



SPECIAL CONTRIBUTION

The Practice of Emergency Medicine

Approach considerations for the management of strangulation in the emergency department

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Abstract

Patients with a history of strangulation present to the emergency department with a variety of different circumstances and injury patterns. We review the terminology, pathophysiology, evaluation, management, and special considerations for strangulation injuries, including an overview of forensic considerations and legal framework for strangulation events.

KEYWORDS

airway, asphyxiation, carotid, choking, emergency medicine, strangulation

1 | INTRODUCTION

Patients present to the emergency department (ED) for evaluation after strangulation, and the contexts and resulting injury patterns can vary widely. Emergency clinicians should be familiar with the terminology describing these events, the pathophysiology behind the

potential injuries, the signs and symptoms that can be present, the suggested management, and some of the special circumstances of occurrence. Neck compression incidents are common, and the injuries can be serious.¹ Hangings, strangulation, and suffocation account for 30% of suicides, 2.5% of homicides, and 5.9% of intimate partner associate homicides.² Strangulation specifically accounts for around

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10% of violent deaths in the United States, with most victims being female.³⁻⁴ The rate of homicide by asphyxiation in the United States is in the range of 0.2 per 100,000 women ≥ 15 years old.⁵ Up to 68% of domestic violence victims have been strangled by their partners in their lifetime, and up to 47% of domestic violence victims have been strangled in the last year.⁶ Assault victims in the ED have reported strangulation 23% of the time; 38% of the time during a domestic violence event and 12% of the time during sexual assault.⁷

1.1 | Terminology

Many terms describe forceful neck compression. The overarching medical term “strangulation” describes compression of all anatomic structures, including the vasculature, trachea, esophagus, musculature, and bone, regardless of the context or mechanism of injury.⁸⁻⁹ “Choking” formally refers to internal airway obstruction.⁸⁻⁹ However, the term choking is commonly used interchangeably with strangulation. In combat sports, “choke” commonly refers to neck compression techniques, including those exclusively focused on compression of vasculature as opposed to the airway.⁹⁻¹⁰ In law enforcement, terms used to describe neck compression include neck hold, vascular neck restraint (VNR), carotid restraint, and choke hold.¹¹⁻¹³

1.2 | Pathophysiology

Strangulation involves pressure applied to the neck resulting in compression. Neck structures do not all compress with similar force. The jugular veins compress with less pressure than the carotid arteries because of malleable vessel walls and lower intravascular pressure.^{8-9,14-16} The carotid arteries, however, are easier to compress than the cartilaginous structure of the trachea.^{8-9,16} Although crushing of the trachea can cause airway compromise, the airway tends to maintain integrity during compression. Hence, vascular compression is the primary mechanism responsible for altering blood flow to and from the brain. Ischemic injuries can occur directly from lack of blood flow from compression, clot formation, or arterial dissection. Hypoxic injuries can occur from airway damage or secondary pulmonary effects.

Cerebral perfusion pressure (CPP) varies directly with the mean arterial pressure (MAP) entering the skull and inversely with the intracranial pressure (ICP); specifically, $CPP = MAP - ICP$. Normal physiologic ranges include MAP 80–100 mmHg, ICP ≈ 10 mmHg, and CPP 70–90 mmHg. Autoregulation of brain microvasculature allows for adequate blood flow at a CPP as low as 50 mmHg; loss of consciousness (LOC) is more likely below this level.⁹ The time and force required to induce LOC from strangulation vary with force and type of compression. LOC after fully established manual^{12,17-21} or machine^{15,17} compression in volunteers typically occurs in 6–14 seconds; this time frame has been verified in fully resisting combatants as well.²² Compression of jugular veins alone can limit blood flow out of the brain enough to raise the ICP, thus lowering the CPP below autoregulation capabilities, independent of carotid compression. With jugular and concurrent

TABLE 1 Potential presenting injuries, signs, and symptoms after a strangulation injury²⁵

