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The neuropsychological outcomes of non-fatal strangulation in domestic and sexual violence: A systematic review

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Abstract

This systematic review draws together evidence from the literature for the pathological, neurological, cognitive, psychological, and behavioural outcomes of non-fatal strangulation in domestic and sexual violence. A systematic search of PubMed, PsycINFO, CINHAL, Proquest, ASSIA, Web of Science, WestLaw, Open Grey, and Ethos was conducted, with no date limits set, to identify eligible studies. Thirty empirical, peer-reviewed studies were found which met the inclusion criteria. Pathological changes included arterial dissection and stroke. Neurological consequences included loss of consciousness, indicating at least mild acquired brain injury, seizures, motor and speech disorders, and paralysis. Psychological outcomes included PTSD, depression, suicidality, and dissociation. Cognitive and behavioural sequelae were described less frequently, but included memory loss, increased aggression, compliance, and lack of help-seeking. However, no studies used formal neuropsychological assessment: the majority were medical case studies, or based on self-report. Furthermore, few authors were able to control for possible confounds, including other physical violence and existing psychosocial difficulties. There is therefore a need for further neuropsychological research, focusing on cognitive and behavioural outcomes, using standardised tools, and control groups where possible. This is urgent, given societal normalisation of strangulation, and legal systems which often do not reflect the act's severity and its consequences.

Keywords

Intimate partner violence; sexual assault; choking; hypoxic-ischaemic; systematic review

Introduction

Brain injury within domestic and sexual violence is belatedly gaining academic, medical, and legal attention. This is welcome, given the scale of the problem. More than one in three women are victims of intimate partner violence[1] (IPV; WHO, 2019), 44% report sexual assault, and 20% rape (McQuown et al., 2016). In the majority of sexual assaults, the perpetrator is the victim's partner, so there is a significant overlap between the two areas (Bagwell-Grey, Messing & Baldwin-White, 2015). Corrigan and colleagues (2003) reported loss of consciousness in 30% of IPV cases in emergency rooms, indicating at least a mild brain injury, and 67% presenting with residual problems that could be neurologically-based. This is perhaps unsurprising, given evidence showing over 90% of IPV survivors have injuries to the head, neck, and face (Banks, 2007). The risk of brain injury within IPV thus appears significantly higher, both in terms of percentage, and absolute numbers, than the risk in contact sports and military action, despite not having benefitted from the same degree of clinical and academic focus (Chapman & Diaz-Arrastia, 2014; Koh, Cassidy & Watkinson, 2003).

Within this new field, the research emphasis has been on traumatic brain injury (TBI). However, strangulation has emerged as a "hidden epidemic" (Taliaferro, Mills & Walker, 2001, p.294). A systematic review reported the lifetime prevalence of strangulation to be between 3.0% and 9.7% in community-living adults; amongst women who are victims of systematic abuse, this rises to 50-68% (Kwako et al., 2011; Sorenson, Joshi, & Sivitz, 2014; Wilbur et al., 2001). Evidence indicates up to 17% of those strangled lose consciousness, indicating at least a mild TBI (Wilbur et al., 2001). Incidence is also high: in a US study of IPV/sexual assault health encounters, strangulation was reported in 23% of the assaults (McQuown et al., 2016). A similar UK audit noted strangulation in one in five cases

[1] The WHO (p.2, 2019) define IPV as "behaviour by an intimate partner or ex-partner that causes physical, sexual or psychological harm, including physical aggression, sexual coercion, psychological abuse and controlling behaviours".

presenting at a sexual assault referral centre (White, 2018). For incidence to be so high versus lifetime prevalence is suggestive of repeated injuries and, indeed, the literature confirms this, with studies showing half of survivors reporting being strangled between three and 20 times (Vella, 2013; Wilbur et al., 2001).

Although it is possible for a woman to strangle a man, as it can take more pressure to open a canned drink than to occlude the jugular vein (Green, 2017), strangulation appears to be a gendered crime. Sorenson and colleagues (2014) report lifetime discrepancy between four and eleven-fold. In a review of 300 cases within the San Diego City Attorney's Office, 298 involved a male perpetrator and a female victim (McClane, Strack & Hawley, 2001). In White's SARC audit (2018), only two out of 70 victims were male. Indeed, a meta-analysis reviewing gender differences in violence stated strangulation "is very clearly a male act" (Archer, 2000, p. 327). There may be anatomical reasons behind this, in terms of hand and neck span, but the literature also suggests a power dynamic, often triggered by jealousy, and a desire to assert control (Joshi, Thomas & Sorenson, 2012; Sorenson et al., 2014). Thomas and colleagues (2014) describe strangulation's role as "setting the stage" (p.125): ensuring that it is understood that the main actor can or will kill.

