EMA Emergency Medicine Australasia

Emergency Medicine Australasia (2019) **31**, 302–308 doi: 10.1111/1742-6723.13243

REVIEW ARTICLE

Review article: Non-fatal strangulation: Hidden injuries, hidden risks

Julia DE BOOS

Emergency Department, Mount Isa Base Hospital, Mornington, Queensland, Australia

Abstract

Non-fatal strangulation (NFS) can be a cause of severe injury. However, the prevalence and rates of injuries from NFS are unknown, as few victims present to medical attention after strangulation. As up to 40% of fatal strangulations have no external signs, and the majority of surviving victims have few or minor injuries, finding those people severely injured remains challenging. The majority of the evidence regarding NFS is largely based on case reports and case series with no robust studies estimating rates of injuries or the best investigation tools. The injuries that are reported make clear that strangulation is a potentially lethal form of injury that should not be ignored in those presenting having been strangled, or in those presenting with neurological symptoms, including strokes, seizures and vascular abnormalities. The safety implications of strangulation are also important as it can be a prelude to homicide. A search of the literature was carried out with the following terms: Nonfatal strangulation (10), Nonfatal strangulation (17), 'Strangulation injuries' (19), 'Manual strangulation' (92) – laboratory testing eliminated, and 'choking game'. The PubMed database was used first, followed by the collections of Monash University and the Strangulation Institute (as some articles were too old to find electronically). This article summarises the injuries that can occur following strangulation and discusses the quality of the evidence thus far.

Key words: *choking, external neck compression, head-lock, non-fatal strangulation, strangulation.*

Key findings

- NFS can be a cause of severe injury, with or without external signs.
- Most surviving strangulation will have no or minor injuries.
- To find those with severe injuries, clinicians need to have a high index of suspicion as they would for sub-arachnoid haemorrhages or thoracic aortic dissections.
- Well designed research is needed to measure the prevalence, how those with severe injury present and the most appropriate investigations.

Non-fatal strangulation (NFS) is an under-recognised form of assault. There is no data on the prevalence of NFS in Australia, but estimates in Europe and North America range from 3% to 9.7% of all women[1] and 27–68% in those experiencing intimate partner violence.[2,3] In Australia, between 2002 and 2012, strangulation or suffocation was the cause of death in 14% of domestic homicides.[4] Importantly, it can be a prelude to homicide of any type, with 43% of homicides in the USA having been preceded by NFS.[2] The risk of homicide by an intimate partner increases 7.5 times.[2] Although the majority of people surviving strangulation will experience no, or only minor, physical injuries, the potential for lethal injury, both immediately and delayed, has resulted in its recognition as a serious form of assault. This article is a review of the literature on strangulation injuries.

Strangulation is defined by the Royal College of Pathologists of Australasia as 'external neck compression that can cause consequences that may be fatal as a result of compression of, and injury to, the vital structures in the neck such as the airways, blood vessels and nerves of the neck'.[5] Strangulation can occur many ways, including (but not limited to) manual pressure (throttling with hands, forearm, kneeling/foot on the neck), sleeper hold (elbow bend compression or headlock), ligature/garroting (e.g. necklace, clothing, cord, belt), neck compression (object pressed against the neck) and hanging. Although different definitions of strangulation have implications for the comparability of research,[6] it is important to recognise that our patients can use a wide variety of terms to refer to strangulation, including throttling, choking, suffocating, carotid restraint, lateral vascular restraint and headlock, irrespective of whether these terms mean something quite different medically.

Correspondence: Dr Julia De Boos, Emergency Department, Mount Isa Base Hospital, 30 Camooweal Street, Mount Isa, QLD 4825, Australia. Email: julia.deboos@health.qld.gov.au

Julia De Boos, FACEM, BMed/BSurg, BA (Hons), BSc, PGDipHSM, Senior Medical Officer/Director of Emergency Medical Training.

Accepted 9 January 2019

Methods

The following terms were searched in the databases listed (number of results in brackets). Articles published in peer-reviewed journals only were considered.

