Original Article

Use of an Alternative Light Source to Assess Strangulation Victims

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Abstract

Alternative light sources (ALSs) are commonly used at crime scenes and in forensic laboratories to collect evidence such as latent fingerprints, body fluids, hair, and fibers. This article describes the use of this technology to reveal soft tissue injuries that are not visible to the naked or unaided eye in patients who report strangulation. The value of this information to the medical, nursing, and judicial systems is discussed. The records of the 172 strangulation patients seen in our forensic nurse examiner program between 2009 and 2010 were reviewed. The SPEX Crimescope (SPEX Forensics, Edison, New Jersey) was used during the assessment of all of them. Ninety-three percent of the patients had no visible evidence of external injuries on physical examination. The ALS revealed positive findings of intradermal injuries in 98% of that group. Information obtained with ALS devices helps medical and nursing practitioners understand the gravity of patients' injuries, influences medical treatment decisions and follow-up care, and supports the prosecution of the perpetrators of crimes of violence. Educational programs about the application of ALS and the interpretation of its findings are valuable for medical, nursing, and other forensic disciplines.

KEY WORDS:

alternative light source; bruising; choking; injury; strangulation; throttling

Police officers respond to a complaint of domestic violence. At the scene, they find a tearful woman who reports having been "choked." She has no visible injuries, she did not pass out, and no weapon was used. The husband is asked to leave the home for the night to let things "cool down." No arrests are made.

This scenario plays out many times each day. Because this type of assault may not leave visible physical proof, law enforcement officials, medical and nursing personnel, and prosecutors struggle to verify that an assault actually occurred. Victims of manual strangulation (the most common type of strangulation) are at an extreme disadvantage because their injuries are seldom visible to the naked eye. This creates challenges for forensic medical and nursing staff in collecting photographic evidence and for medical care providers in diagnosing and treating life-threatening injuries. Our Forensic Nurse Examiner (FNE) Program, located in an urban medical center on the east coast of the United States, uses light source technology that identifies bruising and other wounds at the intradermal level, enabling hospital care providers to treat injuries and assess for potential physical complications.

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Use of an Alternative Light Source in Our FNE Program

Our FNE program is the designated center for the assessment of victims (>13 years old) of sexual assault and the perpetrators of that crime in a major U.S. city. The program also conducts forensic medical examinations on victims of interpersonal violence. Thirty-one FNEs cover a 24/7 schedule and staff a mobile unit that brings forensic medical care to victims considered too injured or ill to be transferred to the medical center where the forensic program is located.

In 2006, we began a search for solutions to several frustrations surrounding the care of patients who reported being strangled and the subsequent prosecution of the people who had attacked them. Medical personnel had no definitive protocol stipulating when to request computed tomography scans, soft-tissue films, and other studies of the neck on these patients. A literature search revealed a limited amount of published research on the assessment of live victims of strangulation; however, there is a growing interest in applying the science of alternative light source (ALS) technology to the visualization of intradermal bruising (Rowan, Hill, Gresham, Goodall, & Moore, 2010).

As a result of our inquiries, we pioneered the use of an ALS for use in forensic nursing examinations in our program. An ALS consists of a powerful lamp that emits ultraviolet, visible, and infrared wavelengths. It filters the light into individual color bands (wavelengths) that enhance the visualization of evidence by light interaction techniques: fluorescence (evidence that glows), absorption (evidence that darkens), and oblique lighting (small particle evidence that is revealed). These light sources can reveal bruises and patterned wound details that are invisible under normal white-light illumination. The visible light spectrum extends from ultraviolet wavelengths (190–290 nm) to infrared wavelengths (>700 nm; see Figure 1). As the wavelength increases, the amount of energy decreases. Because these wavelengths are so bright, examiners wear goggles as a filter, allowing fluorescence or absorption to be visualized. Goggle lenses vary in color from clear to yellow, orange, and red. The patient should wear red goggles, for maximum protection, during the examination. It is recommended that the examiner use multiple wavelengths as well as various colored goggles for optimal visualization of injury and debris during a forensic nursing examination. The SPEX CrimeScope utilized for these study cases contained filters for wavelengths of 415-535 nm as well as ultraviolet wavelengths (SPEX Forensics, 2012).

