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Review

Epileptic seizures and criminal acts: Is there a relationship?☆

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ABSTRACT

Background: The relation between epilepsy and criminal acts has been debated for over a century. The general perception persists that epileptic seizures can be associated with violent behavior. Some studies have provided evidence for such an association; however, it remains uncertain whether it really exists. This review critically evaluates the scientific literature on the possible relation between epileptic seizures and criminal acts.
Methods: A PubMed search was undertaken using the search terms "epilepsy and crime", "epilepsy and automatism", "epilepsy and law", and "epilepsy and dyscontrol syndrome" with the aim of identifying studies examining the possible association between epileptic seizure and crime.
Results: The combined keywords "epilepsy and crime" yielded 495 articles, the keywords "epilepsy and automatism" 402 results, the keywords "epilepsy and law" 969 articles, and the keywords "epilepsy and dyscontrol syndrome" resulted in 22 search results. After removing publications such as reviews and opinion pieces, we identified and analyzed a total of 24 research articles with relevant original data. These included single case reports. The reviewed literature suggests that there are very rare occasions when criminal acts are committed during the ictal or postictal period, mostly by patients with focal epilepsy.
Conclusion: The literature on the relation between epileptic seizures and criminal acts is not conclusive. Behavioral disturbances often seem more closely related to comorbidities of epilepsy than particular seizures characteristics. These comorbidities are often not well-described. There is an urgent need for more systematic and detailed data gathering and reporting, in order to allow a more detailed investigation of the relation between epileptic seizures and criminal acts.

1. Introduction

The question of a possible association between criminal acts and epileptic seizures is of critical importance. If such an association exists, seizures may be considered as a defense or mitigating factor in criminal trials. If it does not, the stigmatizing characterization of individuals with epileptic seizure as being prone to violent or other criminal behavior needs to be revised. The notion that epileptic seizures may be linked to aggressive behavior and crimes of violence dates back at least as far as the late nineteenth and early twentieth century, especially to the writings of the Italian Professor of Psychiatry and Criminal Anthropology Cesare Lombroso [1]. However, a link between epileptic seizure and violence was also made around the same time by Hughlings Jackson, still considered as one of the founding fathers of epileptology. In 1875, Jackson published an article entitled "On temporary mental disorders after epileptic paroxysm" in which he described a patient with epilepsy who exhibited episodes of violent behavior [2]. These two influential figures played a key role in shaping the idea that epilepsy/epileptic seizures are associated with violent and criminal behavior, which may have contributed to negative perceptions of epilepsy in the general population as well as within the medical community, and which persist to the present time [3,4].

However, is there any clear evidence of an association between criminal behavior and epileptic seizures? In order to address this question, we undertook a review of the scientific literature.

2. Methods

A PubMed search (May 2019) was carried out using the search terms "epilepsy and crime", "epilepsy and automatism", "epilepsy and law", and "epilepsy and dyscontrol syndrome" with the aim of identifying studies examining the possible association between epilepsy and crime. No time restraint was set. The search focused solely on articles in English. Further publications (in English) were identified through a manual search of references cited in papers initially identified. Only original research articles published in peer-reviewed journals was considered for our analysis. Articles that discussed the data of other authors,

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such as review papers or opinion pieces, were excluded. We included only original papers, case reports and series that investigated the potential relation between epileptic seizures and criminal acts. Research results only published or accessible in abstract form were not considered. We excluded articles on epilepsy and suicide, because we considered suicide as a violent act against the self, while our article's main objective was to investigate possible epilepsy-associated violence toward third parties or objects. Demographic (Table 1) and clinical data (Table 2) relating to patients described in these papers were extracted and tabulated. As the quality of the reporting of clinical data in the studies identified was variable and not all data of interest were provided in many publications, quantitative analyses were not feasible. When no information was available on variables of interest, the lack of data was recorded as "Not Mentioned" in the tabulated overview. For presentational purposes, we grouped the tabulated data into studies that found an association between epileptic seizures and crime and those that did not find such an association. When studies reported an association between epileptic seizures and crime, the precise timing of the criminal behavior in relation to epileptic seizures was extracted (i.e., whether the behavior occurred in the pre-, intra-, or postictal period; Table 2). The most representative studies were selected and summarized separately in the Results section (studies discussing dyscontrol syndrome, epilepsy, and crime were regrouped and presented in the Results section). Since our article is a review, and all papers cited used the pre-2017 terminology/classification of epileptic seizures, we felt that it would be misleading to attempt to "translate" the terminology to that suggested in the latest version of the International League Against Epilepsy (ILAE) classification of epilepsy and seizure types. Instead we largely use the terminology employed by the authors of the original reports we discuss.