1. Nonfatal strangulation, refined to peer-reviewed journals (79)
2. Nonfatal strangulation in CINAHL complete (8)
3. Non-fatal strangulation in CINAHL complete (0)
4. Strangulation in CINAHL complete (429)
5. Nonfatal strangulation in Medline complete (19)
6. Strangulation in Medline complete (848)
7. Nonfatal strangulation in PubMed (19)
8. Non-fatal strangulation in PubMed (10)
9. Strangulation in Cochrane (0)
10. Nonfatal strangulation in Proquest (81)
11. Non-fatal strangulation in Proquest (136)

Results

In total, 68 relevant articles were found. Of these, 22 were case reports (of up to three cases per article),[7–27] and 22 were case series involving both non-fatal and fatal strangulation.[28–48] However, three articles were written about one case series of 300,[34,40,48] and four involved the analysis of a growing list of videos of autoerotic asphyxia. The cases that generated these articles are therefore over-represented as a result.[44–47] Three of the case series focused on imaging.[30,31,42] There were seven retrospective observational studies in which either the prevalence of NFS or its injuries were measured.[3,49–54] There was one case control trial.[2] Fifteen review articles were found examining the existing literature, 11 of which were from a predominantly medical perspective.[55–64] There were also four reviews that considered the legal and social implications.[1,48,65,66]

What does the literature tell us?

There are four generally recognised mechanisms that cause death from strangulation:[7,34]

1. Anoxia from occlusion of the arteries. The pressure required varies with the surface area compressed, and the depth and position of the force, but it has been estimated that only 11 psi or 3.5 kg is all that is required (the average male handshake is 80–100 psi).[15,37,57] Occlusion of the vertebral arteries depends on the position of the pressure, not the amount of pressure (at the base of the neck, before they are protected by the transverse processes of the cervical vertebrae). Occlusion of arteries not only deprives the brain of oxygen, but nutrients and waste disposal. Loss of consciousness usually occurs within 10 s of complete occlusion.[36]
2. Congestion, followed by anoxia from venous occlusion. Occlusion of the veins requires an estimated 4 psi, or 2 kg.[15,37,57] Congestion of the blood flow through the head and face results in the blood leakage from capillaries and small vessels, resulting in petechial bruises in soft tissues, including the brain.
3. Hypoxia from occlusion of the airway. Occlusion of the airway requires 34 psi, or 1758 mmHg,[37] or up to 15 kg on cadavers.[55] Airway obstruction takes the longest to result in loss of consciousness and death as the body depletes its overall level of oxygen.
4. Stimulation of the baro-receptors in the carotid sinus and carotid sheath can result in asystolic arrest.[7]

Injuries from strangulation

Although most patients presenting after strangulation will have no or minor injuries, the potential for severe morbidity and mortality exists and is often underestimated. The assessment of injury can be made more difficult by a lack of external physical signs despite serious injury. It is important to note that fatal strangulations can occur without external signs of injury and rates of up to 40% of fatal strangulations with no external signs have been reported.[33,34]

The following list of serious injuries is taken from case series and case reports. Their prevalence has never been measured in the Australian population, but American sources estimate the rate of serious injury at 1% of those presenting to medical attention.[62]

Injury to the carotid arteries and jugular veins

In 2011, the Northern Territory Government guideline on hanging (including strangulation without a drop by a ligature) estimated the rate of damage to the carotid artery at 5%.[67] Furthermore, there are numerous case reports of unilateral and bilateral carotid artery dissections and jugular venous thrombus following NFS, including manual strangulation.[7,9,15,57,68] For example, in 2005, a woman with no external signs, presented to an ED 2 days after a manual NFS event complaining of headache. Computed tomography angiogram revealed bilateral common carotid artery dissections.[9]

Hypotheses regarding why damage occurs to the blood vessels during strangulation (whereas repeated arterial compressions such as those caused by blood pressure cuffs do not cause such damage) include that strangulation may be part of a struggle and the pressure may go on and off, repeatedly, with shearing force.[57] The tears to the intima occur as the vessel is compressed between the external force and the transverse processes of the vertebrae.

Although damage to the arteries appears to be uncommon (an American source estimates 1%[62]), the damage may have immediate or very delayed lethal consequences and it is worth noting that up to 20% of strokes in people less than 45 years old are caused by extra-cranial carotid artery dissection.[69,70]

Ischaemic, watershed and haemorrhagic strokes

Ischaemic and watershed strokes have been reported, with and without damage to the carotid artery

after manual strangulation.[19,22] The delay between NFS and neurological deficit can be hours to years.[13,19,20,22,24,66] Loss of consciousness from strangulation is not required for a stroke to occur. A case in the USA involved a police officer tapping out of a strangulation hold during police training, still conscious, but sustaining a significant stroke.[62]

Petechial haemorrhages

A result of venous congestion when the veins are occluded but arteries patent, petechial haemorrhages occur at or above the level of compression. They can be seen on the skin, the palate, or as subconjunctival haemorrhages, but of more concern, they can occur throughout the brain, and can be considered proof of a life threatening event.[41]