The bruising caused by strangulation was most often visualized with wavelengths of 415–515 nm and multiple colored goggles (see Figures 2–5). As all patients have capillary rupture at different thresholds of injury, no consistent positive ALS finding occurs with any one wavelength or color goggle. Multiple wavelengths are necessary because different colors penetrate to different depths of the skin. Therefore, depending on the depth of the bruise or wound, the wavelength needed for visualization can vary. Because of the variability of bruising in each patient as well as varying times between assault and treatment, it is imperative

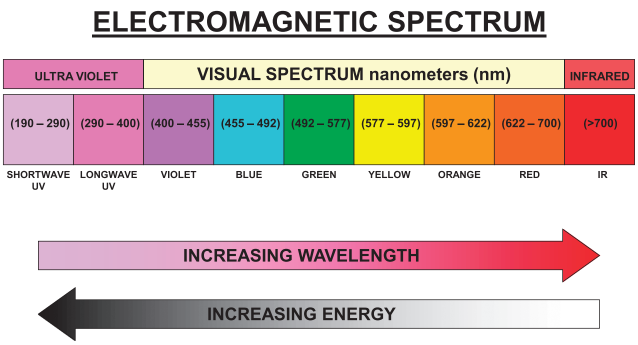

FIGURE 1. Visible light spectrum (courtesy of John Goldey).

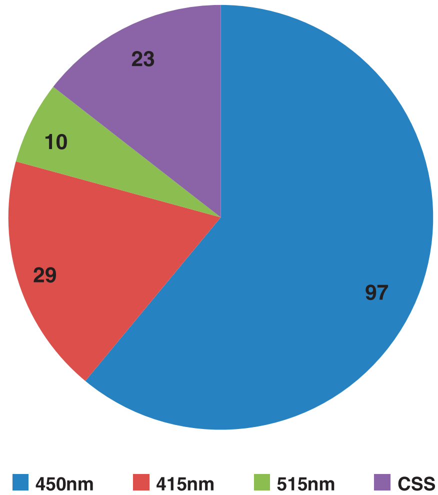

FIGURE 2. ALS wavelengths used in the detection of 172 strangulation victims.

to use all wavelengths as well as multiple colored goggles when assessing each patient. Bernstein, Nichols, and Blair (2012) note that wounds at a subcutaneous level may require the use of infrared illumination to achieve sufficient skin penetration. However, infrared wavelengths were not utilized because of the constraints of available filters in the system used by this program.

As blood does not fluoresce, it appears as absorption of the ALS and dark in color. Topical blood will be visible to the unaided eye and should not be confused as bruising. In addition, tattoos, veins and arteries, and hyperpigmented areas will also absorb light. These are also seen by the unaided eye and are excluded as areas of latent injury. For this practice, latent injury and latent bruise absorption will refer to that injury, which, although capable of emerging, is not visible or obvious to the unaided eye but is detected with an ALS system (SPEX Forensics, 2012). ALS may also assist in the detection of patterned injuries, such

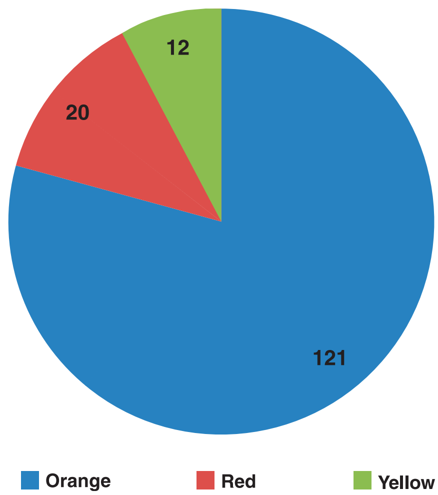

FIGURE 3. Goggle colors used in the assessment of 172 strangulation victims.

FIGURE 4. Photograph in white light (courtesy of Erin Lamar).

as shoe prints and belt marks, which corroborate patient history and reveal mechanism of injury (Figures 6 and 7).

