Neuropathological Changes in the Brains of Suicide Killers

Subjects: Pathology

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Homicide combined with subsequent suicide of the perpetrator is a particular form of interpersonal violence and, at the same time, a manifestation of extreme aggression directed against oneself. Despite the relatively well-described individual acts of homicide and suicide, both in terms of psychopathology and law, acts of homicide and subsequent suicide committed by the same person are not well-studied phenomena. The importance of emotional factors, including the influence of mental state deviations (psychopathology), on this phenomenon, is discussed in the literature, but still there is relatively little data with which to attempt neuropathological assessments of the brains of suicide killers.

homicide suicide murderer's brain murder–suicide extended suicide neuropathological changes neurodegenerative changes

1. Introduction

A homicide followed by suicide by the perpetrator is most commonly referred to in the literature as a "murder–suicide" or an "extended suicide". The number of such cases has remained stable over time and across populations, ranging from 0.05 to 0.3 per populations of 100,000. It is a phenomenon that is classified both as suicide and as homicide, however, it also has separate, distinguishing characteristics that are different from such acts committed individually. As studies show, the perpetrators of murder–suicide are men in 80–90% of cases, and the victims are women (70–80%) and children [1][2][3]. In order not to introduce terminological ambiguity, we have assumed that the term "murder–suicide" used in this paper refers to a particular type of homicide that occurs as a result of a deliberate and planned action. The term "murder–suicide", in legal terms, would allow for the possibility of an unintentional homicide, as well as the consideration of prosecuting the perpetrator in a criminal trial, which is not usually the case here [4][5]. Among the characteristic types of murder–suicide are: those that are causally related to the disclosure of (1) anger and paranoia; (2) fear of detection; (3) an act of terrorism (suicide bombers), in which suicide is, as it were, "incidental" to the crime [6]. There is relatively little data on the extent to which psychopathological and neurobiological factors, specifically the ones related to organic brain damage in perpetrators, remain associated with impaired emotion control, inhibition, and impulse control. Isolated studies only indicate that among murderers and perpetrators of attempted murders diagnosed with Acute Stress Disorder (ASD) or Posttraumatic Stress Disorder (PTSD) during the act committed, approximately 75% were much more often diagnosed in neuroimaging examinations with frontal lobe atrophy, rather than with temporal lobe atrophy. It was also observed that the ratio of subcortical to cortical atrophy is twice as high, which may be related to the non-

accidentally close proximity to the limbic system, which is essential for initiating neurobiological responses to stress [7]. There is insufficient research to support the importance of chronic stress response and neurohormonal, catecholaminergic, inflammatory, and immunosuppressive consequences in motivation and decision-making processes among suicide killers [8]. It is estimated that approximately 25–65% of those who committed murder–suicide had been previously diagnosed with some mental disorder and in most cases this was depression [9]. Some researchers suggest depression with psychotic symptoms [10]. Due to the above characteristics, it is indicated [11] that perpetrators of murder–suicide are more similar to those who commit suicide. However, other authors [12] divide the perpetrators of these acts into two groups: one group with a diagnosis of depression (closer to people who commit suicide) and another group with a history of domestic violence and substance abuse (and therefore closer to perpetrators of murders). Hillebrand [8] points to the possible predominance of biological factors in the aetiology of such events. He refers to the “serotonin-aggression” hypothesis [13], according to which decreased activity of the serotonergic system releases the inhibition of aggression. Examinations of the brains of individuals with a history of aggressive and antisocial behaviour allowed neuroanatomical changes throughout the brain to be described, included amongst which were decreased prefrontal cortex, temporal lobe, and amygdala, and an increased volume of putamen in basal ganglia. An increase in the volume of putamen was attributed to neurodevelopmental disorders, with implications for behavioural disorders, positing that the putamen is involved in an inhibitory mechanism [14]. In addition, a study by Laakso and colleagues demonstrated a negative correlation between antisocial traits and the volume of prefrontal cortex, hippocampus, and amygdala, as well as an increase in impulsiveness and predisposition to aggressive behavior [15]. Significantly smaller volumes of white matter in the frontal lobe in patients diagnosed with schizophrenia-like psychosis, compared to healthy individuals, may be associated with the features of demyelination described in neuropathological studies and a reduced number of oligodendrocytes responsible, among others, for regulating glutamate concentration [16]. For this study we have conducted an analysis of the literature and drawn on our clinical experience and observation of the behaviour of people with behavioural disorders (experience of psychiatric experts). Initiating our study, we asked ourselves whether there were neuropathological changes in the central nervous system in suicidal murderers that could be linked to endo- and/or exogenous factors influencing behaviour at the time of the incident.