Airway and respiratory occlusion

Pharyngeal, laryngeal, supraglotic and sub-glossal swelling have been described, with delays of up to 36 h before becoming clinically apparent.[16]

Dysphagia and odynophagia

Painful and or compromised swallowing following strangulation has numerous causes that include fracture of the hyoid bone, cricoid or thyroid cartilage, haematomas and soft tissue swelling.[8] Fractured hyoid bones result from pressure above the larynx and may present as asymptomatic at rest, but tender on palpation and when swallowing. Possibly the most well known of the strangulation injuries, the rate of hyoid fracture has been reported as 13–54% of fatal ligature strangulation and 17–71% of fatal manual strangulation.[64] The rate in NFS is unknown.

Dysphonia can represent laryngeal injury. Voice changes only occur in 50% of laryngeal injuries and can also represent injury to the laryngeal nerve. Subcutaneous emphysema may also result from such an injury.

Respiratory failure

Hypopharyngeal injuries can include leakage of air into the chest cavity producing pneumothoraces, pneumopericardium,[12] pulmonary oedema and later pneumonia.[29,43] Pulmonary oedema and pneumonia have been implicated in most in-hospital deaths.[58] The mechanism for pulmonary oedema may be both neurogenic (similar to sub-arachnoid haemorrhages) and/or secondary to the large changes in intrathoracic pressure, which can be as low as -100 cm H_2O.[40,71]

Thyroid storm

Damaged to thyroid tissue has resulted in thyroid storm after hanging and strangulation with a ligature in case reports.[23,72]

Delayed anoxic encephalopathy

Delayed anoxic encephalopathy has been described as brain damage that has presented days to weeks later.[10] Blindness, choreoathetosis, dystonia, pseudobulbar paralysis have occurred in people who initially appeared normal. Not all brain cells are equally susceptible to anoxia. Nerve cell death in the brain is therefore patchy. Nerve cells of the hippocampus and dentate nucleus, and the Purkinje cells of the cerebellum are more susceptible than cortical and glial cells.[60,73]

Vertebral and spinal cord damage

Cervical spine damage is rare and tends to occur with strangulation where someone has been lifted off the ground or shaken by the neck. Where these mechanisms have occurred, damage to the anterior and posterior longitudinal ligaments, spinous process fractures, epidural haemorrhages, and spinal cord bruising can occur.[37,38,62] However, the use of cervical immobilisation collars to prevent spinal cord damage may reduce venous return in the setting of swelling, compromising the circulation of the brain. Where spinal cord immobilisation is considered important, head blocks rather than collars are more appropriate.

Mental health consequences

Patients experiencing the trauma of strangulation can have mental health consequences that include post-traumatic stress disorder. Strangulation is increasingly seen as an expression of power,[74] involving the disempowerment of the victim, who may think they are going to die. The impact of strangulation on mental health may not be only an emotional response to a severe trauma, but a pathophysiological response of the cells of the limbic system, which are particularly sensitive to hypoxia, giving this a potentially physical component.

How do people present in Australia?

The presentation of victims of NFS to EDs in Australia has not been studied. A recent study conducted in Western Australia in 2016 reported the signs and symptoms of women alleging NFS who were seen by a sexual assault service who could see them in hospital if necessary.[54] The study was a cross sectional survey and the study measured a prevalence rate of 7.4%. In 58% of alleged sexual assaults involving NFS, the intimate partner was the alleged assailant compared to 16% where NFS was not a feature. The prevalence of NFS also changed significantly with age, and the women aged 30–39 years who were allegedly assaulted by their intimate partner had a one in three chance of NFS. Overall, the study showed that 23% of alleged sexual assaults by an intimate partner involved NFS.

The symptoms and signs reported by this study are shown in Figures 1 and 2. The most common symptoms were neck or throat pain (47%), followed by tenderness to palpation (34%), pain and/or difficulty swallowing (19%) and vocal changes (15%). Importantly, 33% of presentations reported no symptoms. The most common signs were linear abrasions (32%), petechial bruising