Although strangulation can result in blunt force trauma to the neck, the method and physiological impact on the brain is different from most TBI. Strangulation can be defined as the external compression of the airway and/or blood vessels, leading to restricted oxygenated blood flow to, and deoxygenated blood from, the brain. This can be achieved with a ligature (garrotting), by body weight (throttling, or positional strangulation), or manually. Evidence largely gleaned from autopsies, and from assessing the risk of the 'choke hold' carotid restraint used by police, has been able to show the pathophysiology of strangulation, as set out below (Clarot, Vaz, Papin & Proust, 2005; de Boos, 2019; Hawley, McClane & Strack,

2001; Monahan, Purushotham & Biegon, 2019). Figure 1 serves as reference for the location of the relevant anatomical structures.

Firstly, the larynx can be obstructed, cutting off airflow to the lungs (i.e. asphyxiation, leading to hypoxia), which may continue after pressure has been lifted if the neck structure has been damaged (e.g. hyoid fracture). Secondly, jugular veins can be occluded, leading to venous congestion, increased intracranial pressure, decreased respiration, and possible pinpoint haemorrhage (petechiae). Thirdly, there is risk of internal carotid artery occlusion, restricting blood flow to the brain (i.e. ischaemic). This is more likely to happen when the attacker is facing the victim. If pressure is at the base of the neck, vertebral arteries may also be affected. Again, this may continue once pressure has been removed if there has been arterial dissection. Fourthly, there may be triggering of the carotid sinus reflex, leading to dysrhythmia, possible cardiac arrest, and thus further lack of blood to the brain (hypoxic-ischaemic). Finally, the thyroid gland can be damaged, resulting in possible 'thyroid storm', in which acute hyperthyroidism can cause congestive heart and multi-organ failure.

[Figure 1 goes approximately here]

Any or all of these mechanisms could damage the brain, and quickly. In the notorious Red Wing studies (Kabat & Anderson, 1943), in which psychiatric inmates and prisoners were strangled in order to increase the US military's understanding of why wartime airmen were blacking out, consciousness (and therefore memory of, and control over, events) was lost within four to ten seconds of arterial pressure, followed by anoxic seizures at six to eight seconds. Bladder control can be lost after 15 seconds, and bowels after 30, with decerebrate posturing after 20 seconds, indicating damage at a brain stem level, and, finally, brain death at between one and six minutes (de Boos, 2019). For asphyxiation only (so breathing prevented, but blood still flowing to the brain), the course depends on how much oxygen is

present in the blood and lungs. Panic-induced struggling against the attacker may cause its own injuries. Eventually consciousness will be lost as the brain runs out of oxygen.

The relatively small amount of pressure required to affect the various injuries is sobering: 4.4lbs for the jugular (less than opening a can of drink), 11lbs for the carotid arteries, 33lbs for the trachea, and 66lbs for the vertebral arteries (Shields, Corey, Weakley-Jones & Stewart, 2009). Figure 1 also highlights the lack of skeletal protection for the key structures, and their proximity; one can infer how difficult it would be to affect one in isolation. For those who survive strangulation, different brain areas react to a different time scale. Some parts of the brain stem and the hippocampus are known to be particularly vulnerable to lack of blood flow, along with the dentate nucleus, and the cerebellum (Hawley et al., 2001). Some cells may survive for days before dying, and the wider literature contains reports of stroke delayed by almost two weeks following other methods of carotid dissection (Levack, Pettitt, & Winston, 2009). In fact, in a large study (N = 300) only 39% had symptoms on the day of the injury (Strack, McClane & Hawley, 2001).

In addition to the neurological damage, leading to possible cognitive and behavioural changes, there is also the risk of significant psychological trauma. Strangulation has been called “the edge of homicide” (Strack & Gwinn, 2011, p.32). If a woman has been strangled by her partner, the risk of attempted murder increases sevenfold, and death by a factor of eight (Glass et al., 2008). Not being able to breathe – air hunger – is a primal fear, experienced even in controlled laboratory tests (Banzett, Lansing, Evans & Shea, 1996). In the uncontrolled IPV/sexual assault situation, the perpetrator, literally, has the woman’s life in his hands; a woman who could well be his wife or girlfriend. He dictates whether she takes her next breath or not, and may have his gaze locked on her as she struggles. Strangulation is a uniquely intimate act of terrorism (Johnson, 2010), and it is not difficult to see why it could leave more than physical marks, such as PTSD and other trauma reactions.

Attempts have already been made to synthesise our understanding of this new and important area. Pritchard and colleagues (2017) produced a narrative review, outlining the history of the subject, with particular focus on the US legal response, where strangulation has now been reclassified as a felony. However, the search was not systematic, and the study does not reference outcomes. An integrative review (Patch, Anderson and Campbell, 2018) did follow PRISMA guidelines, but excluded studies before 2000, and was undertaken from a nursing perspective, requiring there to have been an emergency healthcare interaction. Given we know there is significant under-reporting, and the San Diego study suggested as few as 5% of women will seek medical attention (Strack et al., 2001), it was felt that a more liberal and transdisciplinary approach might yield fuller findings.

This review therefore aims to map the knowledge currently held within the medical, legal, social work, policing, and psychological literature. Specifically, what evidence do we have for the pathological, neurological, cognitive, psychological, and behavioural impact of strangulation within IPV and sexual assault?

