

PAPER**PATHOLOGY/BIOLOGY**

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Asphyxia Homicides in Finland, 1983–2012

ABSTRACT: Finland has one of the highest homicide rates in Western Europe, and almost every tenth homicide is caused by asphyxiation. Reliable statistics, a strict legislation, and an exceptionally high medico-legal autopsy rate formed a base for a nationwide analysis of asphyxia homicides ($n = 383$) during 30 years. The cases were identified through multiple records, and all the forensic pathology case files were studied in detail. In more than one out of five cases, there were indications of staging, and the homicide was revealed first at autopsy in close to one in ten cases. The vast majority of the homicides took place in private locations and involved persons known to each other. Every third victim was an intimate partner, and every tenth a child. Almost half of the victims died from manual strangulation, one in three from ligature strangulation. Smothering, choking, neck compression with a firm object, and thoracic compression were more rare methods. Drownings were excluded from this study material. Of all the victims, 7% had no observable external injuries. Petechiae were recorded in approximately in 61%, laryngohyoid fractures in 47%, and vocal cord hemorrhages in 16% of the cases. Every tenth female victim had genital injuries. Toxicological analyses were performed in close to all of the cases, and almost three out of four victims tested positive for blood alcohol. The various aspects of the demographics and autopsy findings covered in this study contribute reliable and accurate data to further strengthen the spectrum of observable medico-legal characteristics of asphyxia homicides.

KEYWORDS: forensic pathology, homicide, asphyxia, strangulation, suffocation, Finland

The homicide represents a longstanding and significant societal problem, and Finland with its currently 5.5 million inhabitants has one of the highest homicide rates in Western Europe. In 1990–2012, the mean annual number of homicides per 100,000 inhabitants was in England 0.75, in France 1.31, in the Netherlands 1.36, and in the neighboring Nordic countries Norway 1.11 and Sweden 1.45 (1). In Finland, the mean annual number during 1983–2012 was 2.6 (Official Statistics of Finland), of which almost every tenth (9.7%) was caused by an asphyxiation.

According to the Finnish legislation (2), the police must investigate every unnatural death. The law states that a medico-legal investigation is indicated “when it is known or suspected that a death has been caused by a crime, an accident, an intoxication, a suicide, an occupational disease, a medical procedure, or when a death has been sudden and unexpected, and a deceased has not been treated by a doctor during the last illness”. On request of the police, in approximately 90% of all unnatural deaths including *all* suspected homicides, a medico-legal autopsy is carried out (3,4). After the autopsy and possible additional examinations, the forensic pathologist determines the cause and manner of death.

As a part of a larger survey of homicides in Finland over a time period of three decades, the objective of the present study

was to establish the incidence of various forms of homicides due to asphyxia, and to examine in detail their medico-legal characteristics.

Materials and Methods

This study is a part of a retrospective nationwide survey of homicides in Finland from January 1983 to December 2012. The present study includes all the homicidal deaths due to asphyxia ($n = 383$) during this 30-year study period. In this study, deaths due to a mechanical obstruction of airways, a mechanical impairment of respiratory movements and pressure in the neck as concluded by the certifying forensic pathologists were considered as asphyxia homicides. The cases were identified through a search in the vital statistics (Official Statistics of Finland), obtaining the forensic pathology case files, and extracting manually the asphyxia deaths from the total homicide material. In addition, the database of the Laboratory of Toxicology at the Department of Forensic Medicine, University of Helsinki (where over the study period the overwhelming majority of the toxicological examinations were conducted) was searched, and the police was also consulted to verify that all homicides were included. This was necessary since the official statistics did not contain the death certificates of victims of foreign nationality.

Homicides due to drowning were considered to constitute a specific entity and were not analyzed in the present study.

The forensic pathology case files regarding the 383 victims were used as a primary source of the data and were obtained from the official medico-legal archives. Such a forensic medical case file routinely includes the official requisition from the police for a medico-legal autopsy, the initial police report of the incident, the autopsy protocol, the supplemental reports on the results of additional examinations, the final autopsy statement with conclusions,

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and the death certificate. In each individual case, all the available documents were studied. Auxiliary material such as photographs, body charts, ambulance service forms, police interrogation protocols, crime scene investigation reports as well as past medical records could be found in the files but were not uniformly present. Such auxiliary material was used to supplement the background information. For a number of cases that had already been analyzed as a part of a previous study (5), also the data from the prosecution and court files was considered.

For the present study, the information gathered in each case included demographic characteristics of the victim, the known history of substance abuse, the relationship between the victim and the perpetrator, the time and the place of the offense, circumstances and assumed motives of the offense, the scene of crime information, the medical treatment of the victim, injury patterns, additional examinations, and their results, and the underlying and contributing cause of death. Chronic alcohol abuse was established if a long-term harmful use of alcohol was mentioned in the police and/or medical records available, or if an alcohol-induced disease was diagnosed at the autopsy. For any known perpetrator, the sex and the nationality were taken into account. The more detailed list of variables analyzed can be found in the Appendix 1.

According to the information available, the medico-legal autopsies in this study were conducted using the standard procedures. In Finland, the medico-legal autopsy must always include a thorough external inspection and an internal examination. The autopsy must be complete; that is, all the body cavities are opened and all the organs described, dissected, and weighed. The autopsy is conducted by the protocol and it must include a comprehensive description of both normal tissues and in detail pathological findings and injuries (6). Special procedures such as a neck dissection are used when necessary (7,8).

The information of the case files was transferred to a registration form, and subsequently into an electronic database. Based on the cause of death, the cases were subdivided into following categories: manual strangulation (including forearm choke holds), ligature strangulation, combined (manual and ligature) strangulation, smothering (covering of victim's mouth and nose), choking (blocking the victim's internal airways with a foreign object), neck compression with a stiff object, thoracic compression, cardioinhibitory reflex cardiac arrest due to pressure of the neck, and asphyxiation due to an unknown method.