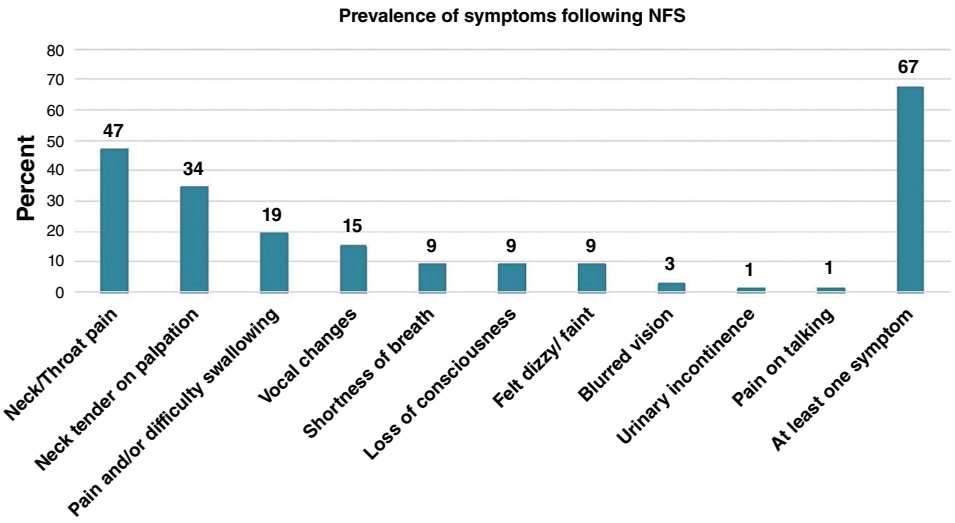

Figure 1. *Symptoms in women presenting after alleged sexual assault involving non-fatal strangulation.*[54] [Colour figure can be viewed at wileyonlinelibrary.com]

(22%), non-petechial bruising (18%) and sub-conjunctival haemorrhages (4%); 49% had no external signs.

Almost one in four women who presented alleging strangulation and sexual assault (24.1%) had neither signs nor symptoms. Most of the patients had delays to presentation with only 39% presenting on the day of the incident. The patients more severely injured were seen by the sexual assault service at the State Trauma Unit, EDs or Intensive Care Units.

The data of this cross-sectional survey is in line with a case series of 300 NFSs in the USA in which police officers rather than doctors examined victims, and found that 50% had no visible markings on the neck and 35% of the victims had very minor injuries.[40] A 2016 American study looking at the prevalence of NFS in survivors of sexual assault and domestic violence, found that it was more strongly associated with domestic violence (38%) than sexual assault (10%), and that they were more likely to be assaulted by their intimate partner than another family member.[50] A 2018 American study also found that the number and severity of injuries increased with repeated strangulations.[51]

Evidence on the potential injuries caused by NFS

Information regarding the short-term effect of strangulation has been well studied, with controlled neck compression in human subjects and expert examination of filmed strangulations.[36,47] The largest study of people who survived strangulation, was a case series of 500 controlled strangulations of sufficient pressure to occlude the carotid arteries, on

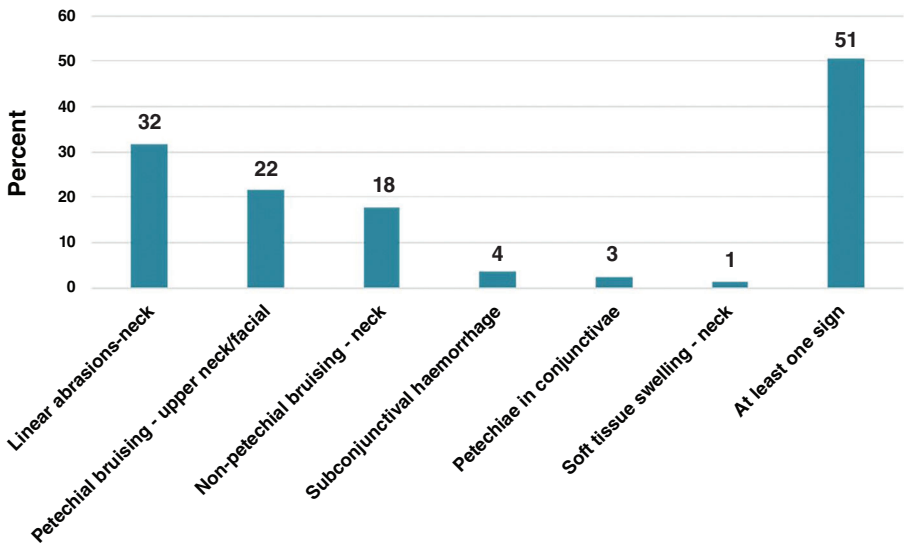

Figure 2. *Signs in women presenting after alleged sexual assault involving non-fatal strangulation.*[54] [Colour figure can be viewed at wileyonlinelibrary.com]

