotation and drop to the grass of the left hand before receiving blowback blood [1]. The right hand was not exposed to detectable GSR. However, blood spatter is on the right hand which would also place this hand close to the nose and mouth, the only sources of blood shedding. The death scene photographs (e.g., Figure 1) show the victim's right hand near the mouth. White arrows: route of the gas expellation (blow back) while the shotgun muzzle was in the officer's mouth.

The victim somehow fell to his right from the chair after the shotgun discharged; straightened his body and the chair toppled on top of him in the process.

On the other hand, if death was by homicide, the victim received a blow to the back of his head (e.g., Figure 2B), which caused a large depressed skull fracture and severe brain and brainstem injury. The bludgeoning was fatal. However, the autopsy evidence suggests that it took minutes for death to have occurred. The officer was likely already dead when the intraoral shotgun discharged occurred, the muzzle of which was in contact with his soft palate (Figure 2C).The shotgun was placed in front and partially under the officer and a patio chair was placed on top of him to complete the suicide appearance (Figure 1).

The evidence necessary to support the suicide theory should depend on the unconditional lack of evidence of homicide. The scientific evidence demonstrated by the autopsy findings, skull x-rays, in addition to the crime scene and autopsy photos, only supports the homicide scenario: the officer received a powerful blow to his head which caused a depressed skull fracture and unconsciousness prior to the intraoral shotgun blast.

The Autopsy

The autopsy was performed at the Orange County California Coroner's facility on January 23, 1991. The following observations were taken directly from the autopsy report [2] and autopsy photos:

1. Gunshot wound (entry type) in the mouth to soft palate. No exit wound.
2. Large amount of aspirated blood in the right lung. Left lung weighs 440 grams, the right weighs 970 grams (normal adult male is 400 to 450 grams) [4].
3. Section of the lung tissue shows congested, atelecttic, edematous, hemorrhagic lung with extrusion of hemorrhagic frothy fluid.
4. Pharynx shows a laceration of the right side of the pharyngeal wall.
5. All brain tissue is massively lacerated.
6. No intact brainstem could be identified including medulla, cerebella tissue, midbrain, Pons, cerebral peduncles. A remnant of medulla appeared in the foramen at the base of the skull that was contiguous with spinal cord. Upper portion of spinal cord shows evidence of disintegration.
7. Cerebral cortex is massively lacerated.
8. Ecchymosis around both eyes. ecchymosis of the right ear and posterior.

9. Superficial contusions and lacerations of the lips. Laceration of the anterior [ventral] surface of the tongue and mid tongue area.

Skull X-rays obtained at the autopsy show a large depressed occipital skull fracture. Large subcutaneous and subgaleal hematoma over the depressed occipital skull fracture. The hematoma was devoid of any bone fragments or shotgun pellets. However there was no mention, what so ever, that skull x-rays wer obtained.