Retrospective Chart Review

The information reported herein is part of a larger study that received Institutional Review Board or Internal Review Board approval and represents a summary of a retrospective chart review of patients who reported domestic violence and/or sexual assault with a history of

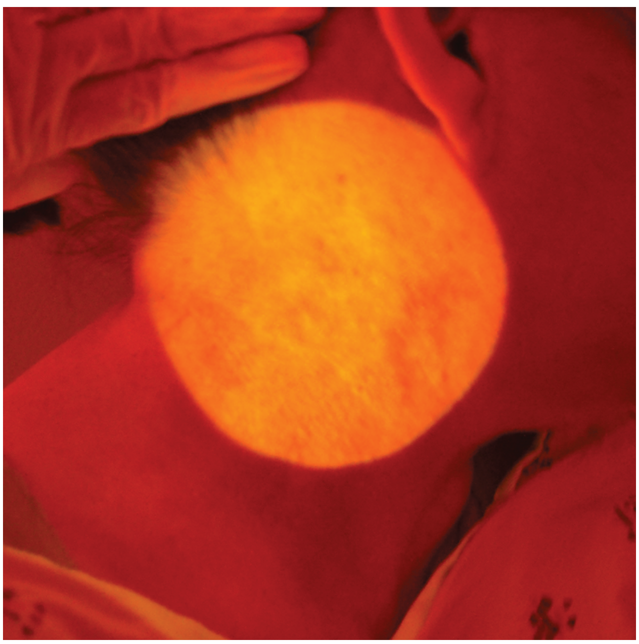

FIGURE 5. Photograph in 415-wavelength ALS (courtesy of Erin Lamar).

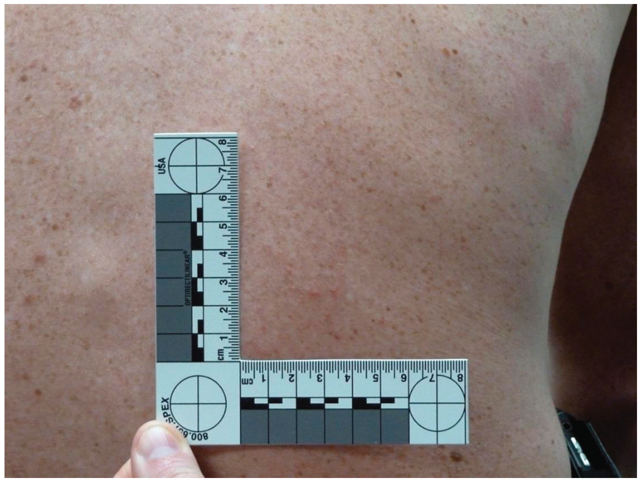

FIGURE 6. Photograph in white light (courtesy of Jon Goldey).

manual strangulation. The charts were reviewed for history of the assault, treatment received in the emergency setting, presenting symptomology, visibility of physical markings on the neck with and without alternative light source (ALS) enhancement, wavelength, goggle color, clinical tests and patient outcomes.

Of this group, 171 of the patients were female, and 1 was male; 118 (69%) of the patients were African American, 47 (27%) patients were Caucasian, while 7 (4%) patients fell into the category of Hispanic or Asian. On physical examination, 93% of the patients had no visible evidence of external injuries; however, the ALS revealed intradermal injuries in 98% of the group. The SPEX CrimeScope® was utilized as the ALS in all 172 cases.

Mechanics of Strangulation

McClane, Strack, and Hawley (2001) report that strangulation is a violent, intentional act, defined as "a form of

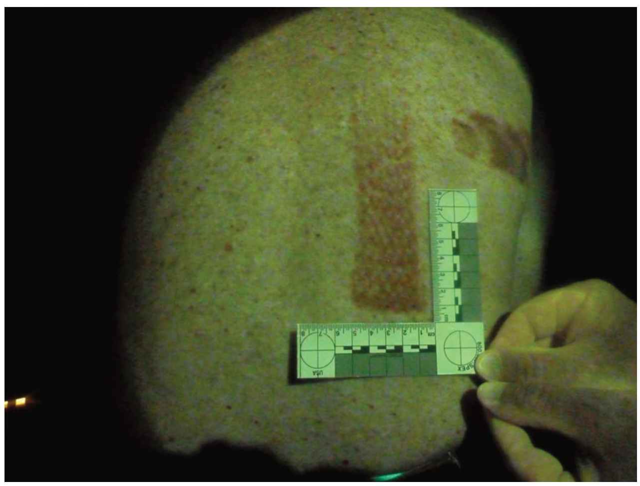

FIGURE 7. Photograph in 450-wavelength ALS (courtesy of John Goldey).