137 prisoners in the USA in 1943 (11 of whom had schizophrenia).[36] The study described the initial 10 s of compression as resulting in fixing of the eyes, with some subjects unable to follow the examiners finger, blurring of the vision, constriction of the visual fields followed by loss of consciousness and then anoxic convulsions. The researchers noted loss of urinary continence after at least 15 s, and loss of faecal continence after at least 30 s (something that they noted to be consistent in repeated prolonged strangulations of the same subjects). They also timed the onset of cyanosis, mydriasis, bradycardia and changes in reflexes. The apparatus used on the subjects contained a jet that could be released by their hands. Interestingly, none of them did so. Most subjects reported that they did not realise they were holding it. Some said they did not feel like releasing it, and some had tried but were unable to move their fingers. Some had no memory of what had occurred.[36]

To the author's knowledge there have been no long-term large follow-up studies of people presenting with NFS. Knowledge of the potential harm of NFS has been largely derived from case series (the largest of which was 300),[40] case reports, case studies and expert opinions. The true rates of serious injury after strangulation are therefore unknown, as is the timespan over which they present. Nor is it known how rates of symptoms and signs vary in the population studied and which ones are associated with more serious injury.

Recognition of the risks of strangulation is starting to gain traction but there has not yet been any prospectively validated decision-making criteria for the radiological investigation of strangulation injuries. Expert opinion in the USA considers computed tomography angiogram of the neck to be the gold standard;[62] however, there may be a role for ultrasound, magnetic resonance imaging[31] and nasopharyngeal endoscopy.[55] The role and duration of clinical observation in the setting of strangulation is also unknown. The Royal College of Pathologists of Australasia recommends 6 h of observation; however, this is predominantly based on expert opinion.[5]

The development of a body of evidence around strangulation injuries is difficult as most people surviving strangulation will not come to medical attention. According to US figures, only 3% present for medical attention, and only 5% of those present within 48 h.[40]

Implications for practice

1. Understanding that the existence of external signs is not an indicator for serious internal injury.
2. Although the chances of serious injury are low, the potential for fatal consequences require clinicians to hold a high index of suspicion of injury, as they would for a thoracic dissection or a subarachnoid haemorrhage. This may involve imaging the neck and major vessels and observation of the patient in the ED or short stay unit. A similar level of care with respect discharge may be those presenting with minor head injury.
3. Transient arterial occlusion may mean that the person has no memory of the event, and may have a headache. Strangulation should be considered an important differential in loss of consciousness, seizure or unexplained urination and defecation.
4. NFS is a risk factor for neurological dysfunction and strokes. A history of it should be sought on presentation of these, particularly in younger people, just as the risk factors for other forms of arterial damage such as hypertension or smoking is sought.
5. Recognition of the considerable danger that the person may be in socially when in the context of domestic violence. An increase of the risk of murder by 7.5 times suggests that social work involvement is warranted. Although not covered in this article, there is considerable evidence regarding the emotional consequences of NFS. It should be handled with the same sensitivity that we would extend to those people presenting with sexual assault.
6. Accurate documentation of injuries is crucial as written evidence may subsequently become important in legal proceedings, criminal prosecutions or in obtaining orders relating to domestic violence.
7. Perhaps most importantly, there is an urgent need for well-designed research such as longitudinal studies of subjects that have experienced strangulation to analyse outcomes over time.

In conclusion, NFS can result in a broad range of serious injuries that can cause death or permanent disability. The injuries may be immediately apparent or take hours, or even weeks to become obvious. However, serious injuries are not common and many people surviving strangulation may have minor injuries or no injuries at all. Studies examining how people present, time to diagnosis and the development and validation of imaging protocols are urgently required.

Competing interests

None declared.

References

1. Sorenson SB, Joshi M, Sivitz E. A systematic review of the epidemiology of nonfatal strangulation, a human rights and health concern. *Am. J. Public Health* 2014; **104**: e54–61.
2. Glass N, Laughon K, Campbell J *et al*. Non-fatal strangulation is an important risk factor for homicide of women. *J. Emerg. Med.* 2008; **35**: 329–35.
3. Wilbur L, Higley M, Hatfield J *et al*. Survey results of women who have been strangled while in an abusive relationship. *J. Emerg. Med.* 2001; **21**: 297–302.
4. Cussen T, Bryant W. Domestic/family homicide in Australia. 2015. [Cited 1 Feb 2019.] Available from URL: https://aic.gov.au/publications/rip/rip38
5. Royal College of Pathologists of Australasia. Clinical forensic