Results

During the 30-year study period, there was a total of 383 homicides due to an asphyxiation with the mean of 12.8 cases annually (range 5 – 22, median 12 per year), representing 9.7% of the total count of homicides in Finland ($n = 3,945$). The annual mean rate for all asphyxia homicides was 0.26 victims per 100,000 population, with the highest rate (0.32) in the province of Eastern Finland and the lowest rate (0.18) in the province of Western Finland. For strangulation homicides, the mean rate for the study period was 0.21 per 100,000 per year.

Circumstances

The overwhelming majority of the asphyxia homicides took place in urban areas (85.9%), indoors (84.3%), and in private locations (74.9%). The shared home of the victim and the perpetrator was the location in 24.3% ($n = 93$) of the cases, the victim's home in 29.8% ($n = 114$), and the perpetrator's home in

13.6% ($n = 52$) of the cases. Official institutions were rarely the scene of the homicide; a hospital ($n = 6$ of which 5 in a psychiatric ward), a prison ($n = 1$), and police custody ($n = 3$).

The majority of the victims (81.1%) did not receive any professional medical care after the offense. In 53 cases (13.8%), some kind of resuscitation attempts were performed (either by medical professionals or by laymen), and 19 victims (5.0%) were treated in hospital.

In altogether, 22.2% ($n = 81$) of the cases where the victim had died at the scene ($n = 364$), the perpetrator had in some way tried to conceal the offense and to mislead the police. The body of the victim in 16.5% of the cases (60/364) had been transported to another location, where the perpetrator had hidden the body in 25 cases, and attempted to dispose the body in 13 cases by burying, burning, or submerging in water. For the cases where a homicide was not initially suspected ($n = 37$), relocating the body or otherwise attempting to alter the circumstances at the scene occurred in 24.3% of cases.

A drinking dispute was estimated to have been the motive in 18.6% ($n = 71$) of all asphyxia homicides, and jealousy, a relationship breakdown, or other domestic dispute in 16.7% ($n = 64$) of the cases. A sexual motive was identified in 21 cases (5.5%), all of which involved a female victim with the youngest being 8 and the oldest 72 years old. Other quite frequent motives included a quarrel ($n = 36$), an extended suicide where the self-destruction of the perpetrator was estimated to have been the main intention ($n = 23$), and revenge ($n = 20$). In 82 cases (21.4%), the probable motive could not be deduced from the data available.

The homicide was revealed first at autopsy in 8.6% of the cases (33/383), and in five cases (1.3%) no compelling evidence was found at the autopsy and the death was proven to be caused by another person only afterward.

Victims and Perpetrators

In the reported asphyxia homicide series, there was no clear difference in the overall sex distribution of the victims with 53.0% males ($n = 203$) and 47.0% females ($n = 180$) (Fig. 1).

Based on the autopsy findings and the police and medical records available, 41.6% of the adult victims (101 males and 37 females) were considered to be chronic alcohol abusers.

According to the information available from the identified perpetrator ($n = 343$), the overwhelming majority of homicides (92.1%, $n = 316$) occurred among persons who were known to each other, and only 7.9% ($n = 27$) of the victims were killed by a stranger. In 39.4% ($n = 135$, of 343), the victims were related to the perpetrator by birth, marriage or common law. Drinking companions accounted for 14.0% of the perpetrators, friends for 13.7% and acquaintances for another 14.0%. Of the 332 adult victims (persons 16 years of age or older), almost one case in three involved intimate partners (29.8%, $n = 99$). In 19.0% of all adult victims, the perpetrator was a legal or common law spouse (57 female and 6 male victims); in 7.5%, a partner in another long-term relationship (23 female and 2 male victims), and in 3.3%, a former spouse (9 female and 2 male victims). Children ($n = 51$) constituted 13.3% of all victims and of them, 30 were killed by their mother and 12 by their father.

Autopsy and Findings

Approximately, half of the victims (48.8%, $n = 187$) died from a manual strangulation, while in 34.2% ($n = 131$) of the

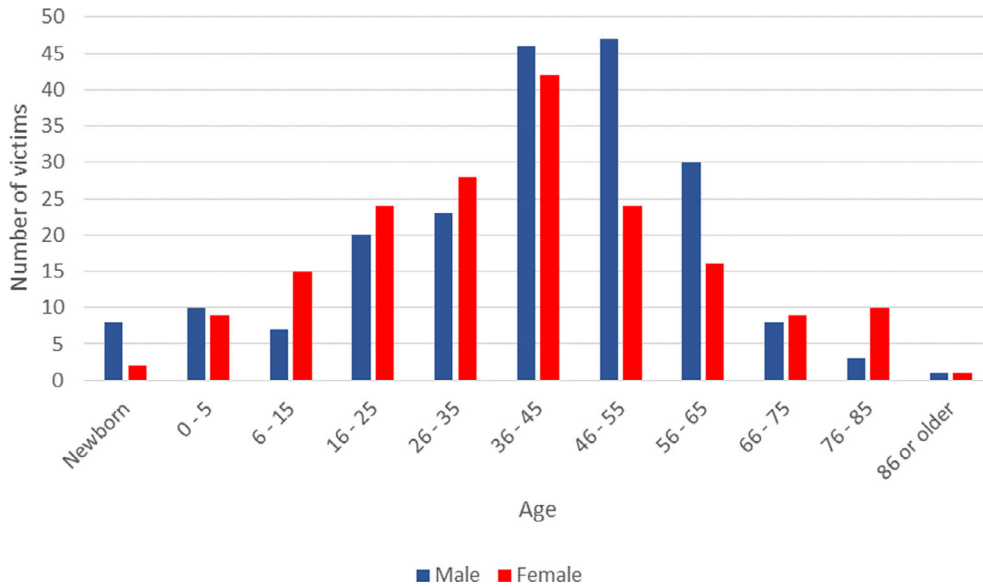


FIG. 1—Age and sex distribution of victims of homicidal asphyxia (n = 383). [Color figure can be viewed at wileyonlinelibrary.com]

cases some kind of ligature had been used, either alone or in connection with the manual strangulation. Smothering, choking, neck compression with a firm object, and thoracic compression were more rare methods. In five cases (1.3%) the forensic pathologist concluded that the death had ultimately been caused by the cardioinhibitory reflex cardiac arrest due to pressure of the neck. In eight cases (2.1%) the method of the asphyxia remained unclear, but the forensic pathologist had certified the death as homicidal asphyxia because of compelling circumstances for the homicide and after exclusion of other reasonable causes of death even though any external or internal findings of a mechanical asphyxia were not found at the autopsy. The percentages of different types of homicidal asphyxia methods are

shown in Fig. 2, and Table 1 illustrates the method by the victim's age.