2. Current Insights

The results indicate the existence of neuropathological changes in the brains of the perpetrators of murder–suicide. The analysed material came from the frontal, parietal, occipital, and temporal lobes with the Brodmann area 28, basal ganglia, midbrain, and, in some cases, from the mammillary body and cerebellum. The study group was diverse in terms of age, education, social status, as well as the type of murder and suicide commit-ted. Nevertheless, in 50% of the histologically stained brain sections, there was evidence of neurodegenerative changes in the form of senile plaques in the cerebral cortex, as well as the presence of the initial stage of neurofibrillary degeneration.

Immunohistochemical reaction to ß-amyloid also revealed multiple deposits of this protein in the studied cortex sections in the form of senile/amyloid plaques and perivascular diffuse plaques. The changes described are found

in the clinical picture of neurodegenerative diseases, such as Alzheimer's disease, in which there is cognitive impairment. Importantly, the clinical data excluded information that the subjects had a family history of Alzheimer's disease. The clinical picture of neurodegenerative diseases may include behavioural disorders, depressive symptoms, agitation, sometimes leading to aggression. Studies indicate that delusional disorders (Capgras syndrome) may accompany Alzheimer's disease in up to 73% of cases, and hallucinations in nearly 49% of cases [17][18][19]. The formation of abnormal forms of ß-amyloid occurs almost throughout human life, but the mechanisms responsible for maintaining them at non-toxic levels are among the major factors involved in the pathogenesis of Alzheimer's disease [20]. The presence of numerous senile plaques is observed in the brains of elderly people, over the age of 65. However, in our study these changes were observed in subjects at much younger ages of 33, 34, 58, and 60 years. In the literature, the link between impulse dyscontrol and atrophy patterns of AD has been described in several publications [21][22][23]. Our findings are in line with previous observations, supporting the influence of the process of atrophy in the crucial brain regions on behavior and impulse control.

Very important in the accumulation of abnormal peptide deposits seems to be the system responsible for removing metabolic waste products from the brain, which is de-void of lymphatic vessels. In the central nervous system, this is the role of the glymphatic system [24]. An important role in this waste clearance system, involving the transport of cerebrospinal fluid along with pathological substances, is played by astrocytes and the aquaporin 4 expressed by the processes in which they are involved [25]. In all the brain fragments studied, significant damage to the astrocytes, which mainly affected their processes, was also observed, suggesting a possible malfunction of the glymphatic system. In two cerebellums out of three studied, an attenuated immunohistochemical response to calbindin (CaBP, a calcium-binding protein) was observed [26]. Ca^{2+} is a unique ion that is involved in many important physiological processes, including the functioning of neurons and astrocytes [27][28]. Calcium ions regulate the release and synthesis of neurotransmitters, hormones, axonal transport, control of enzymatic re-actions, gene transcription, and many other processes throughout the course of human life, starting from the prenatal development period [29][30]. The findings of the study of this non-statistical amount of material are only an indication of future research goals. No significant changes in immunohistochemical expression compared to the control group were observed for the glutamate transporter of neuronal origin (GLAST) and the glutamate transporter of glial origin (GLT1), which does not exclude the involvement, especially with the observed chronic neuronal damage, of the existence of synaptic glutamate deficiencies leading—as in schizophrenia—to psychiatric disorders [31].

The normal expression of serotonin 5-HT2A in cortical neurons, in seven out of eight brains studied, may tentatively support the theory of researchers at the Baker Heart Re-search Institute in Melbourne (Australia) and the researchers at Wayne State University (USA), who maintain that depression or panic disorder (panic anxiety) can go hand in hand with an increase rather than a decrease in serotonin levels [32]. According to some researchers, there are certain groupings of serotonin neurons in the brain that are over-active in people suffering from depression [33]. Interestingly, features of increased impulsivity were observed in analyses of symptoms of depressive disorders [34]. Clinically, drugs affecting serotonergic transmission can be used in the prevention of impulsive and aggressive behavior [35][36]. In contrast, the generalised oedema and ischemic neuronal

degeneration observed in the brain sections we studied should be associated with the direct cause of death in patients, complicated by brain ischaemia and/or hyperaemia and hypoxia.