TABLE 1. Structures of the Neck	
Carotid arteries	Carry oxygenated blood to the structures of the head and neck, including the brain
	Obstruction causes impaired blood flow, brain ischemia or stroke, clotting, loss of consciousness, and/or cardiac arrest
Jugular veins	Return deoxygenated blood from the head to the heart
	Obstruction causes increased intracranial pressure, capillary rupture, intraventricular hemorrhage, cerebral edema, impaired cerebral perfusion, and/or loss of consciousness
Thyroid cartilage	A wing-like cartilage that protects the trachea and the larynx (voice box)
	Pressure causes edema and pressure on internal structures of the neck
Hyoid bone	The only bone that does not articulate with any other bone
	Provides attachment for muscles of the floor of the mouth, tongue, larynx, epiglottis, and pharynx
	Pressure causes fracture, edema, and/or tears to supporting musculature
Trachea	Allows passage of air from the nose and mouth to the lungs
	Pressure causes airway compromise, hypoxia, stridor, voice changes, dysphagia, pneumonia, acute respiratory distress syndrome, and/or death

asphyxia characterized by closure of the blood vessels or air passages of the neck as a result of external pressure" (p. 311). According to the classic definitions of strangulation put forth by Iserson (1984), strangulation is inflicted by one of two methods: (1) manual strangulation, also known as "throttling," is imposed via a one- or two-handed chokehold and (2) ligature strangulation, also known as "garroting," is imposed through the use of a cord, rope, or clothing to compress the neck. Ernoehazy (2011) further divides garroting into two categories: hanging (using the body weight to compress a ligature) and autoerotic (self-induced asphyxiation for sexual gratification).

According to Strack, McClane, and Hawley (2001), manual strangulation is used in 97% of all strangulation scenarios, and ligature strangulation is used in 3% of cases. Most victims of strangulation lack visible evidence of the attack: they have no visible injury (50%), or their injuries are too minor to photograph (35%). We have found that, when the mechanism of injury is an arm or hand exerting pressure on the neck, intradermal capillary beds under the skin may be disrupted but are not visible to the naked eye. Small blunt-force trauma generally causes bruising that can be seen by the unaided eye, whereas large surface trauma generally causes intradermal bruising seen only with the aid of ALS. Kaczor, Pierce, Makoroff, and Corey (2006) have reported that the absence of bruising does not mean that an assault did not occur. In a review of living victims of strangulation, Shields, Corey, Wekley-Jones, and Stewart (2010) reported that a lack of external physical findings is commonly encountered in the living victims of strangulation.

In the series described in this paper, only 12 of the 172 manual strangulation victims (7%) had injuries visible to the naked eye. Although the neck is a relatively unprotected region of the body, it contains the primary structures that support life-sustaining processes (see Table 1). Sheridan and Nash (2007) have observed that victims often report a variety of signs and symptoms either during or after an assault, including dizziness, visual changes, loss of consciousness, headache, tinnitus, coughing, nausea/vomiting, involuntary loss of bladder or bowels, petechial hemorrhage (notably in the eyes, on the gum line, and behind the ears), muscle spasms, memory loss, shortness of breath, and syncope or near syncope.

On the basis of a chart review of the 172 patients reviewed for this report, we found that 90% of those who had no visible evidence of strangulation and who reported at least two of these conditions tested positive for intradermal indications revealed by the ALS. Relatively few ($n = 5$) of the 172 patients in our study group reported experiencing a full syncopal episode during the strangulation; however, 32 described near-syncopal episodes. This is particularly significant in states such as Maryland, where strangulation is a first-degree felony crime only when the victim experiences a syncopal episode (Md. Code Ann., Crim. L. § 3-202(3)). All the patients who experienced full syncope also displayed petechial hemorrhage in the eyes, in the ears, or at the gum line. Thirty of the thirty-two patients (94%) who described presyncopal episodes exhibited petechial hemorrhage in the eyes only.