Method

The review adhered to the preferred reporting items for systematic reviews and meta-analyses (PRISMA; Moher, Liberati, Tetzlaff & Altman, 2009). It was placed in advance on the National Institute for Health Research's prospective register of systematic reviews (PROSPERO), reference CRD42019160487.

Search sources and strategy

A deliberately wide selection of databases was used, given the transdisciplinary nature of the topic: PubMed, PsycINFO, CINHAL, Proquest, ASSIA, Web of Science, WestLaw, Open Grey, and Ethos. The rationale for including doctoral theses was that a specific search could

then be conducted to ascertain whether a study had been published based on the findings. The initial search consisted of paired combinations, based on titles and key words from other studies, reflecting the injury (strangulation) and the outcomes (brain injury and its sequelae). This was then joined with terms reflecting the context (IPV and sexual assault). The ProQuest script was:

> ((strangl* OR strangulation OR chok* OR "breath play" OR throttl* OR ligature OR garrot*) AND (neuro* OR asphyxi* OR cardiac OR Aneurysm OR stroke OR vascular OR "brain injury" OR "brain damage" OR hypox* OR anox* OR cogniti* OR psych* OR "mental health" OR emotion* OR dementia OR encephalopathy OR behavio* OR ischaemi*)) AND ("sexual assault" OR "sexual abuse" OR "spouse abuse" OR "spousal abuse" OR "partner abuse" OR "domestic violence" OR "sexual violence" OR "intimate partner violence" OR "intimate terrorism" OR "situational couple violence" OR batter* OR rape OR "rough sex" OR "dating violence")

The first search was conducted on the 17th December, 2019. Following editor comments, a second search was conducted on the 6th October, 2020. This was a forward search, looking for citations of the 27 studies originally identified. A total of 1,600 studies were reviewed in total, resulting in 122 potentially eligible full texts, reduced to 30 articles.

Eligibility criteria

To qualify for inclusion, articles needed to be peer-reviewed, empirical studies, and refer to pathological, neurological, cognitive, psychological, and behavioural outcomes of strangulation (manual, ligature, or throttling) within domestic or sexual violence. No date limits were set, given the need for breadth. Exclusion criteria were: general violence not limited to IPV or sexual assault; focus on perpetrator; strangulation not separated out from other forms of violence; fatal; non-neurological outcomes only (e.g. neck lacerations, bruising); limited to policing or legal process; not adult or human; self-inflicted (e.g. auto-erotic asphyxia or hanging); no English version available.

Quality assessment

Based on specialist librarian advice, all studies were assessed using the suite of critical appraisal tools from the Joanna Briggs Institute (2017). Analytical cross-sectional studies were measured against an eight item checklist, e.g. were confounding factors identified and controlled for, were outcomes measured in a valid and reliable way, and was appropriate statistical analysis undertaken. Case reports were appraised against a different eight item checklist, e.g. was there clear description of the patient's demographic characteristics and history, and were diagnostic tests and assessment methods specified. There was a 10-item checklist for qualitative research, e.g. congruity between research objectives and methodology, addressing the influence of the researcher on the research, and whether the conclusions drawn flowed from the analysis of the data. These are all checklists for inclusion in reviews, and are not intended to provide a formal grading system, or cut-off scores. However, our appraisal against the checklists has been included in the data extraction tables, with a higher score indicating that the authors have more closely adhered to methodological best practice.

Risk of bias

The first author conducted both searches at title and abstract level. Potentially eligible full texts (112) were reviewed with CB, with only three instances of disagreement, all from grey literature, resolved in consultation with the other authors. Data on outcomes were extracted, and recorded in Table 1 by the first author. Again, outcome data and quality assessments were inspected and refined by CB, and then the whole review was checked by the remaining authors, who were available in case of disagreement, but this was not necessary.

Results

Information extraction

The initial search yielded 1,433 articles, with a further 43 added from reference lists, and 124 from the later forward search for citations of key studies. Subsequent selection involved four main phases; see Figure 2. A total of 30 articles were included in the final sample.

[Figure 2 goes approximately here]

Analysis of the articles

Table 1 provides key features of the final list of articles. They were published between 1980 and 2020 across 10 countries, with the USA being the main contributor, with 16/30.

Characteristics of samples

Samples were analysed in terms of recruitment, size, demographics, medical history, and use of controls. There were no randomised, population, or prospective samples. People were identified through their contact with the healthcare, police, or justice systems, or had been helped by IPV organisations. Sample size was bimodal, with 10 case reports (N = 1 to 3), and eleven large retrospective analyses of existing records (N = 102 to 1,064).

The majority of studies (24/30) had entirely female samples, and one study interviewed heterosexual couples with a male attacker. Of those studies where men had also been victims, they were in the minority, ranging from 2/14 (Yen et al., 2007) to 2/300 (Strack et al., 2001). Most studies reported a mean age in the early thirties.