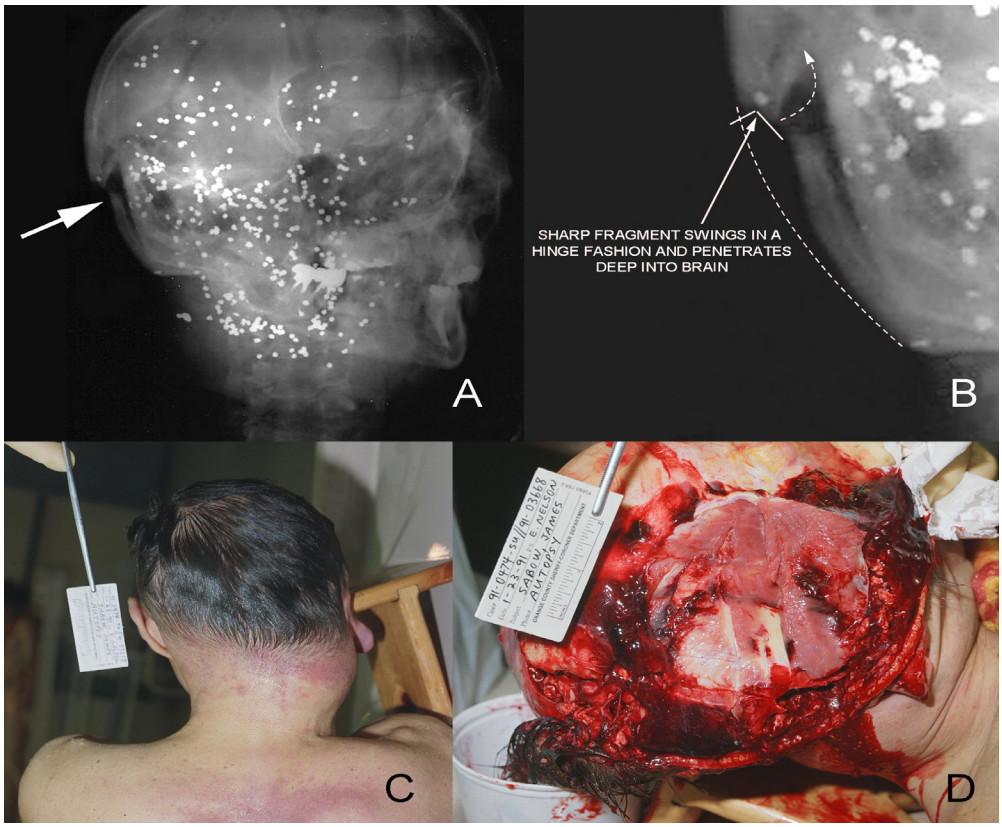

Figure 3: A- X-ray of the victim's skull from the right side showing a depressed right occipital fracture; arrow points to the depressed fracture of the right occipital region. The small bright objects are shotgun pellets. B- Enlargement of the fracture area showing a fragment of skull has had rotated into the brain. A shotgun blast would have caused bone fragments to project out. C- Posterior of the body after cleaning; the region posterior to the right pinna and the right pinna shows ecchymosed typical of "Battle's sign" (see text). D- Autopsy image with the officer's reflected scalp revealing part of the massive hematoma that had formed over the depressed skull fracture.

Skull Fracture

A 2.5 cm diameter, depressed (approximately 2 cm) occipital skull fracture was demonstrated on autopsy X-rays (Figure 3A and 3B). A photograph taken prior to the autopsy (Figure 3C) demonstrates massive swelling of the right posterior head and neck. A massive hematoma (Figure 3D) was found immediately under that swollen area and over the depressed skull fracture. All the shotgun pellets were located within the confines of the skull. There were no bone fragments or shotgun pellets within the hematoma. The x-ray (Figure 3B) shows the fractured bone protruding inwardly, not outwardly, as would occur if the fracture was the result of the intraoral shotgun discharge.

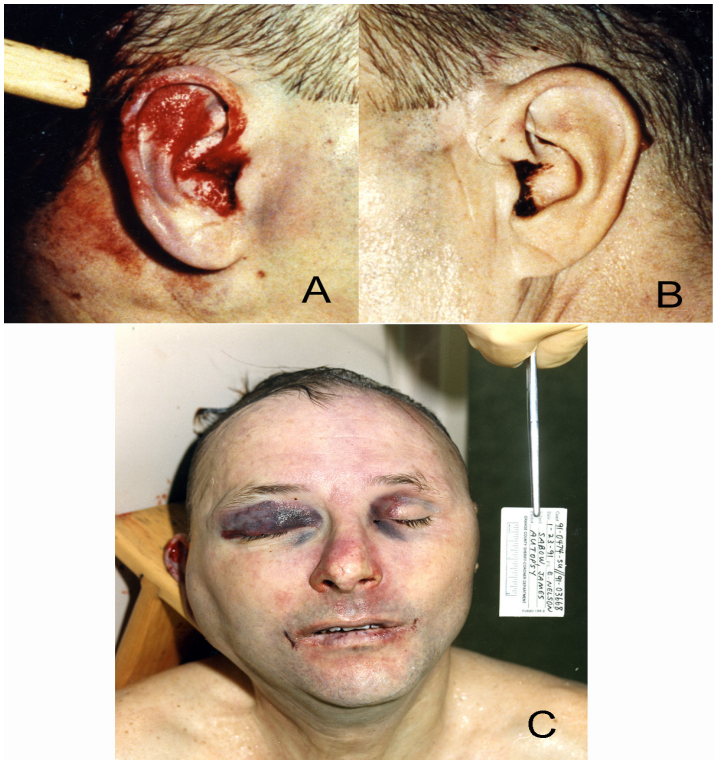

Figure 4: A- Ecchymosis of the right pinna and posterior and anterior to the pinna, or Battles sign. B- The left ear has normal coloration. C-Face of the victim showing ecchymosed of the eyes or "raccoon eyes" typical of basilar skull fracture. Extensive swelling on the right side of the face is also