assessment and management of non-fatal strangulation. 2018
6. Sauvageau A, Boghossian E. Classification of asphyxia: the need for standardization. *J. Forensic Sci.* 2010; **55**: 1259–67.
7. Anscombe AM, Knight BH. Case report. Delayed death after pressure on the neck: possible causal mechanisms and implications for mode of death in manual strangulation discussed. *Forensic Sci. Int.* 1996; **78**: 193–7.
8. Briddell J, Mallon A, DeFatta RA, Chowdhury F, Nagorsky M. Dysphagia after strangulation. *Ear Nose Throat J.* 2012; **91**: E30–1.
9. Clarot F, Vaz E, Papin F, Proust B. Fatal and non-fatal bilateral delayed carotid artery dissection after manual strangulation. *Forensic Sci. Int.* 2005; **149**: 143–50.
10. Dooling EC, Richardson EP. Delayed encephalopathy after strangling. *Arch. Neurol.* 1976; **33**: 196–9.
11. Fineron PW, Turnbull JA, Busuttil A. Fracture of the hyoid bone in survivors of attempted manual strangulation. *J. Clin. Forensic Med.* 1995; **2**: 195–7.
12. Giger R, Friedrich JP, Dulguerov P, Landis BN. Pneumopericardium after manual strangulation. *Am. J. Med.* 2004; **116**: 788–90.
13. Hori A, Hirose G, Kataoka S, Tsukada K, Furui K, Tonami H. Delayed postanoxic encephalopathy after strangulation: serial neuroradiological and neurochemical studies. *Arch. Neurol.* 1991; **48**: 871.
14. Iacovou E, Nayar M, Fleming J, Lew-Gor S. A pain in the neck: a rare case of isolated hyoid bone trauma. *J. Surg. Case Rep.* 2011; **2011**: 3.
15. Kiani SH, Simes DC. Delayed bilateral internal carotid artery thrombosis following accidental strangulation. *Br. J. Anaesth.* 2000; **84**: 521–4.
16. Kuriloff DB, Pincus RL. Delayed airway obstruction and neck abscess following manual strangulation injury. *Ann. Otol. Rhinol. Laryngol.* 1989; **98**: 824–7.
17. Le Blanc-Louvry I, Papin F, Vaz E, Proust B. Cervical arterial injury after strangulation--different types of arterial lesions. *J. Forensic Sci.* 2013; **58**: 1640–3.
18. Li W, Liu D, Gallina K, Zhou Y. Delayed death caused by haematoma after manual strangulation: a rare case. *Br. J. Oral Maxillofac. Surg.* 2016; **54**: 1049–50.
19. Malek AM, Higashida RT, Halbach VV *et al.* Patient presentation, angiographic features, and treatment of strangulation-induced bilateral dissection of the cervical internal carotid artery. Report of three cases. *J. Neurosurg.* 2000; **92**: 481–7.
20. Meel BL. A case report on near manual strangulation and Glasgow Coma Scale. *Afr. Health Sci.* 2015; **15**: 1038–40.
21. Mokri B. Dissections of cervical and cephalic arteries. In: *Occlusive Cerebrovascular Disease: Diagnostic and Surgical Management*. Philadelphia, PA: *WB Saunders*, 1987; 38–59.
22. Neto HS, Neville IS, Beer-Furlan A, Tavares WM, Teixeira MJ, Paiva WS. Hemodynamic stroke caused by strangulation. *Int. J. Clin. Exp. Med.* 2014; **7**: 2932–5.