3. Results

The combined keywords "epilepsy and crime" yielded 495 articles, the keywords "epilepsy and automatism" 402 results, the keywords "epilepsy and law" 969 articles, and the keywords "epilepsy and dyscontrol syndrome" 22 search results. A more focused search placing the index word in quotation marks and using "AND" in capitalized form yielded fewer articles; "epilepsy" AND "crime" yielded 137 articles, "epilepsy" AND "automatism" 400 articles, "epilepsy" AND "law" 328 articles, and "epilepsy" AND "dyscontrol syndrome" 17 articles. Fig. 1 illustrates our search strategy. The majority of articles used the term "epilepsy" in the title. This resulted in the high number of initial search results. However, only a small number of articles included original data and addressed the relationship between epilepsy/epileptic seizure and criminal acts. Ultimately, we identified a total of 24 papers from which data could be extracted for this review, including 5 case reports (defined by a maximum subject number of two), 6 case series (defined by maximum subject number of five), and 13 original research studies.

4. Association between epileptic seizure and criminal acts

Delgado et al. [6] analyzed aggressive behavior captured by video surveillance of a total of 13 patients with epilepsy. Aggression at the onset, during the middle or terminal part of the epileptic seizure toward inanimate objects or another person was observed in seven cases. Aggressive acts were sudden in onset, without evidence of planning and of short duration (lasting a mean of 29 s).

The authors proposed a complex diagnostic work-up to establish if the alleged crime was part of a seizure, including careful consideration of the previous history, closed circuit television, and

Table 1
Legend: BID: twice per day, EEG: electroencephalogram, NM: not mentioned, TLE: temporal lobe epilepsy, TLE-A: temporal lobe epilepsy with aggression, N: Number of cases.

Author	Year	N° of patients	Female/Male	Comorbidities
Reporting association of epileptic seizures and criminal acts				
Bacon	1982	1	0/1	Epileptic — psychotic automatism
Delgado	2002	13	2/11	NM
Eisenschenk	2014	1	0/1	Marijuana, Cocaine consumption
Gauffin	2014	3	2/1	N1: NM, N2: head trauma, N3: NM
Grant	2013	2	0/2	N1: Close head injury N2: Systemic lupus erythematosus, deep vein thrombosis
Ito	2007	3	0/3	NM
Kanemoto	2010	3	1/2	N1: NM, N2: Epigastric sensations, N3: Hallucinations
Marsh	2000	5	2/3	N1: Encephalitis with cognitive impairment, N2: NM, N3: NM, N4: miscarriage & depression, N5: Suspicion of postpartum depression
Oueslati	2018	2	0/2	Echinococcosis cerebral cyst
Pandya	2013	1	1/0	Chronic alcoholism and depression
Reuber	2008	13	1/12	Alcohol dependence, personality disorder, head injuries, neuropsychological deficits
Yankovsky	2005	1	0/1	Prenatal encephalopathy, severe mental retardation
Woermann	2000	24 (TLE), 24 (TLE-A), 35 (control)	10/15 (TLE), 8/17 (TLE-A), 17/18 (control)	NM
Reporting no association of epileptic seizures and criminal acts				
Bogdanovic	2000	99	29/70	Trauma Intrauterine/birth/perinatal damage Hippocampal sclerosis Cortical dysplasia Viral encephalitis Rasmussen's Alcohol Congenital hydrocephalus Hypoxia Phenylketonuria Tumor Bacterial meningitis Tuberous sclerosis
Fazel	2011	22,947 (epilepsy group), 334,006 (controls)	10,982, 11,965 (epilepsy), 217,304, 116,702 (controls)	Drug or alcohol addiction
Gunn	1971	17	0/17	N1: NM, N2: Alcohol addiction, malaria history, N3: Alcohol addiction, N4: Narcolepsy, N5–6: NM, N7: "Cardiac lesion" (verbatim reported by authors, no further specification), N8: NM, N9: History of meningitis, N10–17: NM
Kanemoto	1999	30 (postictal group), 33 (interictal group)	13/17 (postictal group), 15/18 (interictal group)	NM
Kim	2011	761	NM	Psychosis
Rantakallio	1992	5966	0/5966	CNS Trauma, perinatal events
Tittensor	2008	26	0/26	Drug or alcohol addiction, deliberate self-harm or parasuicide

electroencephalogram (EEG) documentation of aggression during epileptic automatisms. A neurologist with competence in epilepsy should establish the diagnosis of epilepsy and if the alleged crime was secondary to the seizure.