Referring to the literature, the most frequent type of murder among suicide killers is the murder of a sexual partner with whom the perpetrator was in a relationship. Murderers are most often men who kill their female partners. It is almost unheard of for a woman to be the killer who takes her own life after a murder [37][38]. In the motivation process of women's crimes against their partners, one can find relationships where, prior to murder, women remained in the role of deeply tormented victims embedded in the reality of an attitude of acceptance of violence, and thus the sense of guilt after the act was diminished to such an extent that it was not a factor pushing them to suicide [39][40]. In the literature, murder with subsequent suicide is also referred to as dyadic death or post-aggression suicide [41][42][43]. Descriptions of murder–suicide perpetrators usually present the perpetrator as a middle-aged man and often under the influence of alcohol during the act. The analysis of the perpetrator's motivation processes most often focuses on the features of abnormal personality and the particular pressure of psychosocial stressors in the form of partnership conflicts, erotic jealousy, or financial difficulties [44][45][46][47][48]. Sometimes, especially when the homicide itself is exceptionally brutal, psychotic symptoms associated with exacerbation of mental illness or treatment interruption are identified in perpetrators [49]. Unfortunately, we cannot trace the motivational process and ascertain possible mental disorders in our study group because, due to the retrospective nature of the study protocol, we did not collect medical or behavioral data on the perpetrators. Undoubtedly, in subsequent studies such correlations and tracking of relationships would be extremely interesting.

References

1. Marzuk, P.M.; Tardiff, K.; Hirsch, C.S. The epidemiology of murder-suicide. JAMA 1992, 267, 3179–3183.
2. Zimmermann, M.; Tsokos, M. Typology of murder-suicides in Berlin according to a longitudinal study based on autopsy files. Forensic Sci. Med. Pathol. 2021, 17, 247–253.
3. Eliason, S. Murder-suicide: A review of the recent literature. J. Am. Acad. Psychiatry Law 2009, 37, 371–376.
4. Milroy, C.M.; Drastas, M.; Ranson, D. Homicide–suicide in Victoria, Australia. Am. J. Forensic Med. Pathol. 1997, 18, 369–373.
5. Liem, M.; Roberts, D.W. Intimate Partner Homicide by Presence or Absence of a Self-Destructive Act. Homicide Stud. 2009, 13, 339–354.
6. Belfrage, H.; Rying, M. Characteristics of spousal homicide perpetrators: A study of all cases of spousal homicide in Sweden 1990–1999. Crim. Behav. Ment. Health 2004, 14, 121–133.
7. Heitzman, J. Stres w Etiologii Przestępstw Agresywnych. ; Wydawnictwo Uniwersytetu Jagielońskiego: Kraków, Poland, 2002.