Few studies used controls. Joshi et al. (2012) and Thomas et al. (2014) tried to recruit IPV survivors who had not been strangled, but were unable. An exploratory whole brain MRI study compared IPV survivors to non-victims, with most of the former group having been strangled (Daugherty et al., 2020). In the majority of studies (22/30) strangulation was in the

context of IPV. Four involved sexual assault, with partners being the assailant in two of those, and a further four recruited both IPV and sexual assault victims. Ralston and colleagues (2019) specifically excluded sexual assault.

Only seven of the case studies (n = 10), and only one of the retrospective analyses (Ralston et al., 2019) reported on previous medical history, including TBI and mental health. None of the qualitative studies explored co-morbidities or alternative explanations for the participants' current difficulties. Five quantitative studies compared outcomes for strangulation versus other forms of violence, or against multiple strangulations; three of these studies used regression models (Messing et al., 2014; Messing et al., 2017; Mittal et al., 2018). Wilbur and colleagues (2001) included history of childhood abuse in their descriptive statistics. Daugherty and colleagues (2020) controlled for Adverse Childhood Experiences, other domestic violence, depression, and generalised anxiety in their analyses of brain imaging.

Study design and methodological considerations

The collection, analysis, and interpretation of data were reviewed across the articles. All studies were cross-sectional, although three case reports cited GP follow-up after several years. Alongside the ten clinical case reports written by the treating clinicians, there were another five analyses of hospital records, written by ED medics, forensic nurses, or radiologists, and three analyses of police and legal reports. There were no studies written from a neuropsychological perspective. These retrospective analyses depend on the depth and breadth of what was documented at the time, and who was doing this: for example, Strack et al. (2001) emphasise the inconsistency and paucity of symptom reporting by police, limited largely to visible injury. Similarly, using imaging data will be limited to what can be identified on a scan. Five studies were survey-based, and could therefore generate additional, transdisciplinary data.

Of those studies which used statistical analysis, this was largely descriptive. Only five studies used inferential analysis, including t tests and odds ratios, chi-square, binomial/multinomial logistic regression, partial correlations, and risk ratios (Davins-Pujols et al., 2014; Daugherty et al., 2020; Messing et al., 2014 and 2018; Mittal et al., 2019). Where method was stated in the six qualitative studies, this was based on grounded theory or thematic analysis. One used mixed methods, combining analysis of police records and follow-up depth interviews (Farr, 2002). One used repeated depth interviews (Daugherty et al, 2020). The others used focus groups, and found this successful, despite the sensitivity of the topic.

Assessment measures

The methods used to assess outcomes were reviewed. None of the studies used formal neuropsychological assessment. The majority of cognitive and psychological outcomes were based on participants' spontaneous self-reports. Shields et al. (2010) suggest this may underestimate complaints, given participants' tendency towards minimisation and denial, and possible memory loss resulting from strangulation. Where objective assessment was undertaken, this was guided by profession, and varied significantly. For example, Plattner and colleagues (2004) analysed hospital records of imaging results and clinical presentation, but note no evidence of neurological examination. There was no standard strangulation assessment tool identified, in either the medical or policing fields.

Two survey-based studies developed their own questions to record symptoms (Smith et al., 2001; Wilbur et al., 2001). Daugherty et al. (2020), Messing et al. (2014, 2018) and Mittal et al. (2019) were the only authors to used standardised, validated psychometric measures, although none of these were strangulation-specific: Composite Abuse Scale – Short Form (CAS-SF; Ford-Gilboe, 2015), Adverse Childhood Experiences Questionnaire (ACE; Felitti et al., 2019), the PTSD Checklist for DSM-5 (PCL-5; Wortmann et al., 2016), Revised

Conflict Tactics Scale (CTS2; Strauss et al., 1996), Danger Assessment Scale (Campbell et al., 2009), Women's Experience of Battering Scale (Smith, Earp, & DeVellis, 1995), Primary Care Post-Traumatic Stress Disorder Screen (Cameron & Gusman, 2003), Abuse Behaviour Inventory (Zink et al., 2007), Rosenberg Self-Esteen Scale (1965), the Generalized Anxiety Disorder Questionnaire (GAD-7; Spitzer et al., 2006), the Patient Health Questionnaire Depression Subscale (PHQ-9; Kroenke & Spitzer, 2002), and the Centre for Epidemiologic Studies Depression Scale (Radloff, 1977).

The timing of assessment differed. Case reports and retrospective record analyses tended to be based on immediate outcomes. There is therefore the risk that symptoms may not have developed, and victims were not yet in a position to report more specific difficulties. Where studies were delayed, by contrast, this relied on participants' recall, which may have been compromised by time, and memory impairment, and many of the physical symptoms may have receded.