In ligature strangulations (n = 131), the perpetrator had favored a strong material such as a belt, a rope, or an electric cord, which together made up to more than half (57.2%) of the ligatures used. Soft pieces of clothing such as a scarf, a necktie, or a pantyhose were used in 29.0% of the cases. When a body was brought to an autopsy, one out of four victims (24.4%, n = 32) still had the ligature around the neck.

Petechiae were recorded in 60.8% of all the 383 victims (Table 2). Among the cases of manual strangulation (n = 187), 26.2% of the victims showed conjunctival petechiae only, 6.9% in the conjunctivae and eyelids, and 21.4% also in the facial

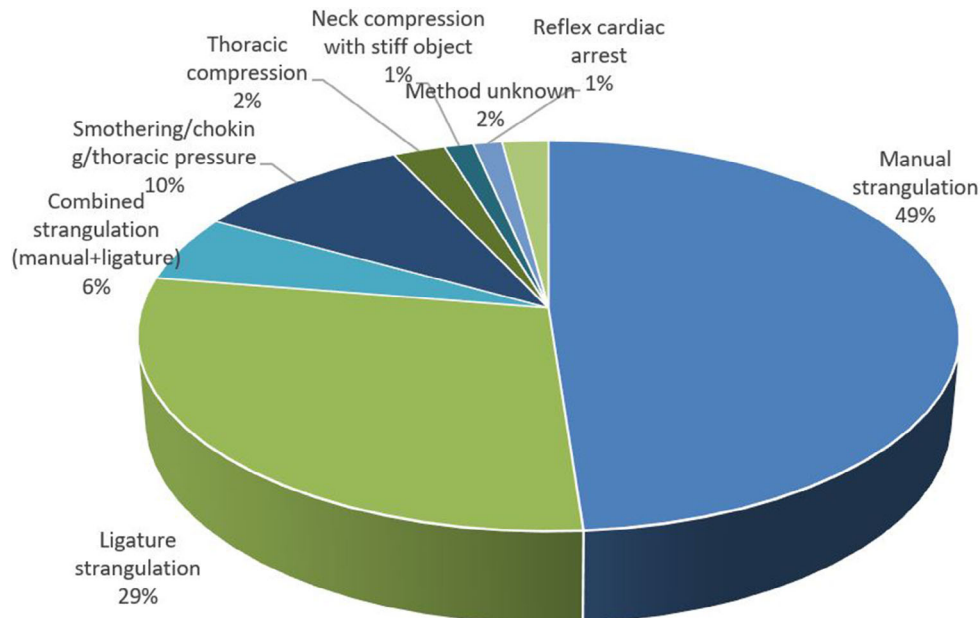


FIG. 2—The percentages of different types of methods used in asphyxia homicides (n = 383). [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 1—The number of different types of methods used in asphyxia homicides (n = 383) by age groups of the victims

	Manual Strangulation (n)	Ligature Strangulation (n)	Combined Strangulation (n)	Smothering or Choking (n)	Thoracic Pressure (n)	Neck Compression with Stiff Object (n)	Reflex Cardiac Arrest (n)	Method Unknown (n)
Newborn	1	1		3	2			3
0–5	3	4		11	1			
6–15	11	6		4				1
16–25	21	16	2	3			2	
26–35	25	16	5	2	2			1
36–45	45	31	5	4		1	1	1
46–55	40	16	5	5	1	3	1	
56–65	20	16	2	5	2		1	
66–75	13	3				1		
76–85	7	1	2		1			2
86 or older	1			1				

skin, whereas 40.1% of the cases had no petechiae mentioned in the autopsy protocol. Among the cases of ligature strangulation (n = 110), petechiae were reported in the conjunctivae only in 16.4% of the cases, in the conjunctivae and eyelids in 6.4%, and in the skin of the face in 37.3% of the cases, whereas 29.1% of the cases had no petechiae mentioned in the autopsy protocols. Two-thirds of the bodies (n = 22, of 32) with the ligature still in place at the time of the autopsy showed petechiae, whereas they were not mentioned in ten of those cases.

The autopsy protocol in 7.2% of the strangulation cases stated specifically that the neck dissection had been performed in a bloodless field. In the overwhelming majority of all the strangulation cases, cervical structures had been evaluated by a visual and palpatory examination and dissection *in situ*, and in 1.8% of the cases (n = 6) the laryngochoyoid complex had been dissected after its removal and formalin-fixation.

The gross autopsy findings of the strangulation cases (n = 318) are presented in Fig. 3.

Hemorrhages of the vocal cords were recorded in the autopsy protocol in 18.2% (n = 34, of 187) of the manual, 12.7% (n = 14, of 110) of the ligature, and 19.0% (n = 4, of 21) of the combined strangulation cases. Fractures of the thyroid cartilage, the hyoid bone, or both structures were detected in 46.8% (n = 149, of 318) of all strangulation cases. Fig. 4 shows the percentage of strangulation cases with vocal cord hemorrhages in connection with laryngochoyoid fractures and in relation to the victim's age.

In the available documents, cardiopulmonary resuscitation attempts were mentioned in connection of one in ten victims

(10.2%, n = 39), and an endotracheal intubation tube was recorded in the autopsy protocol in 28 of these. Hemorrhages of the vocal cords were found in six out of the 39 resuscitated cases.

Of all victims, 7.1% (n = 27) had no observable external injuries. The percentage of asphyxia homicides where the victim showed no injuries other than those related to the cause of death was 25.8% (60 male and 39 female victims), and in an additional 14.6% (24 male and 32 female victims) the findings were inconclusive as to their relation to the incident investigated. 59.5% of the victims (119 males and 109 females) had been subjected to additional types of violence (irrespective of the extent of the trauma), mainly blunt force (73.7%). Genital injuries were found in 5.0% of the victims (1 male and 18 females). More than one in ten victims (13.0%, n = 50) showed additional injuries inflicted with multiple methods.

