

STRANGULATION: A FULL SPECTRUM OF BLUNT NECK TRAUMA

WARREN S. LINE, JR, MD

ROBERT B. STANLEY, JR, MD, DDS

JOSEPH H. CHOI, MD

LOS ANGELES, CALIFORNIA

Strangulation accounts for up to 10% of violent or criminally related deaths in the United States annually. Strangulation techniques include hanging, throttling, garrotting, and chokeholds. These methods are thought to cause unconsciousness or death by compression of either the airway or the major vessels of the neck. A review of the records of 112 nonsurvivors and 59 survivors of strangulation revealed that hyoid bone and laryngotracheal fractures occurred in both groups, particularly in throttling victims. The laryngeal injuries themselves could not be implicated as the cause of death, and survivors usually presented without airway compromise. However, failure to appreciate such injuries in survivors may lead to permanent voice complications. A full understanding of the spectrum of strangulation is also required if the otolaryngologist is called to testify as an expert witness in such cases.

KEY WORDS — larynx, strangulation.

For the year 1980, the United States census reported approximately 3,500 deaths due to suicidal strangulations and hangings. It is also estimated that up to 10% of violent or criminally related deaths in large urban areas are due to some form of strangulation.^{1,2} Strangulation represents an important form of blunt neck trauma that is probably better understood by the forensic pathologist than the otolaryngologist-head and neck surgeon. Although blunt neck injuries resulting from high speed deceleration crashes have been well described in the otolaryngology literature,³ discussion of strangulation injuries has been infrequent.⁴ The force required to produce a laryngeal injury that would require the attention of a clinician may be immediately lethal. For this reason, strangulation injury is often viewed only by the pathologist on postmortem examination.

Any discussion of the spectrum of strangulation requires an understanding of the various maneuvers used for the common goal of ending life. Death by hanging involves the constriction of the neck by a ligature that is pulled tight by the weight of the body as it is suspended either totally or partly.⁵ Hangings may be judicial, suicidal, or accidental. Accidental hangings are seen in infants who become entangled in their clothing or bed linen and in adults involved in autoerotic sexual activities that

involve hanging or self-strangulation.^{6,7} Death by ligature strangulation, or garrotting, involves the constriction of the neck by a ligature that is pulled tight by a force (usually the assailant's hands) other than the victim's body weight. Throttling, or manual strangulation, is the compression of the neck with the human hands.⁵ Chokeholds are maneuvers originally designed to allow law enforcement officers to subdue violent criminals. The "carotid sleeper" involves compression of the neck structures in the bend of the elbow and the "bar arm" maneuver utilizes the rigid forearm for compression.⁸ Only suicidal and accidental hangings do not require the active role of an assailant.

Both superficial and deep injuries have been well described in the forensic pathology literature. External markings of a ligature strangulation may range from a parchment-like compression groove around the neck in a victim of a successful hanging attempt to a broad hemorrhagic ligature mark caused by extravasation of blood from damaged small vessels when the ligature tension is removed in a survivor.^{5,9} Abrasions or fingernail scratches may be present in ligature strangulations if the victim fought to remove the ligature, or in the throttling victim, from the assailant's or the struggling victim's hands¹⁰ (Fig 1). Victims may also show signs of vascular conges-

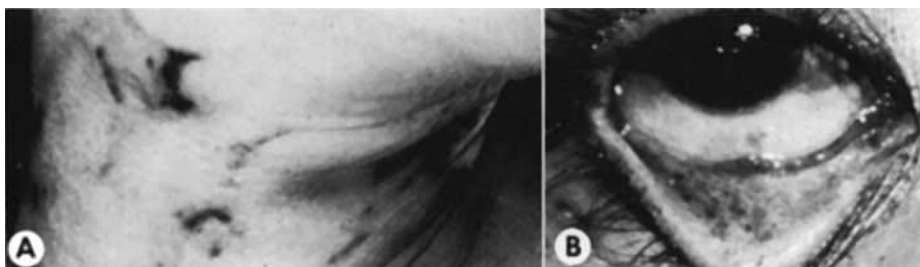


Fig 1. Manual strangulation victim with A) abrasions of neck from assailant's and victim's own fingernails as result of struggle, and B) subconjunctival petechiae.