Quality of evidence

Potential biases were assessed by considering the appropriateness of method and design, and scored using the suite of critical appraisal tools from the Joanna Briggs Institute (JBI; 2017). Qualitative researchers, despite intending to, found it difficult to recruit comparison groups who had not been strangled, given the high prevalence and incidence figures (Joshi et al., 2012; Thomas et al., 2014). Douglas & Fitzgerald (2020) drew their sample from a larger study which included non-strangled IPV survivors, but did not contrast the two groups. However, Daugherty et al. (2020), Davins-Pujols et al. (2014), Messing et al. (2014, 2018), and Zilkens et al. (2016) were able to identify IPV victims not reporting strangulation to act as a comparison, and were the only studies thereby to attempt to control for confounding factors. Smith and colleagues (2001) were able to compare multiple to single strangulation

events. There were only two clinical follow-ups by authors (Clarot et al., 2004; Malek et al, 2000), and one anecdotal report from the patient's GP after several years (Milligan & Anderson, 1980). Only 4/30 studies used standardised psychometric measures (Daugherty et al., 2020; Messing et al., 2014 & 2018; Mittal et al., 2019).

Overall, therefore, the quality of the evidence would have been low if measured by standard grading tools. Using the JBI critical appraisal tools the median score for both cross sectional studies and case reports was 6/8. Quality was higher, albeit against different criteria, for the qualitative studies, although there was a widespread failure to frame the research in terms of relevant theory, or address the influence of the researcher on the research.

[Table 1 goes approximately here]

Summary of main findings

This review's objective was to ascertain the empirical evidence for the pathological, neurological, cognitive, psychological, and behavioural impact of strangulation within IPV and sexual assault.

Pathological changes

There were six case reports of arterial dissection: five involving the carotid arteries, and one the vertebral artery. There were 11 case reports featuring stroke, with two of these delayed by three months (Malek et al., 2000). Twelve studies reported petechiae, sub-conjunctival haemorrhage, and other signs of venous congestion. One case report included tracheal perforation, and one mentioned hyoid facture. Observable lesions and infarctions reported included: basal ganglia, left posterior frontal lobe, left frontoparietal, bilateral frontal infarcts

following the watershed distribution of the middle and anterior cerebral arteries, left opercular, both cerebellar lobes, and the area distal to the left posterior cerebral artery.

An exploratory study used whole brain MRI scanning to compare IPV survivors, 18 of whom had been strangled, with non-victims (Daugherty et al., 2020). Controlling for other factors, including TBI, sociodemographics, and childhood trauma, strangulation showed a significant negative correlation with cortical thickness in the horizontal ramus of the anterior segment of the lateral sulcus, which feeds into language areas (-0.35). There were no between-group structural differences in the hippocampus. However, the authors excluded participants with neurological illness, such as seizures, as well as cognitive impairment and substance misuse, which may have removed those most severely affected. They did not assess for loss of consciousness, so strangulation severity could not be included in the analysis. Finally, as an exploratory study, they did not account for performing multiple analyses. They concede therefore that a larger study might not replicate these findings.

Neurological outcomes

Potentially serious neurological outcomes were reported in 23/30 studies. Loss of, and alterations to, consciousness, were widespread, suggesting at least mild brain injury per the Mayo classification system (Malek et al., 2007). For those studies reporting incidence, loss of consciousness ranged from 8.9% (Zilkens et al., 2016) to 38% of strangulation attempts (Shields et al., 2010). Importantly, figures were higher when taken from medical settings, where consciousness was assessed objectively. When women self-reported at a later date, lower figures may be due to memory loss, or not understanding what ‘blacking out’ or ‘passing out’ signify.

Other widely reported neurological consequences, with number of articles in parentheses, include: changes to vision, including hemianopia, pain, and dysarthria, dysphonia, or other

voice changes (10); headache, and dyspnoea or breathing difficulty (9); facial or limb paralysis, urinary or faecal incontinence, dysthesia or loss of or changes to sensation, and lightheadedness or dizziness (7); limb weakness, and swallowing difficulty or dysphagia (6); tinnitus or dysphasia (4); spasms/tremor/shaking (3); coma, seizure, ataxia, facial droop, confusion, nausea and vomiting, or ptosis or Horner's Syndrome (2); hyperreflexia (1).

In the eight studies that reported follow-up outcomes, or were based on surveys or interviews with survivors at a later date, ongoing symptoms, with number of articles in parentheses, included: pain, tinnitus, vision changes, paralysis, and headache (4); sensory and voice changes (3); swallowing difficulty, ptosis, incontinence, facial droop (2); seizures, dizziness, breathing difficulty, and muscle spasm (1).

Cognitive outcomes

Only one case report mentioned an immediate cognitive outcome, which was amnesia for the strangulation incident (De Boos, 2019). Six studies reported delayed cognitive outcomes, all of which cited memory. One participant who had lost consciousness several times following strangulation commented: "I have really bad problems with my short-term memory. At work I have to have a notepad and I have to write down…if I don't when I get back to my desk two minutes later, I can't remember what they asked for" (Douglas & Fitzgerald, 2020; p. 9). Farr (2002) reported two victims having been taken into public by the attacker afterwards and making no attempt to escape, which is deemed to be "traumatic immobility" (p. 276). This may have had a psychological basis – fear – but could also be cognitive, e.g. agnosia or lack of initiation. Pritchard et al. (2018) reported 22% of police records mentioning "any psychological symptoms", but then refers to "memory problems, slurred speech etc" (p. 171), which seem to be more neurocognitive, and are, unfortunately, not separated out.