Auxiliary Examinations

At autopsy, samples for additional examinations were retained in a large proportion of the cases. Toxicological analyses were performed in 95.6% (n = 366) of all the cases. Among these, 8.4% (n = 32) concerned alcohol only, whereas in 87.2% (n = 334) of the cases both alcohol and licit and/or illicit drugs were analyzed. Of the 332 adult victims, 96.4% (n = 320) were tested for alcohol and 72.5% of them (n = 232, of 320) tested positive. The blood alcohol concentration (BAC) levels in the peripheral blood ranged from 0.23 to 5.30 grams per liter, and in over half of the adult victims (56.9%, n = 189), BAC exceeded

TABLE 2—Recorded location of petechiae by method of asphyxia homicides

	No	%	Manual Strangulation (n = 187)	Ligature Strangulation (n = 110)	Combined Strangulation (n = 21)	Neck Compression with Stiff Object (n = 5)	Smothering (n = 29)	Thoracic Pressure (n = 9)	Choking (n = 9)	Reflex Cardiac Arrest (n = 5)	Method Unknown (n = 8)
Conjunctivae and eyelids	186	48.7	93	61	14	3	3	5	3	2	2
Oral mucosa	46	12.0	24	16	3	1	1		1		
Skin of the face	103	27.0	40	41	7		8	2	1	3	1
Skin of the upper neck	48	12.6	18	18	2		5	1	1	2	1
Petechiae	233	60.8	112 (59.9%)	78 (70.9%)	15 (71.4%)	3 (60.0%)	11 (37.9%)	5 (55.6%)	3 (33.3%)	4 (80.0%)	2 (25.0%)
No petechiae	150	39.2	75 (40.1%)	32 (29.1%)	6 (28.6%)	2 (40.0%)	18 (62.1%)	4 (44.4%)	6 (66.7%)	1 (20.0%)	6 (75.0%)

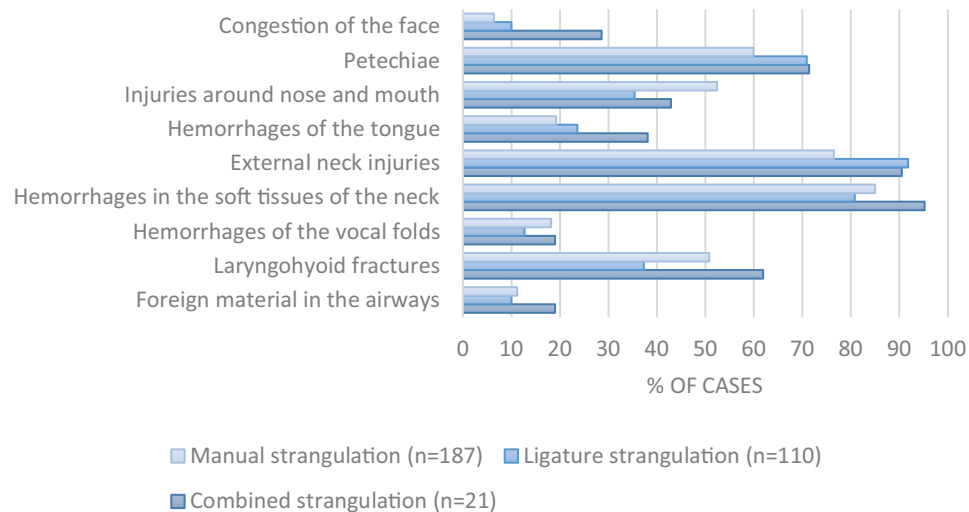


FIG. 3—Gross autopsy findings of the victims in cases of manual strangulation ($n = 187$), of ligature strangulation ($n = 110$), and of combination of manual and ligature strangulation ($n = 21$). [Color figure can be viewed at wileyonlinelibrary.com]

1.50 grams per liter. Male victims were three times more likely than female victims to have been under influence of alcohol with a BAC exceeding 2.0 grams per liter (34.0% and 11.5% of the cases, respectively). The distribution of the BACs detected is shown in Fig. 5.

Toxicological analyses for drugs other than alcohol were performed on 334 victims out of 383. Of these 13.5% ($n = 45$) tested positive for benzodiazepines ($n = 30$), cannabinoids ($n = 7$), opiates ($n = 4$), amphetamines ($n = 3$), and/or buprenorphine ($n = 1$). In addition, a number of licit drugs below toxic levels were encountered in the samples.

Sexual assault swabs were retained from 22.5% of the victims (70 females and 16 males). The samples were studied by microscopy only in 40 cases, and by microscopy and detection of acid phosphatase in 22 cases. Fifteen swabs were sent to the criminal laboratory for testing, and in further 9 cases, there was no mention of results in the files. Semen was detected in 13 of the 86 cases.

Discussion

Asphyxia Homicides in Finland

Previously in Finland, asphyxia homicides and their medico-legal investigations were never examined systematically. Several studies of such homicides have been published from other nations (9-14), but never with this scale and thoroughness. During the study period, the annual incidence of strangulation homicides per 100,000 population in Finland was 0.21. Since only a few other studies have reported the annual incidence, ranging from 0.17 in Jordan (9) to 0.90 in South Africa (13), comparisons of the incidence in other nations will not be discussed further.

Although relatively uncommon, the share of asphyxia as a homicide method in Finland was 9.7%. This share is similar to previous reports on strangulation deaths; 9% of homicides in Finland, Sweden and The Netherlands (15), 8.6% in Greece (16), and 7.4% in Jordan (9). However, substantially, higher percentage of the reported strangulations and suffocations of all homicides has, without any obvious explanation, been reported

in geographically and demographically close Nordic countries, Norway (20.5%) and Denmark (22.9%) (11).

Manual strangulations constituted half the number of the asphyxia homicides in Finland, analogous to studies in Norway and Denmark (11), Jordan (9), and Germany (12). The use of hands only as the lethal agent strengthens the assessment that strangulation homicides are often crimes of an opportunity without a premeditation.