8. Tanaka, M.; Tóth, F.; Polyák, H.; Szabó, Á.; Mándi, Y.; Vécsei, L. Immune Influencers in Action: Metabolites and Enzymes of the Tryptophan-Kynurenine Metabolic Pathway. Biomedicines 2021, 9, 734.
9. Roma, P.; Pazzelli, F.; Pompili, M.; Lester, D.; Girardi, P.; Ferracuti, S. Mental illness in homicide-suicide: A review. J. Am. Acad. Psychiatry Law 2012, 40, 462–468.
10. Flynn, S.; Gask, L.; Appleby, L.; Shaw, J. Homicide-suicide and the role of mental disorder: A national consecutive case series. Soc. Psychiatry Psychiatr. Epidemiol. 2016, 51, 877–884.
11. Hillbrand, M. The Oxford Handbook of Behavioral Emergencies and Crises; Kleespies, P.M., Ed.; Oxford University Press: New York, NY, USA, 2017; Volume XIX, pp. 215–226.
12. Flynn, S.; Gask, L.; Shaw, J. Newspaper reporting of homicide-suicide and mental illness. BJPsych Bull. 2015, 39, 268–272.
13. Coccaro, E.F.; Kavoussi, R.J.; Hauger, R.L. Physiological responses to d-fenfluramine and ipsapirone challenge correlate with indices of aggression in males with personality disorder. Int. Clin. Psychopharmacol. 1995, 10, 177–179.
14. Barkataki, I.; Kumari, V.; Das, M.; Taylor, P.; Sharma, T. Volumetric structural brain abnormalities in men with schizophre-nia or antisocial personality disorder. Behav. Brain Res. 2006, 169, 239–247.
15. Laakso, E.; Hakko, H.; Räsänen, P.; Riala, K. Suicidality and unhealthy weight control behaviors among female underaged psychiatric inpatients. Compr. Psychiatry 2013, 54, 117–122.
16. Mighdoll, M.I.; Tao, R.; Kleinman, J.E.; Hyde, T.M. Myelin, myelin-related disorders, and psychosis. Schizophr. Res. 2015, 161, 85–93.
17. Kaufman, K.R.; Newman, N.B.; Dawood, A. Capgras delusion with violent behavior in Alzheimer dementia: Case analysis with literature review. Ann. Clin. Psychiatry 2014, 26, 187–191.
18. Mega, M.S.; Cummings, J.L.; Fiorello, T.; Gornbein, J. The spectrum of behavioral changes in Alzheimer’s disease. Neurology 1996, 46, 130–135.
19. Wragg, R.E.; Jeste, D.V. Overview of depression and psychosis in Alzheimer’s disease. Am. J. Psychiatry 1989, 146, 577–587.
20. Bartoszewska, M. Molecular mechanisms of Alzheimer disease. Postępy Biologii Komórki 2008, 3, 333–350.
21. Gill, S.; Wang, M.; Mouches, P.; Rajashekar, D.; Sajobi, T.; MacMaster, F.P.; Smith, E.E.; Forkert, N.D.; Ismail, Z. Alzheimer’s Disease Neuroimaging Initiative. Neural correlates of the impulse dyscontrol domain of mild behavioral impairment. Int. J. Geriatr. Psychiatry 2021, 36, 1398–1406.

22. Trzepacz, P.T.; Yu, P.; Bhamidipati, P.K.; Willis, B.; Forrester, T.; Tabas, L.; Schwarz, A.J.; Saykin, A.J. Alzheimer's Disease Neuroimaging Initiative. Frontolimbic atrophy is associated with agitation and aggression in mild cognitive impairment and Alzheimer's disease. Alzheimer's Dement. 2013, 9 (Suppl. 5), S95–S104.
23. Hu, X.; Meiberth, D.; Newport, B.; Jessen, F. Anatomical correlates of the neuropsychiatric symptoms in Alzheimer's disease. Curr. Alzheimer Res. 2015, 12, 266–277.
24. Plog, B.A.; Nedergaard, M. The Glymphatic System in Central Nervous System Health and Disease: Past, Present, and Future. Annu. Rev. Pathol. 2018, 13, 379–394.
25. Nagelhus, E.A.; Ottersen, O.P. Physiological Roles of Aquaporin-4 in Brain. Physiol. Rev. 2013, 93, 1543–1562.
26. Heizmann, C.W.; Braun, K. Changes in Ca2+-binding proteins in human neurodegenerative disorders. Trends Neurosci. 1992, 15, 259–264.
27. Lledo, P.M.; Somasundaram, B.; Morton, A.J.; Emson, P.C.; Mason, W.T. Stable transfection of calbindin-D28k into the GH3 cell line alters calcium currents and intracellular calcium homeostasis. Neuron 1992, 9, 943–954.
28. Røttingen, J.; Iversen, J.G. Ruled by waves? Intracellular and intercellular calcium signalling. Acta Physiol. Scand. 2000, 169, 203–219.
29. Laure-Kamionowska, M.; Maślińska, D. Calbindin positive Purkinje cells in the pathology of human cerebellum occurring at the time of its development. Folia Neuropathol. 2009, 47, 305.
30. Parent, A.; Fortin, M.; Côté, P.Y.; Cicchetti, F. Calcium-binding proteins in primate basal ganglia. Neurosci. Res. 1996, 25, 309–334.
31. Ganel, R.; Rothstein, J.D. Glutamate transporter dysfunction and neuronal death. In Ionotropic Glutamate Receptors in the CNS; Monyer, H., Gabriel, A., Eds.; Springer: Berlin, Germany, 1999; pp. 472–493.
32. Barton, D.A.; Esler, M.D.; Dawood, T.; Lambert, E.A.; Haikerwal, D.; Brenchley, C.; Socratous, F.; Hastings, J.; Guo, L.; Wiesner, G.; et al. Elevated brain serotonin turnover in patients with depression: Effect of genotype and therapy. Arch. Gen. Psychiatry 2008, 65, 38–46.
33. Paul, E.D.; Johnson, P.L.; Shekhar, A.; Lowry, C.A. The Deakin/Graeff hypothesis: Focus on serotonergic inhibition of panic. Neurosci. Biobehav. Rev. 2014, 46 Pt 3, 379–396.
34. Gosek, P.; Heitzman, J.; Stefanowski, B.; Antosik-Wójcińska, A.Z.; Parnowski, T. Symptomatic differences and symptoms stability in unipolar and bipolar depression. Medical charts review in 99 inpatients. Psychiatr. Polska 2019, 53, 655–672.
35. Völlm, B.A.; Clarke, M.; Herrando, V.T.; Seppänen, A.O.; Gosek, P.; Heitzman, J.; Bulten, E. European Psychiatric Association (EPA) guidance on forensic psychiatry: Evidence based