From the Department of Otolaryngology-Head and Neck Surgery, Los Angeles County-University of Southern California Medical Center (Line, Stanley) and the Office of the Coroner-Medical Examiner (Choi), Los Angeles.

Presented at the meeting of the American Laryngological Association, Miami Beach, Florida, May 25-26, 1985.

REPRINTS — Robert B. Stanley, Jr, MD, DDS, Dept of Otolaryngology-Head and Neck Surgery, Los Angeles County-USC Medical Center, 1200 N State St, Box 795, Los Angeles, CA 90033.



Fig 2. Larynx of strangulation victim, with multiple petechiae visible, but no mucosal lacerations or skeletal fractures.

tion including subconjunctival, gingival, and oral mucosal petechial hemorrhages if the vascular occlusion is slow or intermittent.

Injuries to the laryngotracheal apparatus are frequently found on postmortem examination of non-judicial hanging, garrotting, chokehold, and throttling victims. These may range from hemorrhagic petechiae as found elsewhere due to slow vascular occlusion (Fig 2), to fractures of the hyoid bone or laryngeal cartilages. Fractures of the larynx, in particular the thyroid cartilage, have been most commonly described in throttling victims. However, most of the injuries found on postmortem examination have been of one superior horn and have been considered clinically insignificant.^{5,11} Descriptions of the laryngotracheal injuries in survivors of strangulation have been much less frequent.^{4,8} In order to compare the laryngotracheal injuries in survivors and nonsurvivors of strangulation injuries, the records of the Los Angeles County-University of Southern California (LAC/USC) Medical Center and the Los Angeles County Coroner-Medical Examiner's Office were reviewed for similar time periods. Observations were made concerning the methods of strangulation, the types of injuries found, and the relationship of the injury to the outcome of the patient.

STUDY GROUP

The Los Angeles County Coroner's Office is one of the busiest in the world. For example, during the years 1982 and 1983, approximately 33,500 cases

TABLE 1. AGE AND SEX DISTRIBUTION IN STRANGULATION DEATHS

	Number of Subjects by Age in Years					Total
	0-20	21-40	41-60	61-80	80	
Males	9	6	9	3	1	28
Females	19	24	21	16	4	84
Total	28	30	30	19	5	112

TABLE 2. FORENSIC STUDY: METHOD OF STRANGULATION AND RESULTANT LARYNGOTRACHEAL AND HYOID INJURIES

	Number of Victims	
	Total	With Injuries
Suicidal hangings Ligature strangulation }	52 (46%)	13
Throttling	49 (44%)	34
Chokehold	8 (7%)	3
Unknown	3 (3%)	1
Total	112	51

were examined. Included were 424 strangulation victims, of which 340 were suicides by hanging and 84 homicides by strangulation. The usual examination for the suicide cases is limited to a description of the external injuries and an examination of the ligature. However, for cases where evidence of suicide is equivocal and for all homicide cases, a complete necropsy is performed. The forensic section of this report is based on detailed records from the personal experience of one of the authors (JHC) for 112 such cases over a 12-year period (1970 to 1982). This is felt to be a representative sample of all strangulation cases handled by the Medical Examiner's Office during that time.

The clinical section of this report is based on a review of the records of victims of strangulation admitted to the LAC/USC Medical Center during the years 1973 through 1984. Emphasis was placed on the last year when all of the patients evaluated by the Otolaryngology-Head and Neck Surgery service for laryngeal trauma were presented to if not personally examined by one of the authors (RBS). Each record, whether consulted on by our service or not, was evaluated for method of strangulation, occurrence of laryngotracheal injury, and final outcome.

RESULTS

Forensic. The age and sex distribution for all victims is shown in Table 1 and the methods of strangulation in Table 2. Eighty-four (75%) of the victims were female. Of the total of 112 victims, 51 (45%) had fractures of the laryngeal cartilages or hyoid bone. Interestingly, only seven of 28 (25%) of the males had fractures compared to 45 of 84 (53.5%) of the females.