In Finland, the sex distribution among victims of asphyxia homicides was almost even, which is close to rates reported from Jordan (9) but contrasts with most other authors demonstrating a clear female preponderance (10,11,13,16), and with a report from India reporting male dominance (17). This finding can at least partly reflect the significant role of alcohol in Finnish homicides since roughly one-fifth of the asphyxia homicides resulted from a drinking dispute—in which males in general are overrepresented. This is further strengthened by the observation that the distribution in different age groups shows a male preponderance in males' late middle age years, whereas a female preponderance can be seen among teenagers and elderly victims.

Asphyxia homicides are often associated with domestic disputes, and also in the current study the location of homicide was a domestic setting in two-thirds of the cases and two out of five victims were related to the perpetrator by birth, marriage, or common law. An intimate partner of the perpetrator made up one third of the adult victims. Among intimate partner homicides, the female victimization was undisputable with 89 female victims and 10 male victims.

Autopsy Findings

Asphyxia homicides can be difficult to discover as they do not always leave external injuries, which was observed in close to one in ten victims in this study. If an autopsy had not been performed due to another reason than a suspicion of a homicide, these homicides would presumably have remained undetected.

The pathological features of asphyxia are extensively described in the forensic medicine literature (18,19,20), and the frequent, albeit nonspecific, findings include cervico-facial

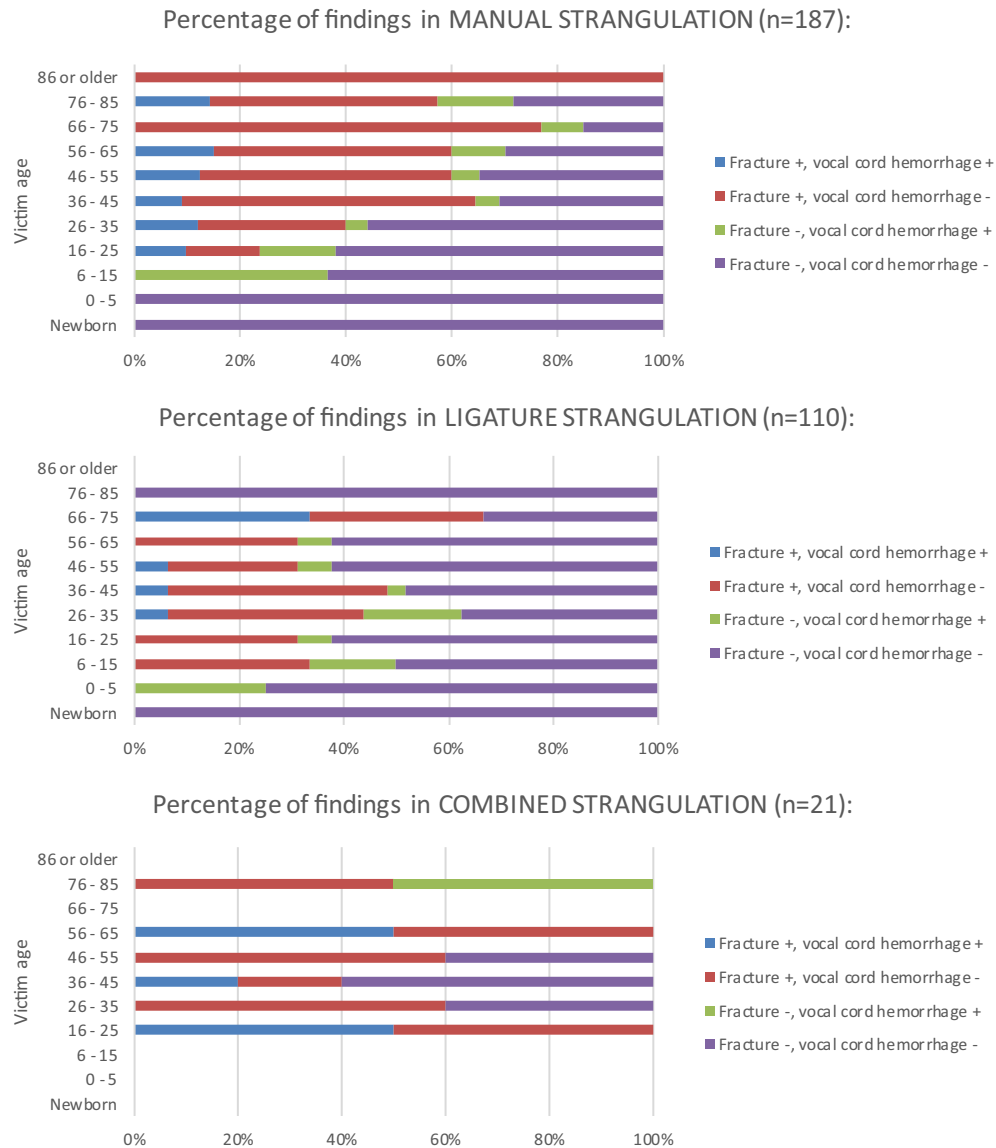


FIG. 4—Reported hemorrhages of the vocal cords and laryngochoyoid fractures in different age groups among strangulation homicide victims. [Color figure can be viewed at wileyonlinelibrary.com]

congestion. In cases with cervical compression external neck injuries, conjunctival, and facial petechiae (21), hemorrhages of the tongue, hemorrhages in soft tissues of the neck, and fractures in hyoid bone and/or thyroid cartilage are typical findings.

In the studied autopsy protocols, congested and dark blue face was explicitly described in only 10.0% of the ligature strangulation cases and in 6.4% of the manual strangulation cases. However, it appeared that a possible congestion was somewhat ignored by the forensic pathologists since, in the protocols, it was commented upon only as a positive finding whereas the majority of the documents did not give any indication of the presence or absence of this feature at all. Conjunctival and cutaneous petechiae were noted in almost two-thirds of all the victims. In contrast to earlier observations (10,20) they were slightly more common in strangulation cases involving ligature than in strangulations performed by hands only. There was no diagnostic difference in the presence of lingual hemorrhages that were observed in approximately one-fifth of the cases in both manual and ligature strangulations.