assessment and treatment of mentally disordered offenders. Eur. Psychiatry 2018, 51, 58–73.

36. Heitzman, J.; Gosek, P.; Luks, M.; Pilszyk, A.; Kotowska, J.; Pacholski, M. Implementation of the European Psychiatric Association (EPA) guidance on forensic psychiatry in Poland. Current state and required measures. Psychiatr. Polska 2020, 54, 553–570.
37. Swatt, M.; He, N. Exploring the Difference Between Male and Female Intimate Partner Homicides: Revisiting the Concept of Situated Transactions. Homicide Stud. 2006, 10, 279–292.
38. Harper, D.W.; Voigt, L. Homicide Followed by Suicide: An Integrated Theoretical Perspective. Homicide Stud. 2007, 11, 295–318.
39. McCarthy, K.J.; Mehta, R.; Haberland, N.A. Gender, power, and violence: A systematic review of measures and their association with male perpetration of IPV. PLoS ONE 2018, 13, e0207091.
40. Mojahed, A.; Alaidarous, N.; Kopp, M.; Pogarell, A.; Thiel, F.; Garthus-Niegel, S. Prevalence of Intimate Partner Violence among Intimate Partners During the Perinatal Period: A Narrative Literature Review. Front. Psychiatry 2021, 12, 601236.
41. Liem, M.; Barber, C.; Markwalder, N.; Killias, M.; Nieuwbeerta, P. Homicide–suicide and other violent deaths: An international comparison. Forensic Sci. Int. 2011, 207, 70–76.
42. Milroy, C.M. The epidemiology of homicide-suicide (dyadic death). Forensic Sci. Int. 1995, 71, 117–122.
43. Gillespie, M.; Hearn, V.; Silverman, R.A. Suicide Following Homicide in Canada. Homicide Stud. 1998, 2, 46–63.
44. LeComte, D.; Fornes, P. Homicide followed by suicide: Paris and its suburbs, 1991–1996. J. Forensic Sci. 1998, 43, 760–764.
45. Milroy, C.M. Reasons for homicide and suicide in episodes of dyadic death in Yorkshire and Humbershire. Med. Sci. Law 1995, 35, 213–217.
46. Brown, M.; Barraclough, B.M. Suicide preceded by murder: The epidemiology of homicide–suicide in England and Wales 1988–92. Psychol. Med. 2002, 32, 577–584.
47. Haines, J.; Williams, C.H.L.; Lester, D. Murder-suicide: A reaction to interpersonal crisis. Forensic Sci. Int. 2010, 202, 93–96.
48. Holland, M.; Brown, S.V.; Hall, J.E.; Logan, J.E. Circumstances preceding homicide-suicides involving child victims: A qual-itative analysis. J. Interpers. Violence 2018, 33, 379–401.
49. Coid, J. The epidemiology of abnormal homicide and murder followed by suicide. Psychol. Med. 1983, 13, 855–860.