Airway/Respiratory	Hoarseness, aphonia, stridor, cough, hypoxia, dyspnea, hemoptysis, and respiratory failure
Cardiac	Cyanosis, arrhythmia, and syncope
Brain	Confusion, headache, seizure, stroke symptoms, neurologic deficit, loss of consciousness, and urinary incontinence
Neck vasculature	Carotid bruit, neck swelling
Dermatologic	Ligature mark, abrasions, facial petechiae, and subcutaneous emphysema
Ophthalmologic	Eyelid/conjunctival petechiae, vision loss, and hemorrhagic retinopathy
Gastrointestinal	Pain with swallowing, difficulty swallowing, and vomiting
Psychiatric	Depression, post-traumatic stress

carotid compression, the ICP may transiently elevate, but ultimately the functional brain MAP decreases below CPP autoregulatory levels. Although pressure on the carotid body can reduce heart rate and blood pressure via vagal stimulation, this is rarely the cause of CPP reduction during strangulation.

2 | EVALUATION AND MANAGEMENT

Compression of the neck vasculature, larynx, or trachea may result in decreased cerebral oxygenation, potentially resulting in LOC or death; additional injuries can also occur.

Obtaining a complete history of the strangulation injury is essential; however, the extent of underlying damage can be underestimated in these injuries, especially as there may be a paucity of outward findings suggesting injury.²³⁻²⁴ Pertinent information includes the nature of the strangulation, persons involved, method used (eg, in ligature strangulation), additional injuries (eg, fall from hanging), timing (eg, time of injury onset, duration of injury), and prehospital care. Physical examination should focus on airway, breathing, circulation, head/neck, neurological, skin, and musculoskeletal assessments. Acute management for those who are found unconscious should focus on general resuscitative measures to maintain cerebrovascular blood flow. Table 1 outlines many of the potential signs and symptoms.

The extent of laboratory and imaging studies ordered depends on the level of suspicion the emergency physician has for injury. Laboratory tests are neither sensitive nor specific for strangulation injuries and should be ordered only on a case-by-case basis. Imaging studies are often employed in cases of strangulation to help rule out life-threatening sequelae such as laryngeal fracture or arterial dissection. In cases where imaging is performed to evaluate for structural damage in the neck, computed tomography (CT) angiogram of the neck is generally regarded as the gold standard. For some subtle traumatic injuries to

the cervical vessels or ischemic insults to the brain, magnetic resonance imaging) can be more sensitive but is not as available as CT.

Although symptom-based clinical decision rules or guidelines have been proposed to help determine the need for advanced imaging, they have not been validated. Retrospective studies generally show a low rate of clinically significant injury and low predictive value of symptoms, such as LOC or headache.²⁶⁻²⁷ A small proportion of patients reporting strangulation will have clinically significant injury patterns. The decision to pursue a CT angiogram depends on the clinician's concern for significant injury balanced against the risk and resources associated with imaging.²⁶⁻²⁸ It is reasonable to pursue advanced imaging of the neck for patients with a Glasgow Coma Scale score <15, focal neurologic symptoms, clear signs of airway injury, or dysphagia.

If the survivor of strangulation is asymptomatic, they can typically be medically cleared with strict return instructions and close follow-up. Patients with clinically significant symptoms with negative evaluation should be observed in the ED or overnight in the hospital depending on clinician concern (persistent symptoms, inability to drink, and lack of safe disposition). Additionally, consideration should be given to psychosocial outcomes in the aftermath. Early involvement of a support team potentially including social work, psychiatry, and law enforcement is essential.

3 | SPECIAL CONSIDERATIONS

3.1 | Prehospital care

Emergency medical services (EMS) personnel play a critical role when responding to calls involving strangulation. EMS involvement may be particularly important in suspected intimate partner violence (IPV) or child/elder abuse where victims may not understand the danger and may be reluctant to seek medical attention or implicate their attacker.²⁹ Victims may be hesitant to voluntarily share details of a strangulation attempt, especially in the presence of their attacker.³⁰ EMS personnel must be able to recognize warning signs of an abusive relationship in order to maintain strangulation on their differential diagnosis. Table 1 outlines potential signs and symptoms. However, half of victims have no visible injuries.^{23,29-31}

EMS personnel must recognize that non-fatal strangulation is a strong predictor of future violence and homicide. In these scenarios, the scene should be viewed as an attempted-homicide. Law enforcement presence should be requested if there is a concern for scene safety. Strangulation victims should be encouraged to undergo transport to an ED for further medical management.