More than eight out of ten strangulation victims demonstrated bruises in the soft tissues of the neck. Laryngochoyoid fractures were present in almost half of the strangulation cases, more often in connection with a manual than with a ligature strangulation, which is in accordance with the observation of Ferris (22). In manual strangulations, a hyoid bone fracture was the most common finding, followed by a fracture of a single thyroid horn. In ligature strangulations, one-fifth of the victims presented a fracture of a single thyroid horn and in one-seventh of a hyoid bone, which is usually a rarer finding according to the literature (20). Bilateral fractures to the superior horns of the thyroid cartilage were observed in approximately one in ten cases and were slightly more common in manual than in ligature strangulation victims. In all strangulation cases, fractures of thyroid laminae and cricoid cartilage were rare. As expected due to the elasticity of larynx, no fractures in the laryngochoyoid complex were observed in the youngest victims of strangulation which is in accordance with findings reported earlier (17,23,24). However, fractures were observed quite frequently in older victims.

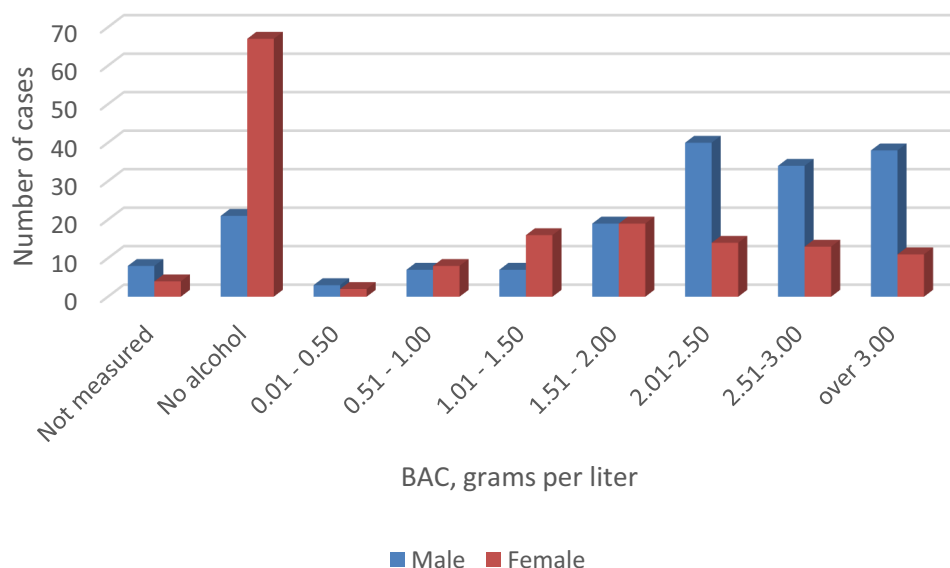


FIG. 5—Postmortem blood alcohol concentration (BAC) in victims >16 years of age ($n = 332$). [Color figure can be viewed at wileyonlinelibrary.com]

Laryngo-hyoid fractures were rarely associated with hemorrhages of the vocal folds. It is nonetheless important to note that these hemorrhages must be specifically looked for at the autopsy in order to detect them (12,25). Since also this feature was commented upon in the autopsy protocols only as a positive finding (whereas in many cases the state of the airways was just summarized as being “normal”), it leaves room for speculation if the sign had possibly been overlooked at the autopsy.

In a study of airway lesions caused by a resuscitative intubation, injuries to the mucosal surface of the larynx were observed in 64% of the cases (26). In the current material, only one out of five victims received professional medical care. An endotracheal intubation tube was present in 28 of 383 victims at the autopsy, and 6 of them had recorded vocal hemorrhages.

According to various recommendations (18,27-29), in cases where a neck trauma is suspected, a careful dissection of cervical structures should always be performed after a removal of the brain and thoracic organs. A detailed layer-by-layer dissection of soft tissues, neck musculature, and cartilaginous structures is necessary to identify hemorrhages and fractures. To enable an identification of small fissures and to avoid artificial hemorrhages in small muscles, a complete preparation of the laryngopharynx framework after formalin-fixation is recommended in cases of suspected strangulations (12,22,23,29,30). While the authors acknowledge that this formalin-fixation procedure is not routinely performed at least in the Nordic countries, it is recommended by the Council of Europe on the document on harmonization of medico-legal autopsy rules. In this study, the formalin-fixation procedure was explicitly commented upon in only six autopsy protocols (1.6%) but the ratio of found fractures was nevertheless high which can indicate that the above mentioned and recommended measures are not necessarily indispensable in revealing the lesions. On the other hand, the failure to apply the recommended autopsy techniques and to describe all the injuries accurately make some of the reported findings debatable. This in turn results in a level of uncertainty as to whether at least some of the fractures and/or hemorrhages mentioned in the protocols might have actually been artifacts due to suboptimal examination procedures and

misinterpretations of their ante mortem origin. This, of course, cannot be validated retrospectively but it does exemplify the need of standardized procedures, accurate documentation, and, quality controls.

Role of Alcohol

As seen in previous studies (5,15,31,32), homicides in Finland are often related to the use of alcohol, and alcohol proved to be a vast problem clearly associated with violent altercations between the perpetrators and adult victims, also in cases of asphyxia homicides. In the results of this present study, it also appears that harmful long-term drinking in homicide victimization is a common feature, since more than two out of five of the adult victims showed the evidence of chronic alcohol abuse. As expected, this was more common among men with a male-to-female ratio of 1:0.4.

In Finland, the forensic pathologists routinely retain samples for toxicological screening on homicide victims. In the great majority of the adult victims, this material was tested for blood alcohol with almost three out of four tested positive. The ratio of alcohol negative cases (27.5%) was substantially lower than in studies reported elsewhere. Rogde et al. (11) studied asphyxia homicides in two Nordic capitals, Oslo and Copenhagen, for a 10-year period and reported that no alcohol was detected in 33% of the male and in 49% of the female victims >10 years of age ($n = 111$). The report did not, however, state if the alcohol was screened in every case. A more detailed description of the homicide victim material (33), that the study of Rogde et al. was based on, revealed that toxicology screening was performed only in 46.8% of the Oslo homicide cases ($n = 156$) and in only 62.2% of the Copenhagen cases ($n = 275$). In a study from Johannesburg, South Africa (13), postmortem alcohol analyses were performed only in 31.7% of the mechanical asphyxiation homicides with 60.7% of tested male and 75.4% of tested female victims yielding no alcohol. When comparing the ratios, one must thus keep in mind that many reported results are evidently based on only a, possibly selected, fraction of the cases and should, accordingly, be assessed with great caution.