23. Ramírez JI, Petrone P, Kuncir EJ, Asensio JA. Thyroid storm induced by strangulation. *South. Med. J.* 2004; **97**: 608–10.
24. Sethi PK, Sethi NK, Torgovnick J, Arsura E. Delayed left anterior and middle cerebral artery hemorrhagic infarctions after attempted strangulation: a case report. *Am. J. Forensic Med. Pathol.* 2012; **33**: 105–6.
25. Szeremeta W, Morovati SS. Isolated hyoid bone fracture: a case report and review of the literature. *J. Trauma* 1991; **31**: 268–71.
26. Vanezis P, Claydon SM, Chapman RC, Al-Alousi LM. Internal carotid artery thrombosis following manual strangulation. *Med. Sci. Law* 1993; **33**: 69–71.
27. Wu XM, Zhang XD, Yun LB, Liu M, Yi XF. Sudden death from ruptured intracranial vascular malformations during mechanical asphyxia: a domestic violence case report. *Am. J. Forensic Med. Pathol.* 2017; **38**: 35–8.
28. AlBuhairan F, AlMutairi A, Al Eissa M, Naeem M, Almuneef M. Non-suicidal self-strangulation among adolescents in Saudi Arabia: case series of the choking game. *J. Forensic Legal Med.* 2015; **30**: 43–5.
29. Castiglioni C, Baumann P, Fracasso T. Acute pulmonary emphysema in death by hanging: a morphometric digital study. *Int. J. Legal Med.* 2016; **130**: 1281–5.
30. Christe A, Thoeny H, Ross S *et al.* Life-threatening versus non-life-threatening manual strangulation: are there appropriate criteria for MR imaging of the neck. *Eur. Radiol.* 2009; **19**: 1882–9.
31. Christe A, Oesterhelweg L, Ross S *et al.* Can MRI of the neck compete with clinical findings in assessing danger to life for survivors of manual strangulation? A statistical analysis. *Legal Med.* 2010; **12**: 228–32.
32. Fedotov DD, Tseĭtlin VA, Chudin AS, Petukhova GN. Mental disorder in strangulation asphyxia. *Zh. Nevropatol. Psikhiatr. Im. S. S. Korsakova* 1976; **76**: 249–52.
33. Gill JR, Cavalli DP, Ely SF, Stahl-Herz J. Homicidal neck compression of females: autopsy and sexual assault findings. *Acad. Forensic Path.* 2013; **3**: 454–7.
34. Hawley DA, McClane GE, Strack GB. A review of 300 attempted strangulation cases Part III: injuries in fatal cases. *J. Emerg. Med.* 2001; **21**: 317–22.
35. Hlavaty L, Sung L. Strangulation and its role in multiple causes of death. *Am. J. Forensic Med. Pathol.* 2017; **38**: 283–8.
36. Kabat H, Anderson JP. Acute arrest of cerebral circulation in man: Lieutenant ralph rossen (mc), u.s.n.r. *Arch. Neurol. Psychiatr.* 1943; **50**: 510–28.
37. Kornblum R. Medical analysis of police choke holds and general neck trauma part 1. *Dent. Traumatol.* 1986; **27**: 7–60.
38. Kornblum R. Medical analysis of police choke holds and general neck trauma part 2. *Dent. Traumatol.* 1986; **28**: 13–64.
39. Line WS, Stanley RB, Choi JH. Strangulation: a full spectrum of blunt neck trauma. *Ann. Otol. Rhinol. Laryngol.* 1985; **94**: 542–6.
40. McClane GE, Strack GB, Hawley D. A review of 300 attempted strangulation cases Part II: clinical evaluation of the