EMS personnel may also encounter instances of strangulation when responding to scenes of street fights or organized combat sports. Other instances in which these injuries may be encountered include adolescent choking games, autoerotic asphyxia, bondage, discipline, sadism, and masochism (BDSM), and as part of law enforcement use of force (these topics are discussed later). Similar to victims of IPV, individuals who have experienced strangulation in these cases may not

voluntarily share details of their injuries or may not recall events due to LOC from asphyxia. Emergency response personnel should maintain awareness of scene details and bystander reports, coupled with the previously described signs and symptoms of these injuries to better recognize them.

Acute management on scene should prioritize airway and maximizing cerebral blood flow. Depending on the mechanism of strangulation, cervical spine injuries may need to be considered but cervical collar application should not take priority over airway management.

3.2 | Pediatrics

Children may suffer strangulation injuries but have unique mechanisms, presentations and anatomic considerations. Children are at increased risk for significant airway compromise secondary to the smaller size of their larynx and laxity of their soft tissues. Neck hematomas may expand more quickly with devastating consequences. Unusual mechanisms associated with choking of younger children include strangulation injuries from car windows, drapes, blind cords, power cords, and highchairs. Teenagers may sustain strangulation injuries from autoerotic asphyxiation or the "choking game," a game entailing strangulation for the euphoric sensation before LOC.³²

Pediatric and adolescent deaths from strangulation have not been well studied. One series of 28 young strangulation deaths from 1993 to 2004 showed female victims were more common than males, ligature strangulation (clothing and personal belongings) was 3 times more frequent than manual strangulation, 93% were homicidal, and the remaining 7% accidental. Fracture of neck structures was found in 25% of the cases and other associated injuries on different body parts were observed in more than half of the cases.³³ A separate series of 66 pediatric victims of hanging or strangulation, however, revealed no vascular injuries or cervical spine fractures.³⁴ In another series of 41 patients, two thirds were adolescents. No cervical spine fractures or cord injuries were found in this series.³⁵

Similar to adults, strangulation injuries in children may have subtle presentations. Bruising is the most common injury associated with physical child abuse and frequently overlooked or misdiagnosed as non-abusive. Pierce et al. conducted a prospective, multicenter study that refined and validated the TEN-4 (torso, ear, neck, <4.99 months of age) bruising clinical decision rule (sensitivity of 96% and specificity of 87%).³⁶ The body region injured was helpful in differentiating abusive and non-abusive bruises. The torso, ear, and neck alone correctly identified 81% of abuse patients. Pierce et al. also validated that bruising anywhere on an infant < 5 months of age or younger was a key predictor of abuse.³⁶ Clinical findings may be absent, subtle, or significant and include cough, stridor, muffled voice, or tenderness of the larynx. Subconjunctival hemorrhage, petechiae, or Tardieu spots may be present. Unfortunately, absence of physical signs does not exclude injury. Emergency treatment for pediatric strangulation injuries mirrors that for adults. CT imaging, specifically neck imaging, may be helpful to guide management, although studies are lacking in pediatrics.

TABLE 2 Use of force definitions from the National Consensus on Use of Force

Deadly force ^a	Force that creates a substantial risk of causing death or serious bodily injury.
Less-lethal force ^a	Force other than deadly force that involves physical effort to control, restrain, or overcome the resistance of another.
Choke hold	Maneuver that restricts the ability to breathe for the purposes of incapacitation; the consensus only allows their use when deadly force is authorized.
Vascular neck restraint	Technique that can be used to incapacitate individuals by restricting the flow of blood to their brain; the consensus recognizes the potentially dangerous nature of these restraints and allows their use only when deadly force is authorized.