Eisenschenk et al. [7] described the case of a patient with epilepsy who regularly consumed cocaine and marijuana. Nine months prior to committing homicide his treatment had been changed: while valproate was continued, carbamazepine was tapered, and levetiracetam started. He reported experiencing auditory hallucinations of Jesus telling him to kill his mother before committing the crime. After the homicide, he called the police without subsequently being able to recall specifics of the conversation. The authors concluded, that based on witness account and medical records, the homicide could have been due to postictal psychosis. Further, the authors argued that levetiracetam has known behavioral adverse effects including aggressive psychotic behavior, while carbamazepine (which was stopped) may have had mood-stabilizing properties.

Gauffin et al. [8] presented three cases in which children were hurt or even killed by a parent with epilepsy, although the exact circumstances and possible relationship with epileptic attacks remained unclear. In the first case, a woman with juvenile myoclonic epilepsy killed her child. The period in which it occurred was described by the authors as particularly stressful because of relationship issues with her partner. On the day the child was killed, the mother had attempted suicide with a drug overdose and by cutting her wrist. The patient could not remember the events that followed until she woke up and saw her child lying dead from suffocation beside her on the bed. She informed the police and presented herself as responsible for the death of her 2-year-old son. She reported that she had had multiple seizures related to the drug overdose. The second case describes a man with posttraumatic epilepsy presenting with focal seizures who had been found guilty of child abuse. His treatment consisted of lamotrigine and carbamazepine. The child had been a victim of repeated trauma, with evidence of multiple fractures of different ages. In court, expert opinions diverged, his neurologist considered the possibility that the child may have been abused during a period of postictal confusion, while another neurologist, as well as a pediatrician, thought that it was more likely that the child abuse had not been related to the man's epilepsy. The second neurologist claimed that these acts could not have been carried out during a focal seizure with impaired consciousness. In the third case, a woman with focal epilepsy and psychogenic nonepileptic seizures claimed that she had inadvertently hit her child because of the movements caused by what was thought be a psychogenic nonepileptic seizure. The authors concluded that, albeit unlikely, it was not impossible that the children were hurt because of seizures although no causality could be established.

Grant et al. [9] described two individuals with epilepsy who showed violent behavior in a state of apparent postictal confusion (bizarre behavior and violence directed at any nearby objects).

In the first case, the patient suffered from complex partial seizures with secondary generalization followed by postictal wandering; his family did not restrain him as this tended to aggravate agitation and resistance. One day a houseguest unfamiliar with his epilepsy attempted to stop the patient from leaving the room after a seizure. The patient overcame the houseguest's efforts and left the room through an open window falling to his death. The second case describes a man with a seven-year history of seizures. His postictal state was characterized by agitation and, at times, violent behavior such as striking walls and furniture with a baseball bat. During these episodes the patient was unresponsive to his environment. Interictally, he was calm, and he felt embarrassed by his postictal behavior. He lost his work (as an office clerical worker) after he had had two seizures followed by his typical postictal behavior in his office.

Pandya et al. [13] described a female patient with medically refractory temporal lobe epilepsy (TLE) who suffered from comorbidities including depression and chronic alcoholism. During the period when her epilepsy became refractory to antiepileptic drug (AED) treatment, she exhibited increasingly violent behavior, ultimately culminating in homicide. The patient showed interictal aggressiveness, which the authors attributed to her TLE. The aggressiveness improved after epilepsy surgery.

Reuber et al. [14] reported 13 subjects who had been found "Not guilty by reason of insanity" because of epilepsy or epileptic seizures in British Criminal Courts. They only found a weak link between epileptic seizures and criminal acts, which were mostly thought to have occurred during the postictal phase.

4.1. No association between epileptic seizure and criminal acts

By contrast, other authors did not find a direct relationship between epileptic seizures and criminal behavior. For example, Bogdanovic et al. [17] described 99 patients with epilepsy with multiple comorbidities. In 81% of the patients, magnetic resonance imaging (MRI) scanning revealed abnormalities (not further specified). All patients exhibited elements of aggression, which however, according to the authors, were mostly not associated with seizure activity, but were much more closely related to states of frustration.