Basilar skull fracture

There is evidence the victim also sustained basilar skull fractures in addition to the depressed right occipital skull fracture of the cranial vault. A clinical indicator of the presence of a basilar skull fracture is a purplish discoloration of the skin (ecchymosis) behind the ear which extends into the skin mostly covering the back of the right pinna cartilage (Figure 3C) as well as portions of the anterior aspect of the right pinna (Figure 4A). Compare with the normal coloration of the left pinna (Figure 4B). This is characteristic of a basilar skull fracture of the temporal pyramids at the skull base and is known as Battles sign [5]. (Figure 5C) shows another classic clinical sign of a basilar skull fracture, ecchymosis around the eyes, the so-called raccoon eyes [6]. The fracture extends anteriorly and involves the sphenoid bone, which often accompanies the severe cranial fracturing as observed with the officer [5, 6]. Both of these signs are the result of bleeding from the fracture sites with enough perfusion pressure to dissect through adjacent tissues to produce these visible subcutaneous hematomas [7]. The presence of these signs indicates that the basilar fractures occurred while the victim maintained a significant systolic blood pressure which of necessity was high enough and long enough to dissect through these tissues. If the victim's death was instantaneous, these classical sign of basilar skull fractures could not have developed.

Respiratory System

The autopsy report states that the victim not only had blood in his large breathing passages, but the blood filled his alveoli, producing hemorrhagic frothy fluid. This was discovered when the lung tissue was sectioned at autopsy. The right lung weighed 970 grams and the left lung 440 grams. The average normal male adult lung weights are 450g (R) and 375g (L) [4]. Therefore, there was an excess of approximately 545g in the right lung. The autopsy report concluded that the extra weight was blood. The specific gravity of blood is 1.058 [7], which indicate that there was slightly more than 500 ml of aspirated blood in the right lung. The left lung weighed 440 grams indicating that there was very little aspirated blood in that lung. The excess lung weight could not be a result of terminal neurogenic pulmonary edema, for if that was the case, the excess weight would be evenly distributed to both lungs. Consequently, the victim had to have been laying on his right side when he aspirated the blood into his right lung. Central neurogenic hyperventilation is a characteristic respiratory pattern seen in severe brain stem injuries where the victim is near death [8].

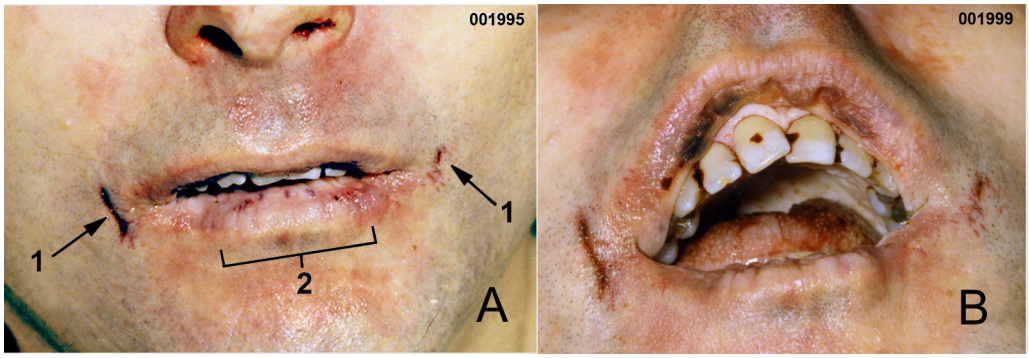

Figure 5: Evidence of the victim biting his lips, likely in decorticate/decerebrate rigidity before the shotgun blast. A- Frontal view, 1: linear abrasions at the angles of the mouth resulted from the stretch of facial tissues at moment of intraoral shotgun discharge. 2: The linear bruising and abrasions coincide with the upper middle and lateral incisors. B- A more inferior aspect image that better shows the swelling of the lower lip, and bruising/laceration of the upper lip by the lower front teeth. Images A and B slightly enhance by Adobe Photoshop Levels.

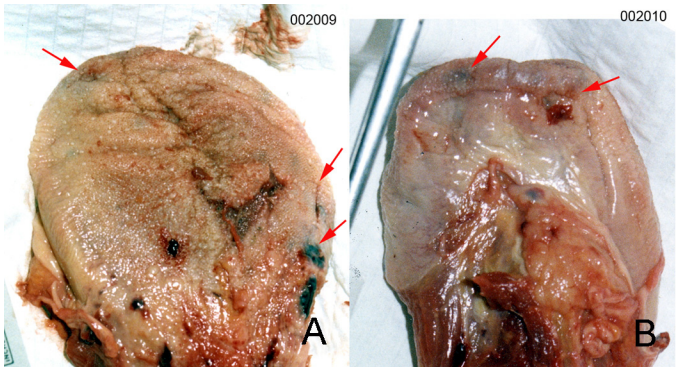

Figure 6: Autopsy images of the tongue; arrows point to bruising and lacerations made by the victim's teeth. A- Dorsal tongue. B- Ventral tongue.