^aThe consensus report notes that deadly and less-lethal force cannot be differentiated simply by the technique or tool applied, as many force options may result in death or serious bodily injury, and defines holds and restraints as less-lethal force.

3.3 | Vascular neck restraint by law enforcement

VNR was adopted by law enforcement decades ago as a less-lethal alternative to firearms and airway chokes and was formalized with training in the 1970s.^{37–38} The goal is not to induce LOC but to gain subject compliance. The mechanism for vascular restraint is a combination of venous compression and partial carotid artery occlusion.

There are few reliable studies on law enforcement VNR. Medical opinions tend to be based on case reviews of in-custody deaths, with resultant selection bias. There is a paucity of scientific literature that documents non-fatal use of vascular restraints. Most data available have been collected by individual departments, not by an independent third party, and lack the depth necessary for reliable analysis. In-house studies by agencies such as the Grand Junction Police Department³⁹ and Calgary Police Service⁴⁰ have shown the technique to be safe and effective, with lower risk of injury than batons and open hand controls. A study from Washington State, using third-party data, showed an association between VNR use and lower rates of weapon use and subject injury.⁴¹

High profile incidents have led to calls to ban law enforcement VNR. In 2016, leading law enforcement organizations drafted the National Consensus Policy on Use of Force.⁴² This provided a framework for use-of-force policies (Table 2). The policy goes on to stipulate that even when used under the context of deadly force, choke holds and VNR should meet the general provisions shown in Table 3.

Kneeling on a restrained subject's neck is not an accepted technique for VNR. Law enforcement has been cognizant of the risks and perceived risks associated with choke holds and VNR for some time. Most police leadership recommends that both be considered a deadly-force option and be viewed as such under the criteria of

TABLE 3 Provisions of law enforcement use of neck compression maneuvers

1. Physical force should be discontinued when resistance ceases or the incident is under control.
2. Physical force should not be used against individuals in restraints, except as objectively reasonable to prevent escape or imminent bodily injury to the individual, officer, or others.
3. As soon as practical and safe to do so, the officer should provide appropriate medical care. This may include providing first aid, requesting EMS, or arranging transportation to an emergency medical facility.

Abbreviation: EMS, emergency medical services.

objective reasonableness. Although there is little debate regarding the dangers of intentional anterior airway compression chokes, VNR remains understudied and a potentially viable option when looking at comparative use of force options.

3.4 | Combat sports

In combat sports, such as mixed martial arts (MMAs) and Brazilian Jiu Jitsu, neck compression maneuvers, or sportive chokes, are common. In elite-level MMA >15% of fights end due to voluntary submission or LOC from sportive chokes.⁴³ In the same series of MMA competitions, which included 5834 fights, 99 (11%) of the 904 fight-ending chokes were associated with LOC.⁴³ This rate of LOC is likely greater in elite competitions than in training, but even in training LOC is common enough that > 25% of grapplers reported having been choked to LOC at least once.¹⁰ One third of those surveyed reported having been choked > 500 times.¹⁰ This chronic repeated transient neck compression appears safe, but injuries can occur.^{10,44}

Medical personnel should be aware of the prevalence of sportive chokes and the potential of related injuries to guide their management. The main injuries for providers to be aware of in this context, as described previously, are structural neck injuries, particularly to the arterial vasculature,^{45–48} and ischemic brain injuries.^{49–50} The latter are exceedingly rare in the sportive context and generally accompany an arterial dissection and/or thromboembolic ischemic stroke as opposed to prolonged neck compression. Differing from other sports-related brain injuries, the mechanism is more similar to other ischemic phenomena as opposed to blunt traumatic effect, although within striking-inclusive sports such as MMA, blunt trauma is a clear confounder.^{51–54}