After adjustment for familial confounding factors Fazel et al. [18] found that epilepsy was not associated with increased risk of violent crime in a large longitudinal population-based study based on 22,947 patients with epilepsy and 334,006 controls.

Kim et al. [20] reported on the potential relationship between epilepsy and crime in their national center-based retrospective study. Between 2007 and 2008, 761 criminals were admitted to the Korean National Forensic Hospital, where individuals who committed a crime because of their psychiatric illness are incarcerated. Seventeen of these criminals with epilepsy (frontal lobe epilepsy or TLE) were enrolled in the study. The criminal behavior ranged from murder, attempted murder, rape, arson, assault, to robbery. The authors did not find any strong evidence that epilepsy had been associated with these criminal behaviors, as there was no close temporal relationship between criminal acts and seizures. Furthermore, they found no evidence of alteration of consciousness while the criminal acts were committed.

Rantakallio et al. [22] reported a cohort of 5966 male subjects with epilepsy who had engaged in juvenile crime. The authors found no evidence of an association between epilepsy and crime.

However, they stated that their definition of epilepsy was "broad" without providing specifics. Statistical analysis did not show an increase in incidence of delinquency in subjects with epilepsy. The authors argued that juvenile delinquency is multifactorial, related to childhood and adolescent psychiatry, sociology, psychology, neuropsychology, and criminology.

The study by Kanemoto et al. [29] was more difficult to classify. The authors showed that the incidence of well-directed violent behavior against humans was increased during episodes of postictal psychosis. However, Kanemoto and colleagues argued that violent behavior was not a feature of epileptic psychosis, but rather of postictal psychosis and therefore linked to epilepsy to a lesser degree.

4.2. Dyscontrol syndrome, epilepsy, and crime

Elliot defined dyscontrol syndrome (DS) as recurrent attacks of uncontrollable rage with minimal provocation and frequently out of proportion [30]. This syndrome was described within the context of multiple disease, such as TLE, organic brain syndromes, and psychoses [30]. The author published widely on episodic dyscontrol syndrome (EDS), with "explosive rage" being one of its features. In several papers, they highlighted the organic basis of intermittent behavioral disturbances such as aggression and violence [30,31]. In his article on EDS, Elliot [32] described 286 patients with a wide spectrum of diagnoses ranging from stroke to multiples sclerosis and including 47 patients with epilepsy. In a previous paper [31], Elliot had discussed the anatomy and etiology of "explosive rage" and suggested that TLE (often related to

Table 2
Epilepsy and criminal behavior.