Psychological outcomes

Only five studies reported on psychological distress in the immediate aftermath of the strangulation, which all hinged on a sense of existential threat, the firm conviction that they were about to die (De Boos, 2019; Funk & Schuppel, 2003; Jordan et al., 2020; Shields et al., 2010; Strack et al., 2001).

A further 14 studies reported on delayed psychological outcomes. These included (with number of articles in parentheses): existential threat (7); depression, anxiety, suicidality, and nightmares (4); insomnia, PTSD (3); generalised fear and feelings of danger, powerlessness and vulnerability, dissociation at the time of the attack, and ongoing, including possible dissociative seizures, minimisation and denial of events (2); and then single articles reported increased shame, hypervigilance, diagnosed post-concussion syndrome, participants believing they had actually died, interpersonal difficulties, personality change, feelings of worthlessness, further unspecified trauma reaction, and exacerbation of existing mental health difficulties.

The verbal threats to kill made by attackers were mentioned in four studies, and give substance to the existential fear reported by victims (Douglas & Fitzgerald, 2020; Shields et al., 2010; Strack et al., 2001; Zilkens et al., 2016). Chilling examples include: "I am going to commit an OJ on you and leave no visible marks" or "Die, die" (Strack et al., 2001, p. 307). Messing et al. (2018) found that IPV victims who were strangled had significantly increased odds of believing their partner could and would kill them (ARR, 1.81). Both studies by Joshi et al (2014 & 2018) reported dissociative reactions at the time of the strangulation, seeing life flashing before their eyes, and possible non-epileptic absence seizures as a long-term consequence: "I black out, you can be talking to me right now and I can't see you, can't hear you (p. 1,636). One of Farr's participants (2002) describes the sense of "being killed and watching it" (p. 275). In Yen et al. (2007) 7/14 of forensic examinations contain reports of seeing a "black void". Thomas et al. (2014) draw attention to the highly personal nature of

the crime, as well as this dissociative element, with a victim stating it is "painful to watch the man who so-called loves you try to kill you" (p. 130)

A further tragic outcome in several of the studies was miscarriage following the strangulation event. Messing et al. (2018) reported increased odds (ARR, 2.95) for strangled versus non-strangled IPV survivors, and that this increased for those who had experienced multiple incidents. Wilbur and colleagues (2001) reported an 11% incidence amongst women in refuges who had been strangled. Amongst 24 women in Douglas and Fitzgerald's 2020 study, one had miscarried, and one given birth prematurely. Although miscarriage does not directly fall within immediate psychological outcomes, the potential effect does, as large effects have been shown elsewhere for depression, guilt, and complicated grief (Adolfsson, 2011).

Behavioural outcomes

One qualitative study (Thomas et al., 2014) mentioned behavioural changes after strangulation, indicative of power dynamics. These included increased compliant and submissive behaviour, self-isolation and not leaving the house, and, for one participant, increased aggression towards her partner.

One qualitative study discussed the survivalist mode the victim entered following the realisation that death was imminent: "then I knew it's either him or me" (Eiskovits & Winstok, 2002, p. 695). Another qualitative study (Douglas & Fitzgerald, 2020) highlighted the defensive responses, including kicking, twisting the attacker's hand, and grabbing a kitchen knife: "…he had me round the throat. I could hardly breathe. It was like survival of the fittest. When you're in flight mode, you'll do whatever you need to…" (p. 10). The authors point out the risk that this self-defence will be characterised as abuse itself.

Several studies drew attention to the lack of help-seeking behaviour by strangulation victims (Joshi et al, 2012; Pritchard et al., 2018; Ralston et al., 2019). Only 39% of women at a

refuge who had been strangled had sought medical attention, despite more than half having been strangled twice or more (Smith et al., 2001). This dropped to 5% in a study of 300 prosecution files (Strack et al., 2001).

Discussion

Our systematic literature search identified 30 empirical, peer-reviewed studies which documented the outcomes of non-fatal strangulation in IPV and sexual assault. Almost all victims were female. Severe, life-threatening injuries were reported, including stroke, arterial dissection, and symptoms of hypoxia and venous congestion. Clinical outcomes included loss of consciousness, changes to vision and voice, motor difficulties, and sensory loss. Psychological outcomes indicated profound trauma reactions, including acute and chronic fear, PTSD, dissociation, depression, anxiety and suicidality. Fewer studies reported on cognitive and behavioural changes. Those that did highlighted memory loss, executive difficulties, aggression towards the attacker, and lack of help-seeking. There were no studies conducted from a neuropsychological perspective: the majority of studies found in our search were hospital-based case reports, or retrospective analyses of police and legal records. As such, they tended to focus on acute physical and visible injury. Moreover, few of the studies attempted to control for possible confounds, including other physical violence, or existing mental health difficulties.