Sexual Assault Findings

In the study material, a sexual motive was identified in 21 cases with female victims (5.5% of all victims). According to Gill et al. (34) who studied the autopsy and sexual assault findings in cases of a homicidal neck compression of females, the number of victims with genital trauma was 5/77 (6.5%). In the present study, genital trauma was observed almost twice as often (10.0% of all female victims) implying that a sexual component in the violence inflicted on women in Finland is higher. Sexual assault swabs were retained from one out of five victims but semen was detected only in 15.1% of those cases.

In conclusion, the results in this study contribute significant data to further strengthen the spectrum of observable medico-legal characteristics of asphyxia homicides. While some of the features covered in the present study can be seen to reflect the national situation in Finland, most of the observations and autopsy findings can be applied to all asphyxia deaths. Moreover, the results strongly indicate that partial or total absence of some of the classic autopsy findings is quite common. This underlines the importance of thorough investigations and a comprehensive medico-legal autopsy of all suspicious deaths in order to reveal homicides that might otherwise remain undetected.

Strengths and Limitations of This Study

Previously, asphyxia homicides and their medico-legal investigation had never been examined systematically in Finland or elsewhere to this extent and detail. The solid statistical procedures, the rigorous legislation and the unusually high medico-legal autopsy rate in Finland combined with systematic postmortem toxicological analyses form a unique and extensive base for a systematic nationwide analysis of, among others, homicides, and the results of this study can be considered to be comprehensive and reliable. Since the investigative system also makes it probable that the overall number of undetected homicides in Finland is very low, the homicide rates can be considered particularly accurate (4). Since in almost one out of ten cases in the current study there was no suspicion of a crime prior to the autopsy and in more than one out of five cases the perpetrator had somehow attempted to conceal the offense, it is plausible that the proportion of undetected cases in countries with lower autopsy rates might be substantially higher distorting reported homicide figures. Comparisons with previous publications were further limited by the fact that very few previous studies have reported the incidence of different types of homicides.

The strength of this study lies in an exceptionally large study material covering an extended time period of 30 years of a whole nation. The cases were identified through multiple records and the material can, thus, be expected to include all asphyxia homicides that were diagnosed as such after a medico-legal autopsy. It is possible that there were a very few asphyxia cases where the forensic pathologist had not classified the manner of death as *homicide* but where the perpetrator had been convicted of such, and these cases are missing from the material (due to the theoretical failure of the forensic pathologist to introduce a corrected death certificate after conviction). As the information from the original documents was collected, categorized, and studied by only one person, there should be no significant variation in the consistency of the collection of the data in this study.

References

- Roser M, Ritchie H. Homicides - 2020. <https://ourworldindata.org/homicides> (accessed March 15, 2020).