The combat sports use of the term “choke” is a misnomer, because these maneuvers are strangles and almost exclusively focus on vascular compression to accomplish the goal of inducing a submission by the opponent, or LOC if no voluntary submission occurs.⁹ The anatomic target of sportive chokes is bilateral compression of the jugular veins and, with greater force, the carotid arteries. This reduces CPP and decreases oxygen delivery to the brain, ultimately forcing LOC if there is no submission.⁹ That LOC can occur in as little as 2.5–3 seconds, but averages slightly <10 seconds once the choke is fully established.²²

Assessment and management of athletes exposed to sportive chokes is very much the same as strangling victims in other contexts. A special note on the physical examination is that neck marks are common and rarely representative of underlying damage, especially when athletes are training or competing in the traditional judo or jiu jitsu gi.

3.5 | Erotic/sexual asphyxiation

Erotic or sexual asphyxiation refers to the strangulation of oneself (autoerotic asphyxiation) or a partner for sexual pleasure. Within the BDSM community, erotic asphyxiation can be referred to as “breath play.” In contrast to IPV, such activity is often consensual. However, a consensual sexual encounter can also lead to non-consensual initiation of breath play, which is more often reported by women than men.⁵⁵ Erotic asphyxiation can involve choking, pliable ligatures, plastic wrap, or specialized hoods. The practice can be lethal, with estimated mortality of 250 to 1000 deaths each year in the United States.⁵⁶ However, cases may be unreported, as family members finding autoerotic asphyxiation victims may alter the scene because of social stigma, thus leading to underreported classification of these events as suicides or accidental hangings. Although erotic asphyxiation with consent is dangerous even if supervised, autoasphyxiation is extremely dangerous because of the lack of another person’s control.^{57–58} Those presenting with erotic asphyxiation should have screening for IPV as well as counseling about dangers associated with the practice.

3.6 | Hanging

Hanging is a special strangulation context where a fixed ligature provides the interface for the neck compression. Owing to the force of the body weight being transmitted into the ligature, spinal column and airway injuries are more common. In a retrospective evaluation of hanging deaths including 632 with complete autopsies, hyoid and larynx fractures occurred in 7.3%, cricoid fractures occurred in 0.5%, and cervical spine injuries occurred in 1.1%.⁵⁹ Such injuries are more common in male subjects, long drop hangings, and with complete suspension. Early airway intervention may be necessary with signs and symptoms of upper airway obstruction.⁶⁰ Hanging can also cause further pulmonary complications. Negative intrathoracic pressure from breath attempts against an obstructed airway can result in non-cardiogenic pulmonary edema and respiratory failure, even in the context of near hanging with successful removal from the pressure of the ligature.^{61–63} With these injury pattern caveats in mind and knowing certain interventions may be more necessary, emergency physicians can approach hanging victims similar to other cases of strangulation.

3.7 | Forensic considerations

The presence of signs and symptoms in strangulation survivors can be variable. In a large series of domestic violence related strangulations, Strack et al found that only 50% of women showed external physi-

cal injuries from the strangulation.²³ Of those with injuries, 35% were minor and 15% were significant enough for photographic documentation. Even in strangulation homicides, there may be no visible signs of strangulation and autopsy of the brain and neck is often needed.⁶⁴ Thus, documentation of a complete and accurate history and physical examination is important. If available, forensic examiner (FE) consultation should be considered for strangulation victims.⁶⁵

FEs have specialized training in forensic evaluation and documentation. Many have additional training in evaluating IPV and strangled patients. After medical stabilization, an FE can be consulted to conduct a thorough history of the event, a complete strangulation-related review of systems, and a detailed examination for injuries to include appropriate forensic descriptions, measurements, and photographs. These nurses can also provide strangulation-specific discharge instructions and referral to supportive services.