It was unfortunate that the one study identified in the course of the search which most precisely answered the research question had to be excluded: it was a doctoral thesis, and had not been peer-reviewed (Pierquet, 1997). In her study, Pierquet administered a comprehensive neuropsychological battery with 45 women who had endured IPV. She recorded data on the types of violence suffered, including strangulation, if this had been to

the point of unconsciousness (13/45, 29% of the sample), and frequency (up to 10). From this, Pierquet was able to demonstrate a significant association between strangulation and cerebral dysfunction, including memory, cognitive flexibility, and motor deficits (Eta squared = 0.549). She was also able to evidence a dose effect, in that the amount of times someone was strangled accounted for almost a third of the variance in cognitive and motor function.

Another unpublished thesis demonstrated a 10-15 fold increased risk of stroke amongst women under 40 who had suffered IPV (n = 237) versus a matched control (Smith, 2009). Smith demonstrated significant associations between strangulation, loss of memory, paralysis, and stroke. Combining this with the incidence figures for strangulation gives substance to the warnings elsewhere in the literature that strangulation may be the second most common cause of stroke in women under 42, and should be included in the differential diagnosis of younger patients, particularly in the context of apparently spontaneous arterial dissection (Clarot et al., 2004; Malek et al., 2000; Milligan & Anderson, 1980). Seven studies we found diagnosed haemorrhagic or ischaemic stroke, often significantly delayed.

Neuropsychological studies such as these, using controls, would permit us to infer more of a causal link between strangulation and the outcomes documented by this review. We need this evidence base in order to build public and institutional understanding of the gravity of strangulation. In a recent British legal case, a prostitute had been strangled by a client (Armstrong, 2012). With her losing consciousness, he had panicked, believed her to be dead, and was in the process of abandoning her body by the roadside when she regained consciousness. The victim then went to her attacker's house, where they drank wine together. Her behaviour after the event was used to undermine the severity of the attack, he was found guilty of the lesser charge of grievous bodily harm, and sentenced to two years. Based on the literature we have reviewed, her behaviour could have been due to existential fear, and therefore displaying compliance in order to survive. Having lost consciousness she would

almost certainly be amnesic for that portion of the attack, but she could also have wider retrograde memory loss. It could be the result of damage to brain areas involved in executive function - she could not problem-solve or plan an escape – and general hypoxic confusion. But if none of this is systematically evidenced, then victims' behaviour will not be seen as the product of a strangled brain.

This lack of appreciation for the severity of strangulation has other far-reaching consequences. The campaign group We Can't Consent To This (2020) has collated 250 cases of women fatally strangled by men during sexual intercourse, in which the legal defence team argued that the victim consented, that therefore the death was accidental, and consequently the assailant not guilty of murder. But from a neuropsychological perspective, cognitively consent hinges on two factors: it must be informed, and there needs to be capacity to withdraw it at any point. If strangulation – its mechanics, its severity – is not understood, then the victim is not informed. The Red Wing studies (Kabat & Anderson, 1943) undermine the second point. The prisoners and psychiatric inmates who were fitted with the mechanical strangulation cuffs were also given an emergency release button. The lead investigator, when testing the equipment on himself, described being close to losing consciousness and finding himself unable to press the button (Smith, Clayton & Robertson, 2011). The potential onset of dyspraxia, amnesia, and unconsciousness itself (in as little as four seconds) are disabling: the very organ that is needed to withdraw consent is compromised by the activity to which that consent applies. The term 'consenting kink' is therefore a potentially fatal misnomer.

This is worrying, in the context of strangulation having become normalised (Edwards, 2016). In a recent UK survey (N = 2,002) 38% of women under 40 had experienced strangulation during sex, with 42% of those saying it was unwanted, and that they had felt pressured, coerced, or forced (BBC, 2019). A recent systematic review calculated a median 7.4% prevalence amongst teenagers for the 'choking game', in which ligatures are used to strangle

oneself, with this filmed and shared on social media, and 99 deaths reported in the literature (Busse, Harrop, Gunell, Kipping, 2015). Although many police forces have abandoned the use of carotid restraint following deaths in custody, it is still used in many countries, and by the military (Stellpflug, Menton, Corry, & Schneir, 2020). 'Near chokes', 'chokes', and 'submission holds' are also legitimate and widely utilised tactics in mixed martial arts (MMA).

To put this into context, waterboarding has now been internationally outlawed as a form of torture, correctly considered inhumane and unacceptably dangerous, even when its stated objective is to prevent multiple deaths. In waterboarding, however, it is only the airway which is occluded. Strangulation is potentially more lethal: not only is breathing interrupted, but also blood flow to and from the brain. As such, it can carry all the consequences of other hypoxic-ischaemic injuries such as cardiac arrest, but with the additional trauma reactions evidenced in the studies we reviewed.