The distribution of the fractures by site and method of strangulation is shown in Table 3. Manual strangulation was the most common cause of a fracture, and hyoid bone fracture was the most common injury, especially in females. Nine patients had fractures of both the hyoid bone and thyroid cartilage,

TABLE 3. FRACTURES IN VICTIMS OF DEATH BY STRANGULATION

Site of Fracture	Method of Strangulation				Total
	Ligature	Throttling	Chokehold	Unknown	
Hyoid	6	21	0	0	27
Thyroid	5	13	2	1	21
Cricoid	3	9	2	0	14

TABLE 4. PATIENTS ADMITTED FOR STRANGULATION INJURIES

	1973-1983	1984	Total
Suicidal hangings	32	16	48
Ligature strangulation	2	0	2
Throttling	0	4	4
Chokeholds	2	2	4
Accidental hanging*	1	0	1
Total	37	22	59

*11-month-old child.

and one patient had fractures of both of these and the cricoid cartilage. Although acute asphyxia from airway compromise was the likely cause of death in many victims, the laryngeal injuries themselves were mostly superior horn fractures or nondisplaced fractures of the thyroid lamina.

No cases were found with gross disruption of the airway as seen in high-speed deceleration injuries. Therefore, none of the injuries could be implicated as the actual cause of death, although it was not possible to totally rule out a contribution by delayed airway obstruction from progressive edema or vocal cord paralysis.

Clinical. Records were found for 59 patients who were admitted for treatment of problems related to strangulation during the 11-year study period. Twenty-two of those were admitted during the last year (1984). It is recognized that this is not a true indication of the incidence of strangulation, but represents those patients who suffered a serious injury or a medical catastrophe related to pressure applied to the neck. A large number of patients seen in the minor trauma area of the main emergency room complaining of being strangled are judged to be asymptomatic and are not referred to the otolaryngology service. The sudden increase in documentable strangulation cases seen at the LAC/USC Medical Center from three to seven per year to 22 cases in 1984 cannot be totally attributed to faulty record-keeping. Two other factors came into play during this time, the first being the adoption of a county-wide Trauma Center concept, and the second being changes in financial reimbursement patterns that necessitated transfer of patients from private hospitals to LAC/USC as soon as they were deemed stable.

The methods of strangulation for the 59 patients are listed in Table 4. Ninety percent of the patients were male, with a mean age of 32 years. Forty-eight (81%) were victims of hanging attempts, 25 of which took place in jail or police custody and two in psychiatric hospitals. Only 26 (56%) of these hanging victims were seen by the otolaryngology service. Serious laryngotracheal injuries were identified in three patients, with the remainder having either normal indirect laryngoscopic examinations or only mild vocal cord edema. The three injuries included one pyriform sinus hematoma; one small transverse tear of the mucosa of the anterior wall of the upper trachea, which caused subcutaneous and mediasti-

nal emphysema; and one complete laryngotracheal separation. This last case was the only one that required operative intervention. The two patients with ligature strangulation and one infant who suffered accidental hanging were not examined.

The eight remaining cases included four victims of chokeholds and four victims of throttling, all of whom underwent indirect examinations. Of the chokehold victims, plain radiographic films showed a possible displaced hyoid bone fracture in one patient, and indirect examination showed supraglottic edema and ecchymosis over the left arytenoid in another. Examination findings in the other two were normal, although they complained of hoarseness. Of the four throttled patients, plain films showed a hyoid bone fracture in one, and computed tomography showed a displaced thyroid cartilage fracture in one and cricoid cartilage fractures in two. These three cases will be discussed in more detail later.

In the total group of 59 patients, five required cardiopulmonary resuscitation prior to arrival in the emergency room, and 17 were intubated at some time during their hospitalization. All but two of these patients were hanging victims. One hanging victim suffered atlanto-occipital dislocation with a spinal cord injury, and 12 others suffered irreversible anoxic brain damage and subsequent death. Only two patients received tracheostomies. The hanging victim with laryngotracheal separation required an emergency tracheostomy for airway control and the throttling victim with the displaced thyroid cartilage fracture underwent tracheostomy to facilitate surgical repair.