TABLE 2. Numbers of Strangulation Victims Assessed in the Forensic Nurse Examiner Program

	No. of victims
June–December 2008	49
January–December 2009	147
January–December 2010	252
January–October 2011	312

Education of Nurses, Physicians, Police Officers, Attorneys, and Judges

Before 2008, relatively few victims of strangulation in our city were brought for emergency medical care. A presentation on the use of the ALS was introduced to the detectives of the felony family violence unit of the city's police department in 2008 and received an overwhelmingly positive reception. Shortly after this presentation, patrol officers began to bring victims of strangulation to our hospital-based FNE program, where we were able to provide a supportive clinical evaluation model, which assisted medical and nursing staff in achieving appropriate diagnosis and level of care. Police intervention has been a major factor in ensuring that assault victims receive effective medical and forensic nursing evidentiary examinations. This is noteworthy, as Wilbur and colleagues (2001) have reported that only 29% of women who were strangled sought medical help independently.

Judges in both district and circuit courts requested bench training on strangulation dynamics and forensic technology as well as information regarding the potential for life-threatening sequelae. Within 6 months, this training on the use of the ALS was presented to more than 70 judges, 80 state attorneys, and 80 detectives, leading to a further increase in the number of strangulation victims transported to our FNE program for evaluation (see Table 2). This training is now a curriculum component at the city's police academy.

In addition, this FNE Program was successful in developing an educational curriculum, which is presented to nursing staff from the emergency departments of 11 local hospitals as well as to medical students and residents from two of the nation's largest schools of medicine. This education has improved referrals of patients for forensic nursing evidentiary examinations and improved patient outcomes.

Conclusion

ALSs have long been used by medical examiners at crime scenes and in death investigation cases. Their use as an examination tool with living patients, however, has not been fully appreciated. Through our clinical practice and our research, we have concluded that the ALS can aid in the examination and treatment of the victims of violence.

Victims of domestic violence are frequently dismissed, because their injuries are often not visible to the naked eye. Strangulation victims are difficult to assess in the emergency department for the same reason—their injuries may not be visible to the naked eye. However, according to Plattner, Bollinger, and Zollinger (2005), small leaks in the vascular system can result in hypoxic cerebral damage, neurological impairment, or death, if not diagnosed in a timely fashion. Performing magnetic resonance imaging or obtaining a computed tomography scan on every strangulation victim is not only time consuming but also not an appropriate use of medical resources and may expose the patient to unnecessary radiation. The use of an ALS combined with the assessment of symptomology can both show injury and indicate which patients need further assessment.

Because bruising caused by strangulation occurs at multiple intradermal levels, no one wavelength or goggle filtration color was found to be effective in all cases. Therefore, it is recommended that practitioners use various wavelengths and goggles with various colored lenses during strangulation assessments. The review of our series revealed no clinical relevance in relation to the patient's age or whether the patient was light or dark skinned. It is important to note that hyperpigmented areas such as skin folds, age spots, and tattoos will absorb light and must not be mistaken for latent bruise absorption.

FNE programs have become an integral part of emergency medicine and are fully equipped to assess injuries and perform evidentiary examinations. FNEs are an excellent conduit for evaluating victims of interpersonal violence and assisting the medical community in achieving appropriate diagnoses and positive patient outcomes.

Implications for Forensic Clinical Practice

The information regarding this retrospective chart review represents approximately one third of the total 500 charts reviewed and reflects trends and findings that are notable for medical and forensic nursing practice. Once complete, findings from the larger comprehensive study should further substantiate these outcomes. In addition, further review of medical protocols defining criteria for ordering radiological and other studies should be reviewed and compared with outcomes of negative physical examination versus positive ALS findings on this patient population.

Finally, it is imperative that all FNEs or other medical professionals using ALS technology should receive in-depth training in both the clinical and didactic settings and be educated by those experienced in the use and science of ALS systems. Clinical objectives that may be utilized in providing this education may include verbalization of the rationale for the utilization of ALS technology, protection of both the patient and practitioner utilizing ALS, demonstration of clinical use of goggles and multiple wavelengths, documentation of findings, and notification of medical staff of pertinent latent clinical findings. Clinical policies are available upon request to the authors.

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