Review limitations

The neuropsychological sequelae of strangulation is an embryonic field, it straddles different disciplines, and multiple terms are used to describe strangulation. Despite our best efforts, it is therefore extremely likely that our search missed studies. In those studies we did find, few controlled for confounding factors, and many were based on subjective report. It was therefore sometimes difficult to separate out what outcomes were specific to strangulation as opposed to the general traumatising effects of IPV and sexual assault. This is particularly relevant for those instances where PTSD was reported, given associations have been demonstrated elsewhere between PTSD and hippocampal volume, speed of processing, and reasoning performance (Twamley, Allard, Thorp & Norman, 2009). We also know that strangulation victims are more at risk of mental health difficulties, alcohol and drug abuse,

and other forms of violence, especially given strangulation tends to be towards the end of an escalating pattern of abuse (Glass et al., 2008; Kwako et al., 2011; WHO, 2019). All of these factors might explain some of the effects found. Aside from those medical reports which were able to relate attack to injury and objectively assessed clinical outcome, it is therefore not possible to make a direct, causal link. Finally, the lack of consistent, validated assessment tools rendered between-study comparisons difficult, and meta-analysis impossible.

Further research and clinical implications

In our opinion, it is imperative that new, methodologically rigorous, and peer-reviewed studies add to our neuropsychological understanding of strangulation, by investigating the cognitive, psychological, and behavioural outcomes, measured with standardised assessment tools, set against control groups. This will help in terms of isolating the effects of strangulation versus other physical violence, and comorbidity, including existing mental health difficulties and substance misuse. It will also be important to recruit from non-hospital or IPV settings (given the majority of victims do not seek assistance). This lack of help-seeking behaviour merits exploration in its own right. The majority of studies were from the USA: does this pattern still exist in countries where healthcare is free at the point of need? What barriers prevent women from presenting? For those who do receive intervention, although it was not the objective of this search, little was found in the literature which evidences best practice and treatment outcomes for holistic, long-term recovery, beyond acute medical care.

Again, although not the aim of this study, the societal normalisation of strangling we observed is worrying. There would be merit in trying to understand the attraction of, and possible pressure to partake in, 'breath play' and the 'choking game'. Similarly, the use of 'chokes' (loss of consciousness) and 'submission holds' (in which respiration is blocked) in

MMA is extremely concerning. Other sports, based on the evidence, have banned repeated heading of balls by young people, given the cumulative effect of multiple concussions on cognitive function, and the future risk of developing chronic traumatic encephalopathy (Stein, Alvarez & McKee, 2014). There are emerging case reports and studies on choking and carotid injury in MMA (Lim, Ho & Ho, 2019; Powell et al., 2018). There was a recent systematic review on TBI in MMA (Lockwood, Frame, Lin & Ackerley, 2018), but it focused on 'knockouts' rather than strangulation.

One of the strangulation mechanisms described in the Introduction is thyroid storm: thyrocytosis resulting from damage to the gland, which can cause multiple organ failure, including lethal arrhythmias. Malek et al. (2001) reported hyperthyroidism in their cases but stated this was pre-morbid. Given hyperthyroidism's non-fatal effects can include anxiety, insomnia, and several other strangulation outcomes attributed to the psychological impact, there may be merit in exploring further this interaction, as its incidence may be under-reported.

We found a high incidence of miscarriage and delayed stroke. Further epidemiological investigation could be conducted to substantiate a call to healthcare providers to consider strangulation a differential diagnosis for both events. These could be rare and critical moments in which to identify IPV victims, who may have no other physical signs of strangulation, and provide life-saving intervention.

Finally, the severity of the outcomes found in our review, combined with high prevalence and incidence, and a lack of help-seeking behaviour, support a proactive approach by clinicians. Given societal normalisation, and the documented delay between strangulation and sequelae, it may be helpful to ask IPV victims explicitly about strangulation, as information may not be volunteered. Neuropsychological assessment could start with a similar testing battery used for

other hypoxic-ischaemic injuries such as cardiac arrest, but with additional tools to investigate potential psychological trauma.

Conclusion

This systematic review found 30 empirical, peer-reviewed studies which together evidence the severe outcomes of strangulation within IPV and sexual assault. Given the mechanisms, involving potential occlusion of the airway, blood flow to and from the brain, and the triggering of the carotid sinus reflex, the neurological consequences can include all those associated with hypoxic-ischaemic injury, such as cardiac arrest. But there are other psychological outcomes linked to this uniquely intimate terrorism and its traumatising nature: the pain of watching "the man who so-called loves you try to kill you" (Thomas et al., 2014, p. 130). The majority of studies we found were based on hospital case reports, or existing police and legal records. At present there is less evidence for strangulation's cognitive and behavioural sequelae, and none based on objective, neuropsychological testing. There is therefore a need to build the evidence base. This work should control for other physical violence and psychological comorbidity, and use standardised assessment tools. Given the cultural and legal context, this needs to happen urgently, so findings can be used to inform institutions and the public; to reposition strangulation from being a game, to a serious criminal assault, with potentially life-changing outcomes.

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