Of the 22 cases admitted to the LAC/USC Medical Center in 1984, 14 were seen by our service. The eight not seen were all hanging victims, four of whom died of anoxic brain damage while still intubated. The other four had no airway complaints in the emergency room and were admitted directly to the Psychiatry Service or Jail Ward. Among the eight hanging victims who were examined, seven had no evidence of an airway injury although two had required intubation, resuscitation, and a short stay in the intensive care unit when first admitted. The other patient was found to have the pyriform sinus hematoma but no laryngeal fracture on CT scanning. Both chokehold victims and one of the throttling victims had normal examinations and were admitted to the Jail Ward for care of other problems. The remaining three throttling victims suffered laryngeal injuries, including one nondisplaced cricoid fracture seen on CT scanning, one displaced lateral cricoid fracture with a palpable malalignment, and one displaced thyroid cartilage fracture. The patient with the malaligned cricoid fracture had been seen in the emergency room and was discharged without evaluation by our service. He presented in the Otolaryngology Clinic almost

four weeks later complaining of a permanent voice change. Indirect laryngoscopy revealed a subglottic bulge and a shortening of the vocal cord on the involved side. The patient with the thyroid cartilage fracture complained of hoarseness only, and he was found to have a midline fracture that not only widened the anterior commissure, but also put his vocal cords at different levels.

DISCUSSION

Strangulation results from pressure on the neck as part of a suicidal, homicidal, accidental, or judicial event.¹² Determinants of the length of time until death include method of pressure application, amount of force used, and duration of application of force.¹³ Death from strangulation has been attributed to injury of the spinal cord and brain stem, mechanical constriction of the neck structures, and cardiac arrest due to stimulation of the carotid sinus or pericarotid sympathetic and parasympathetic networks.¹⁴ Whereas upper cervical spine fractures and transection or damage of the spinal cord were common with judicial hangings, such injuries are unusual in the other forms of strangulation, including suicidal hanging.^{5,9} It is presently unknown whether arterial occlusion, venous occlusion, or asphyxia plays the greatest role in producing death from these other forms of strangulation.¹²

In our review of 112 victims of death by strangulation and 59 survivors of strangulation attempts, only one case was found with an airway injury that could definitely be described as life-threatening itself. This patient, the hanging victim with the laryngotracheal separation, was the only one with serious internal disruption of the laryngotracheal apparatus. Most suicidal hanging victims either place the ligature too high on the neck to damage the larynx or jump from heights too low to create high velocity compressive forces that will seriously disrupt the larynx. Manual strangulation, chokeholds, and ligature strangulation all involve a force that is static in nature in that the instrument of application is in contact with the neck before the force is applied. Although it is possible that some nonsurvivors may have developed delayed edema and airway problems had they survived the initial assault, it appears that most strangulation victims suffer laryngeal injuries similar to those created by Travis et al¹⁵ in their static force tests. These tests showed that low velocity forces can cause serious thyroid and cricoid cartilage fractures without causing gross crepitation, internal mucosal tears, or compromise of the airway. Therefore, cartilage fractures

may occur but they are unlikely to cause acute airway obstruction after release of the compressive force. Hyoid bone fractures may be accompanied by pharyngeal and supraglottic edema, but again this should not be severe enough to be life-threatening by itself.

Age and degree of calcification in the thyroid cartilage have been considered as very important factors in determining whether a strangulation victim suffers a laryngeal fracture.^{5,15} However, victims in our forensic series under the age of 30 were as likely to have a laryngeal fracture as the older victims. In our clinical series, the three victims who suffered fractures due to throttling were all under 23 years of age. It appears that the method of strangulation was the most important determinant of laryngeal and hyoid bone fractures in both survivors and nonsurvivors. In particular, throttling or manual strangulation was most commonly responsible for these injuries. Of interest is that most nonsurvivors of throttling were female and most survivors male. Although the numbers for comparison are small, it is possible that the laryngeal fracture occurred in both sexes during the initial application of compressive force to the neck. Whereas males were able to break their assailant's grip, females were not, and they then succumbed to asphyxia or prolonged vascular occlusion.