For facilities without FE support, the International Association of Forensic Nurses has created a web-based program, “Non-fatal Strangulation Documentation Toolkit” to assist clinicians in the evaluation of strangled patients.⁶⁶ The toolkit contains introductory educational information, strangulation focused history questions, standardized documentation forms, and discharge instructions, as well as photographic DNA evidence collection protocols. Additionally, training is available through the Training Institute on Strangulation Prevention.⁶⁷

In patients whose strangulation was performed by an unknown assailant, the FE can be used to collect potential probative evidence, namely DNA. Because of the contact of the assailant’s hands with the victim’s neck, it is possible to transfer epithelial cells onto the neck surface.^{68–69} These cells may be collected by standard swab technique and sent to the DNA crime lab for analysis.⁷⁰ Although in theory, this can work, some studies have had mixed results in consistently recovering DNA from the contact.⁷¹ In addition, it may not be helpful in cases where the victim and assailant have a pre-established relationship.⁷² That is why it is recommended only for unknown assailants.

3.8 | Legal considerations

As of July 2021, 48 states have passed some form of strangulation/suffocation felony laws. Although the laws vary, state legislatures have separately concluded that non-fatal strangulation, particularly in IPV, warrants felony prosecution. Additionally, Congress has amended the federal code to include a specific charge of assault or attempted assault by strangulation or suffocation with sentencing recommendations up to 10 years.⁷³ The federal statute defines strangulation as intentionally, knowingly or recklessly impeding the normal breathing or circulation of blood of a person by applying pressure to the neck. It defines suffocation as intentionally, knowingly, or recklessly impeding the normal breathing of a person by covering the mouth and/or nose of the person. Both definitions hold true regardless of whether that conduct results in any visible injury or whether there is any intent to kill or protractedly injure the victim. Multiple US territories and tribes have added strangulation-specific legislation, as has the Code

TABLE 4 Legislative consideration points for current and future implementation

1. Strangulation may result in immobilization of a victim, may cause LOC, injury or even death and has been a factor in a significant number of domestic violence related assaults and fatalities.
2. Assault by strangulation is often knowingly inflicted upon an intimate partner with the intent to commit physical injury or substantial bodily injury.
3. Strangulation is one of the most lethal forms of domestic violence.
4. The particular cruelty of and terror associated with this offense and its potential effects upon a victim, physically, and psychologically, merits categorization as a felony offense.

Abbreviation: LOC, loss of consciousness.

of Military Justice.⁷⁴⁻⁷⁷ As these strangulation laws have passed, the legislative intent has provided direction for professionals seeking to implement these laws, outlined in Table 4.

Additionally, some states have made it a felony to strangle victims while pregnant or in the presence of a minor.⁷⁸⁻⁷⁹ California recently passed the “Duty to Warn and Duty to Track” law, which mandates that law enforcement warns victims about the seriousness of strangulation and tracks individuals who strangle and suffocate their victims, recognizing future homicide risk.⁸⁰⁻⁸¹ Some states now include strangulation-related bail statutes in order to ensure victim safety. Other states have mandated non-fatal strangulation training for law enforcement and legal professionals, and others identify strangulation as an aggravating factor as part of sentencing or a presumption against child custody.

4 | CONCLUSION

Given the frequency of strangulation and the potential for injuries, even with subtle signs and symptoms, emergency physicians need to be knowledgeable about the pathophysiology, evaluation, and proper management. The context in which strangulation occurs vary, but physiology and injuries are very similar. More research is needed on epidemiology and criteria for advanced imaging.

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CONFLICTS OF INTEREST

The authors do not have any conflicts of interest to report.

AUTHOR CONTRIBUTIONS

Ralph Riviello authored the introduction and section on forensic considerations and provided general oversight of the paper. He was subcommittee chair of the project. Samuel J. Stellpflug authored sections on terminology, pathophysiology, epidemiology, hanging, and mixed martial arts as well as editing. William Weber and Robin

Polansky authored the section on emergency department management. Ann Dietrich authored the section on pediatric strangulation. Brian Springer authored the section on tactical, military, and law enforcement. Carolyn Sachs and Antony Hsu authored the section on erotic strangulation. Sarayna McGuire authored the section on emergency medical services. Casey Gwinn and Gael Strack authored the section on legal considerations.

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