If the victim's death was instantaneous, not a single respiratory effort would take place. Consequently, the victim could not have aspirated any blood. Conversely, after a severe brainstem injury where a laceration of the pharynx was present, the ensuing hyperventilation would explain the presence of one-half liter of blood in the right lung.

Oral Mucous Membranes and Tongue

The autopsy photos document lacerations of both the upper and lower lips that correspond to the upper and lower incisors. (Figure 5), as well lacerations of the anterior (ventral) surface of the tongue and mid tongue area (Figure 6). These lacerations and are frequently seen after convulsive epileptic seizure [9]. Severe brainstem injuries result in somewhat similar situations that are termed decerebrate and decorticate posturing [8]. These are violent convulsive-like spasms that virtually always are a prelude to death. In addition, these epileptic-like spasms are accompanied by extreme hyperventilation which can lead to aspiration of blood [9] as was evidenced in this case.

Vertical tears occurred at both sides of the mouth (Figure 5A) which were caused by rapidly expanding gas within the oral cavity and cranial vault from the gunshot generated gas [10] which escaped through the entrance wound, in this case, the mouth.

Blood Loss

Intraoral gunshot wounds are the most mutilating wounds that can be sustained [10]. When there is no exit wound, the mutilation is even more severe due to rapidly expanding gases within the confines of the skull. This results in evisceration and pulpification of the brain [10].

Consequently, one would expect an extremely bloody death scene in the case of a self-inflicted intraoral shotgun wound in contact with the soft palate. However, the naval medical officer that was called to the death scene, estimated that the blood loss was approximately 50 cc [11], hardly more than the volume of a shot glass. Moreover, in the suicide theory, the victim was alleged to have been seated in a patio chair while holding the shotgun barrel in his mouth with his left hand, and with the butt of the gun placed on the ground next to his right foot. This would place the victim's mouth over his torso and thighs. Yet there were no bloodstains,

except for several small drops, on the front of the victim.

Positioning of Victim at Crime Scene

When the victim was discovered in the backyard of his base housing, he was laying on his right side with his lower extremities extended, one on top of the other and both his arms flexed in front of his mouth (Figure 1). His bathrobe neatly covered his body. All in all, the appearance was rather tidy, as if the victim was asleep on his right side. If the decedent had shot himself while sitting in the patio chair, destroying his entire brainstem, the muscles of his body would instantly become flaccid [8] and he would have collapsed like a rag doll. He should have been found with a disheveled bathrobe and his extremities in disarray.

Discussion

Official examinations [3,12-14] of this case have claimed the victim died by suicide after placing the muzzle of a 12-gauge shotgun intraorally and discharging it. These conclusions demonstrated a lack of understanding of basic concepts of brain physiology that are necessary to distinguish between instantaneous death and sudden (or immediate) death.

Instantaneous means occurring in an instant without any perceptible period of time. When death is sudden, it means death must follow the injury with a period of time that is perceptible, although that period may be brief. If an injury severs principle blood vessels and causes the injured person to bleed to death, his death may be regarded as sudden, not instantaneous. The term "sudden" is more elastic in meaning than "instantaneous" [15]. We prefer sudden in this application. Sudden cardiac death refers to natural death from cardiac causes, respiratory arrest (such as due to airway obstruction, which may be seen in cases of choking or asphyxiation), toxicity or poisoning, anaphylaxis, or trauma. In all these cases, there remains some body and neurological function, such as gasping, musculo-skeletal posturing, blinking, etc. These terminal events indicate that death is imminent but has not yet occurred. These events require at least some elemental brainstem function. Conversely, when death is instantaneous, the event that resulted in death caused the person to lose all brainstem function with no perceptible time from that event until death. Obviously, instantaneous death is quite rare but from a forensic standpoint and 'in this case in particular' its recognition (i.e., all the evidence showing it was not an instantaneous death) is critical for determining the manner of death.