Strangulation injuries should be evaluated with more caution than other forms of blunt trauma to the larynx. It is clear that emergency room physicians and physicians handling the medical and psychiatric problems of these patients have a low index of suspicion for laryngeal injuries because they usually do not manifest as the patient's major life-threatening problem. Although injuries that will lead to chronic laryngeal stenosis are unlikely to occur, some survivors of strangulation may suffer injuries that will cause permanent voice change if left unrepaired. We therefore favor an aggressive approach to rule out an injury to the laryngeal skeleton in these patients, and routinely use CT scanning for any case that exhibits more than very mild edema on indirect examination. Not only is the patient better served, but also the consulting otolaryngologist is protected from becoming a central figure in the legal proceedings that frequently develop from these cases. Additionally, the otolaryngologist may be called upon as an expert witness to testify in such personal injury suits or criminal proceedings. Expert testimony requires familiarity with the various forms of strangulation and their potential for laryngotracheal injury.

REFERENCES

1. Statistical abstract of the United States. 101st ed. Washington, DC: US Bureau of the Census, 1980:179.
2. Luke JL. Strangulation as a method of homicide. *Arch Pathol* 1967; 83:64-70.
3. Brandenburg JH. Management of acute blunt laryngeal injuries. *Otolaryngol Clin North Am* 1979; 12:741-51.
4. Stanley RB, Hanson DG. Manual strangulation injuries of the larynx. *Arch Otolaryngol* 1983; 109:344-7.
5. Polson CJ. The essentials of forensic medicine. 3rd ed. New York: Pergamon Press, 1973:371-439.

6. Bass M. Asphyxial crib death. *N Engl J Med* 1977; 296: 555-6.
7. Resnik HLP. Eroticized repetitive hangings: a form of self-destructive behavior. *Am J Psychother* 1972; 26:4-21.
8. Reay DT, Eisele JW. Death from law enforcement neck holds. *Am J Forensic Med Pathol* 1982; 3:253-8.
9. Curran WJ, McGarry AL, Petty CS, eds. *Modern legal medicine, psychiatry, and forensic science*. Philadelphia: FA Davis, 1980:253-66.
10. Spitz WU, Fisher RS, eds. *Medicolegal investigation of death*. Springfield, Ill: Charles C Thomas, 1973:270-95.
11. Green MA. Morbid anatomical findings in strangulation. *Forensic Sci Int* 1973; 2:317-23.
12. Iserson KV. Strangulation: a review of ligature, manual, and postural neck compression injuries. *Ann Emerg Med* 1984; 13:179-85.
13. Rentoul E, Smith H. *Glaister's medical jurisprudence and toxicology*. 13th ed. London: Churchill Livingstone, 1973:169-93.
14. Berlyne N, Strachan M. Neuropsychiatric sequelae of attempted hanging. *Br J Psychiatry* 1968; 114:411-22.
15. Hansch C. Throat-skeleton fractures by strangulation. *Z Rechtsmed* 1977; 79:143-7.



NINCDS NOTES*

NINCDS SEEKS PATIENTS WITH CENTRAL NEUROFIBROMATOSIS

Families with one or more members who have central neurofibromatosis with bilateral acoustic neuromas are being sought for a clinical research study at the National Institute of Neurological and Communicative Disorders and Stroke in Bethesda, Md. The goal of the study is to establish methods for early detection and diagnosis of this type of neurofibromatosis.

Neurofibromatosis with acoustic neuromas is an autosomal-dominant genetic disorder that affects approximately 7,000 to 10,000 Americans and may cause total bilateral hearing loss in early adult life. Although high risk individuals can be indentified by family history, current methods are ineffective in establishing an early diagnosis in those who have actually inherited the disease. Early detection and treatment may prevent total hearing loss, especially if tumors are removed while smaller than 1.5 cm.

The NINCDS investigators will test the efficacy of a battery of screening procedures designed to detect tumors at an early stage. Research participants will undergo an audiologic examination, cerebral imaging studies, and a general neurologic examination. If these tests reveal small tumors, a magnetic resonance imaging scan using the new contrast agent, gadolinium, will also be done.

Clinicians who wish to refer potential candidates or obtain additional information should contact Dr Donald Wright, Surgical Neurology Branch, NINCDS, Bldg 10A, Rm 3E68, Bethesda, MD 20892; (301) 496-2921.

*This information is prepared monthly by the Office of Scientific and Health Reports, NINCDS, NIH, Bldg 31, Rm 8A06, Bethesda, MD 20205; (301) 496-5924.