surviving victim. *J. Emerg. Med.* 2001; **21**: 311–5.
41. Plattner T, Bolliger S, Zollinger U. Forensic assessment of survived strangulation. *Forensic Sci. Int.* 2005; **153**: 202–7.
42. Pollanen MS, Bulger B, Chiasson DA. The location of hyoid fractures in strangulation revealed by xeroradiography. *J. Forensic Sci.* 1995; **40**: 303–5.
43. Sabo RA, Hanigan WC, Flessner K, Rose J, Aaland M. Strangulation injuries in children. Part 1. Clinical analysis. *J. Trauma* 1996; **40**: 68–72.
44. Sauvageau A, Ambrosi C, Kelly S. Three nonlethal ligature strangulations filmed by an autoerotic practitioner: comparison of early agonal responses in strangulation by ligature, hanging, and manual strangulation. *Am. J. Forensic Med. Pathol.* 2012; **33**: 339–40.
45. Sauvageau A. Agonal sequences in four filmed hangings: analysis of respiratory and movement responses to asphyxia by hanging. *J. Forensic Sci.* 2009; **54**: 192–4.
46. Sauvageau A, LaHarpe R, Geberth VJ. Agonal sequences in eight filmed hangings: analysis of respiratory and movement responses to asphyxia by hanging. *J. Forensic Sci.* 2010; **55**: 1278–81.
47. Sauvageau A, LaHarpe R, King D *et al*. Agonal sequences in 14 filmed hangings with comments on the role of the type of suspension, ischemic habituation, and ethanol intoxication on the timing of agonal responses. *Am. J. Forensic Med. Pathol.* 2011; **32**: 104–7.
48. Strack GB, McClane GE, Hawley D. A review of 300 attempted strangulation cases. Part I: criminal legal issues. *J. Emerg. Med.* 2001; **21**: 303–9.
49. Hawton K, Bergen H, Casey D, Simkin S. General hospital presentations of non-fatal hanging over a 28-year period: case–control study. *Br. J. Psychiatry* 2008; **193**: 503–4.
50. Mcquown C, Frey J, Steer S *et al*. Prevalence of strangulation in survivors of sexual assault and domestic violence. *Am. J. Emerg. Med.* 2016; **34**: 1281–5.
51. Messing JT, Patch M, Wilson JS, Kelen GD, Campbell J. Differentiating among attempted, completed, and multiple nonfatal strangulation in women experiencing intimate partner violence. *Womens Health Issues* 2018; **28**: 104–11.
52. Smith DJ, Mills T, Taliaferro EH. Frequency and relationship of reported symptomology in victims of intimate partner violence: the effect of multiple strangulation attacks. *J. Emerg. Med.* 2001; **21**: 323–9.
53. Sugar NF, Fine DN, Eckert LO. Physical injury after sexual assault: findings of a large case series. *Am. J. Obstet. Gynecol.* 2004; **190**: 71–6.
54. Zilkens RR, Phillips MA, Kelly MC, Mukhtar SA, Semmens JB, Smith DA. Non-fatal strangulation in sexual assault: A study of clinical and assault characteristics highlighting the role of intimate partner violence. *J. Forensic Legal Med.* 2016; **43**: 1–7.
55. Armstrong M, Strack GB. Recognition and documentation of strangulation crimes: a review. *JAMA Otolaryngol–Head Neck Surg.* 2016; **142**: 891–7.
56. Downing RI. Manual and ligature strangulation. *Edge* 2006; **12**: 1.
57. Iserson KV. Strangulation: a review of ligature, manual, and postural neck compression injuries. *Ann. Emerg. Med.* 1984; **13**: 179–85.
58. Kaki A, Crosby ET, Lui AC. Airway and respiratory management following non-lethal hanging. *Can. J. Anaesth.* 1997; **44**: 445–50.
59. Kita TFY. Mechanisms of the pulmonary congestion in ligature strangulation. *Igaku Kenkyu* 1989; **59**: 97–8.
60. Oechmichen M, Meissner C. Cerebral hypoxia and ischemia: the forensic point of view: a review. *J. Forensic Sci.* 2006; **51**: 880–7.
61. Pritchard AJ, Reckdenwald A, Nordham C. Nonfatal strangulation as part of domestic violence: a review of research. *Trauma Violence Abuse* 2017; **18**: 407–24.
62. Smock W. The forensic and medical evaluation non-fatal strangulations: Getting a grip on your victim's forensic needs. Presented at the FAMSAC Australia, 30 August 2016.
63. Stanley RB, Hanson DG. Manual strangulation injuries of the larynx. *Arch. Otolaryngol.* 1983; **109**: 344–7.
64. Ubelaker DH. Hyoid fracture and strangulation. *J. Forensic Sci.* 1992; **37**: 1216–22.
65. Strack GB, Gwinn C. On the edge of homicide: Strangulation as a prelude. *Crime Justice* 2011; **26**: 32.
66. Strack GB, Gwinn C, Hawley D, Green W, Smock B, Riviello R. Why didn't someone tell me? Health consequences of strangulation assaults for survivors. *Domestic Violence Report.* 2014; **19**: 87–90.
67. Fryar D. Guideline on hanging and strangulation. *Government of the Northern Territory.* 2011
68. Emmerich J, Fiessinger JN. Stroke from traumatic arterial dissection. *Lancet* 1999; **354**: 160.
69. Leys D, Lucas C, Gobert M, Deklunder G, Pruvo J-P. Cervical artery dissections. *Eur. Neurol.* 1997; **37**: 3–12.
70. Lisovoski F, Rousseaux P. Cerebral infarction in young people. A study of 148 patients with early cerebral angiography. *J. Neurol. Neurosurg. Psychiatry* 1991; **54**: 576–9.
71. Grellner W, Madea B. The value of various lung changes in death by strangulation. *Arch. Kriminol.* 1994; **196**: 38–45.
72. Shrum JM, Byers B, Parhar K. Thyroid storm following suicide attempt by hanging. *BMJ Case Rep.* 2014; **2014**: bcr2014204589.
73. Wolstenholme N, Moore B. The clinical manifestations of anoxic brain injury. *Prog. Neurol. Psychiatry* 2010; **14**: 8–13.
74. Anderson D. *Understanding the Physcial and Psychological Experiences of Intimate Partner Strangulation Survivors*. Ann Arbor, MI: ProQuest Dissertations Publishing, 2016.