Physiological principles must be understood in defining sudden from instantaneous death:

- The brainstem is the upper continuation of the spinal cord. All impulses descending from the brain cortex and upper areas of the brainstem must pass through the medulla, which is the lowest portion of the brainstem [16].
- All information from the periphery must pass through the medulla before it reaches higher brain centers [16].
- The respiratory and cardiac centers are located in the medulla [16].
- Deep within the brainstem, there is a nerve fiber complex known as the ascending reticular activating system (RAS). This fiber complex, among other things, is necessary to maintain consciousness. Disease or injury results in varying degrees of impairment of consciousness [16].
- Within and surrounding the RAS are the nerve fibers that constitute the autonomic nervous system, including the sympathetic and parasympathetic. These systems are necessary for vascular tone and cardiac regulation [16].
- The muscles involved with breathing are the diaphragm and the intercostals or chest muscles. They receive their nerve supply from cells originating in the spinal cord. However, these cells cannot function without input from nerve impulses descending in the spinal cord which originated in the brain and brainstem. There is no respiratory center in the spinal cord [16].
- The abrupt transection of the spinal cord results in instant and total flaccid paralysis of the entire musculo-skeletal system (spinal shock) [14]. Not a gasp can occur under these circumstances. In contrast, clinicians may observe agonal respirations, which require intact neural continuity between the brainstem and spinal cord, after cardiac arrest [17].
- The heart is regulated through the autonomic nervous system with nerve tracts that originate in the medulla. The heart muscle has the ability to beat without extrinsic neural input. However, its rhythm (chronotropic effect) is aberrant and its contraction (ionotropic effect) is weak, due to the loss of sympathetic input. Hence, the cardiac muscle loses its contractile force as well as effective rhythms [17, 18].
- The sympathetic nervous system is responsible for maintaining vascular tone. Sudden loss of the body's entire sympathetic input results in vasomotor paralysis and shock [19,20].

Consequently, since thealleged intraoral shotgun blast of the officer would have resulted in instantaneous death, there must be another explanation for the autopsy and crime scene evidence:

- Aspiration of approximately 500 cc of blood into the right lung.
- Depressed occipital skull fracture.
- Large subcutaneous and subgaleal hemorrhage seen exclu-

sively above the depressed skull fracture.

- Basilar skull fractures associated with both Battles and raccoon signs.
- Lacerations of the tongue and lips that correspond with the upper and lower incisors.
- The estimated death scene blood loss of only 50cc.
- Positioning of victim at death scene.

After considering the medical forensic evidence, not taking into account other compelling factors such as gunshot residue and blood spatter factors, it must be concluded that the first assault on the decedent was a blow to the back of his head (as shown in Figure 2B) that caused a large depressed skull fracture. This resulted in the officer's death. After being struck, he was rendered unconscious and fell to the ground on his right side. A fatal brainstem injury followed. He exhibited the classic signs and symptoms of this injury, which included decerebrate and decorticate posturing. As this took place, there were violent contractions of all extensor muscles of the body and clenching of the jaws. During these severe muscular contractions, biting and laceration of the tongue and lips took place. The injury caused central neurogenic hyperventilation and because he was lying on his right side, he aspirated one-half liter of blood into his right lung. Death soon followed. Because he had already expired when the intraoral shotgun discharge occurred, and was without circulation, only a small amount of blood was part of the blowback. Therefore, essentially no blood was present on the bathrobe of the officer (Figure 1).

In view of this evidence, the officer could not have shot himself. He had to have died by homicide and there was an attempt to stage the body to appear to be a suicide [1] (also see Figure 1).

These basic scientific facts of brainstem physiology when applied to certain death investigations will aid in establishing whether the manner of death was by suicide or by homicide. Indeed, many independent experts question the suicide scenario and affirm homicide upon reviewing the discovery in the case [21-25].

This death investigation is an example of the necessity of not jumping to conclusions when the immediate appearance of a death scene suggests one thing but a careful scientific analysis of the evidence proves the opposite. It further underscores the axiom that the initial death certificate in an unwitnessed violent death should be considered as only a preliminary report, especially when the lion's share of the evidence, such as death scene report and photographs, autopsy photographs and x-rays and bloodstain evidence, were not available at the time of the issuing of the autopsy report and death certificate. In the officer's case, much of this evidence was not available prior to the medical examiner's conclusion of suicide. There was no indication in the autopsy report [2] that skull x-rays were even taken. Since these x-rays showed a large depressed skull fracture that was under a massive subgaleal hematoma, it is likely they were never seen by the medical examiner.

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