- Finnish Law, Act 459/1973 and Statute 948/1973 (in Finnish).
- Penttilä A, Lahti RA, Lunetta P. Ruumiinavaustointa oikeusturvan ja klinisen hoidon laadun takeena [Autopsies as a guarantee of legal protection and quality of patient care]. *Duodecim* 1999;47:1524–30.
- Lunetta P, Lounamaa A, Sihvonen S. Surveillance of injury-related deaths: medicolegal autopsy rates and trends in Finland. *Inj Prev* 2007;13(4):282–4. <https://doi.org/10.1136/ip.2006.012922>.
- Wahlsten P, Koironen V, Saukko P. Survey of medico-legal investigation of homicides in the city of Turku, Finland. *J Forensic Leg Med* 2007;14(5):243–52. <https://doi.org/10.1016/j.jcfm.2006.07.007>.
- Lääkintöhallituksen yleiskirje N:o 1789 Kuolemansyyn selvittäminen [Health administration circular letter number 1789 cause of death investigation]. Helsinki, Finland: Valtion Painatuskeskus, 1982.
- Pounder DJ. Autopsy. In: Siegel J, Saukko P, editors. *Encyclopedia of forensic sciences*. San Diego, CA: Academic Press, 2000;1155–61.
- Saukko P, Knight B. editors. *The forensic autopsy*. In: Knight's forensic pathology, 3rd edn. London, UK: Arnold Publications, 2004;1–51.
- Abder-Rahman HA, Abu-Alrageb SY. Killing tools in mechanical asphyxia. *Leg Med* 1999;1(1):2–5. [https://doi.org/10.1016/S1344-6223\(99\)80002-9](https://doi.org/10.1016/S1344-6223(99)80002-9).
- DiMaio VJM. Homicidal asphyxia. *Am J Forensic Med Pathol* 2000;21(1):1–4. <https://doi.org/10.1097/00000433-200003000-00001>.
- Rogde S, Hougen HP, Poulsen K. Asphyxial homicide in two Scandinavian capitals. *Am J Forensic Med Pathol* 2001;22(2):128–33. <https://doi.org/10.1097/00000433-200106000-00004>.
- Maxeiner H, Bockholdt B. Homicidal and suicidal ligature strangulation – a comparison of the post-mortem findings. *Forensic Sci Int* 2003;137(1):60–6. [https://doi.org/10.1016/S0379-0738\(03\)00279-2](https://doi.org/10.1016/S0379-0738(03)00279-2).
- Suffla S, Seedat M. The epidemiology of homicidal strangulation in the City of Johannesburg South Africa. *J Forensic Leg Med* 2016;37:97–107. <https://doi.org/10.1016/j.jflm.2015.11.005>.
- Hlavaty L, Sung L. Strangulation and its role in multiple causes of death. *Am J Forensic Med Pathol* 2017;38(4):283–8. <https://doi.org/10.1097/PAM.0000000000000341>.
- Liem M, Ganpat S, Granath S, Hagstedt J, Kivivuori J, Lehti M, et al. Homicide in Finland, the Netherlands, and Sweden: first findings from the European homicide monitor. *Homicide Stud* 2013;17(1):75–95. <https://doi.org/10.1177/1088767912452130>.
- Fragkouli K, Boumba V, Vougiouklakis T. Survey of medico-legal investigation of homicide in the region of Epirus (Northwest Greece). *J Forensic Leg Med* 2016;37:39–44. <https://doi.org/10.1016/j.jflm.2015.10.003>.
- Verma SK, Lal S. Strangulation deaths during 1993–2002 in East Delhi (India). *Leg Med (Tokyo)* 2006;8(1):1–4. <https://doi.org/10.1016/j.legalmed.2005.06.004>.
- Pollanen MS. Subtle fatal manual neck compression. *Med Sci Law* 2001;41(2):135–40. <https://doi.org/10.1177/002580240104100209>.
- Saukko P, Knight B. editors. Suffocation and ‘asphyxia’. In: Knight's forensic pathology, 3rd edn. London, UK: Arnold Publications, 2004;353–7.
- Keil W, Lunetta P, Vann R, Madea B. Injuries due to asphyxiation and drowning. In: Madea B, editor. *Handbook of forensic medicine*. Chichester, U.K.: Wiley-Blackwell, 2014;367–411.
- Ely SF, Hirsch CS. Asphyxial deaths and petechiae: a review. *J Forensic Sci* 2000;45(6):1274–7.
- Ferris JAJ. Asphyctic deaths. In: Siegel J, Saukko P, editors. *Encyclopedia of forensic sciences*. San Diego, CA: Academic Press, 2000;308–15.
- Pollanen MS, Chiasson DA. Fracture of the hyoid bone in strangulation: comparison of fractured and unfractured hyoids from victims of strangulation. *J Forensic Sci* 1996;41(1):110–3.
- Fieguth A, Albrecht U-V, Bertolini J, Kleemann WJ. Intracartilaginous haemorrhagic lesions in strangulation? *Int J Legal Med* 2003;117(1):10–3. <https://doi.org/10.1007/s00414-002-0300-4>.
- Maxeiner H. “Hidden” laryngeal injuries in homicidal strangulation: how to detect and interpret these findings. *J Forensic Sci* 1998;43(4):784–91.
- Raven KP, Reay DT, Harruff RC. Artfactual injuries of the larynx produced by resuscitative intubation. *Am J Forensic Med Pathol* 1999;20(1):31–6. <https://doi.org/10.1097/00000433-199903000-00008>.
- Jaffe FA. Manual strangulation: the pathologist's perspective. *Legal Med Q* 1978;2:126–8.
- The National Board of Forensic Medicine. Principles and procedures of forensic autopsy – bases for national guidelines. Stockholm, Sweden: Rättsmedicinaverket, 1994;26–31.
- Council of Europe, Recommendation No. R (99) 3 of the Committee of Ministers to Member States on the Harmonisation of Medico-legal Autopsy Rules, 1999. [https://www.coe.int/t/dg3/healthbioethic/texts_and_documents/RecR\(99\)3.pdf](https://www.coe.int/t/dg3/healthbioethic/texts_and_documents/RecR(99)3.pdf) (accessed March 15, 2020).

30. Khokhlov VD. Trauma to the hyoid bone and laryngeal cartilages in hanging: Review of forensic research series since 1856. *Leg Med* 2015;17(1):17–23. <https://doi.org/10.1016/j.legalmed.2014.09.005>.
31. Lunetta P, Penttilä A, Sarna S. The role of alcohol in accident and violent deaths in Finland. *Alcohol Clin Exp Res* 2001;25(11):1654–61. <https://doi.org/10.1111/j.1530-0277.2001.tb02172.x>.
32. Savolainen J, Lehti M, Kivivuori J. Historical origins of a cross-national puzzle. Homicide in Finland, 1750 to 2000. *Homicide Stud* 2008;12(1):67–89. <https://doi.org/10.1177/1088767907311850>.
33. Hougen HP, Rogde S, Poulsen K. Homicides in two Scandinavian capitals. *Am J Forensic Med Pathol* 1999;20(3):293–9. <https://doi.org/10.1097/0000433-199909000-00015>.
34. Gill JR, Cavalli DP, Ely SF, Stahl-Herz J. Homicidal neck compression of females: autopsy and sexual assault findings. *Acad Forensic Pathol* 2013;3(4):454–7. <https://doi.org/10.1097/10.23907/2013.055>.

Appendix 1

List of variables studied for each case of asphyxia homicides in Finland 1983–2012.

General information

- Scene of the crime
- Region and province
- Date and time
- Medical treatment of the victim
- Uncovering the crime in respect to autopsy
- Location of the body
- Relocating of the body
- Hiding of the body
- Disposal of the body
- Signs of attempted staging
- Place of death if different to the scene of the crime
- Ligature present at discovery
- Type of possible ligature used
- Estimated motive

Appendix 1 Continued.

- Number of killed victims in one incident
- Existence of report of external examination by a physician prior to autopsy
- Victim
 - Age
 - Sex
 - Marital status
 - Known alcohol abuse
 - Kinship with the perpetrator
 - Other relationship with the perpetrator
- Perpetrator
 - Sex
- Autopsy
 - Date of performance
 - Underlying cause of death
 - Conditions contributory to death
 - Was there evidence for only a single act of violence
 - Samples retained
 - Additional examinations performed and documented
 - Alcohol concentration in blood
 - Other significant findings in toxicology
 - Cause of asphyxia
 - Ligature present at autopsy?
 - Endotracheal intubation tube present at autopsy?
 - Observable external injuries
 - Presence and location of petechial hemorrhages
 - External injuries in the neck
 - Injuries around the mouth and/or nostrils
 - Bruises in the neck tissues
 - Means of investigating neck organ complex
 - Fractures of the thyroid cartilage
 - Fractures of the hyoid bone
 - Fractures of the cricoid cartilage
 - Hemorrhages of the vocal folds
 - Existence and type of additional injuries
 - Sexual assault testing