Author	Epilepsy type	Etiology of epilepsy	EEG	Imaging	Crime / Time of violence and crime	Treatment
Positive association epilepsy and crime						
Bacon	TCS	NM	No EEG at time of crime	NM	Violence / NE	Psychotherapy
Delgado	TCS, PCS	Head trauma Encephalitis Birth injury Cerebral anoxia during birth	Seven patients: Interictal EEG – epileptiform paroxysms (spike, sharp wave, or spike–wave complexes) in right temporal regions in patients 1, 2, left temporal areas patients 3, 4, and 8. Complex partial seizures, epileptiform paroxysms-right temporal areas in three patients, left temporal regions three patients, diffusely in both hemispheres one patient	11 normal Slightly enlarged right lateral ventricle on pneumoencephalography (1 patient) Calcification, left Sylvian fissure (1 patient)	Aggression / Interictal	NM
Eisenschenk	NM	LFL	Localized ictal EEG alterations with secondary bilateral synchrony.	NM	Violence / NM	phenytoin, carbamazepine, valproate, and levetiracetam, lorazepam, haloperidol
Gauffin	1. Case 1: Juvenile myoclonic epilepsy 2. Case 2: posttraumatic seizure 3. focal epilepsy and psychogenic nonepileptic seizures	NM	1. Case 1: Polyspike and wave complexes in episodes with generalized distribution. 2. Case 2: normal 3. Case 3: right-sided abnormality with 3- to 4-Hz epileptiform activity localized over right temporal lobe	Normal	Violence / NE	N1: carbamazepine, clonazepam, levetiracetam, N2: carbamazepine, lamotrigine and analgetics including codeine N3: NM
Grant	1. Case 1: CPS with secondary generalization 2. Case 2: Seizures not otherwise specified	TLA	1. Case 1: Interictal EEG: Anterior temporal epileptiform discharges and bitemporal slowing - ictal EEG: sharply contoured, rhythmic 6-Hz theta activity over left anterior temporal region. 2. Case 2: Ictal EEG: Rhythmic 4-Hz activity over anterior left temporal region, maximal at electrodes T1 and F9, then involving the left parasagittal and then right temporal electrode chains, for a duration of max. 150 s.	Case 1, 2: MRI normal	Violence, agitation / Postictal	N1: phenytoin-levetiracetam polytherapy, changed to carbmazepine monotherapy, N2: phenytoin-levetiracetam, later zonisamide was added
Ito	1. Case 1: CPS with secondary generalization 2. Case 2: CPS, SGTCS 3. Case 3: Simple partial seizures (SPSs), CPSs, SGTCSs	TLE	1. Case 1: bilateral independent temporal spikes 2. Case 2: EEG: left occipital and posterior temporal spikes, bilateral independent temporal spikes 3. Case 3: left temporal spikes.	1. Case 1: MRI scan: small lesion in the right superior gyrus, middle temporal gyrus. Interictal SPECT: slight hypoperfusion in the right parietal lobe, frontal cortex, and left mesial temporal lobe. 2. Case 2: MRI normal 3. Case 3: normal	Aggression / Postictal	N1: phenytoin, N2: carbamazepine, phenytoin, and zonisamide, N3: carbamazepine
Kanemoto	1. Case 1: simple and complex partial seizures Case 2, 3 not specified	Case 1: left amygdala, anterior hippocampus; Case 2: left hippocampal sclerosis; Case 3: unknown	1. Case 1: NM 2. Case 2: Interictal EEG with repetitive right anterior temporal sharp waves 3. Case 3: Interictal EEG without epileptiform discharge	Case 1: MRI marked asymmetry of hippocampi (left side smaller than right) Case 2: MRI Left hippocampal sclerosis Case 3: MRI normal findings	Case 1: Uncontrollable rage and violent acting out; Case 2: Violent behavior without irritability nor excitement Case 3: Automatic behavior / Cases 1–3: Postictal	N1: Left inferior temporal lobectomy with hippocampo-amygdalotomy, N2: NM, N3: carbamazepine, later phenytoin, phenobarbital and zonisamide. Haloperidol.
Marsh	1. Case 1: CPS and SGS postencephalitis 2. Case 2: CPS	NM	NM	NM	Violent behavior / Case 1: Periictal Case 2: Postictal	NM

	3. Case 3: Absence seizures and PGE with TCS 4. Case 4: PGE with TCS 5. Case 5: CPS				Case 3, 5: NE Case 4: Interictal	
Oueslati	Case 1, 2: SGE	Post brain surgery: Case 1: Echinococcus cerebral cyst Case 2: Cholesteatoma	1. Case 1: EEG "confirmed the diagnosis of generalized epilepsy" 2. Case 2: TLE	NM	Case 1: Rape Case 2: Stabbed brother with knife Case 1,2: postictal	Case 1: valproic acid, diazepam Case 2: valproic acid, propericiazine
Pandya	CPS with occasional secondary generalization	TLE	1. Interictal EEG: right temporal spikes 2. Ictal EEG: Onset over right temporal region at F8-T4	MRI normal	Homocide / Interictal	valproate (monotherapy), later polytherapy with carbamazepine 600 mg BID, lamotrigine 150 mg BID, clobazepam 10 mg BID and levetiracetam 1000 mg BID. Additionally, venlafaxine, citalopram and right temporal lebectomy
Reuber	1. Partial seizures 2. GTCS 3. Unclassifiable epilepsy	TLE (in 6 of 13 cases)	NM	NM	Various / Most postictal	AEDs without further classification
Yankovsky	CPS with secondary generalization	TLE		Multiple noncontiguous flat and rounded periventricular nodules; diffuse cerebral/cerebellar atrophy.	Aggression and rage / Postictal	valproate, carbamazepine, oxcarbazepine, gabapentin, clobazam and risperidone (2 mg a day)
Woermann	CPS	TLE	NM	fMRI: a decrease in frontal gray matter in patients with TLE and IED compared with control subjects or with patients with TLE without IED.	IED / NM	NM
Negative association epilepsy and crime						
Bogdanovic	NM	NM	NM	81% with MRI abnormalities, not further specified	Aggression	NM
Fazel	1. CPS 2. Other partial seizures 3. Generalized seizures 4. Other or unspecified	NM	NM	NM	1. Homicide 2. Assault 3. Robbery 4. Arson 5. Sexual offense	NM
Gunn	Grand mal seizures	TLE	NM	NM	Violence	N1: phenytoin, primidone, phenobarbitone; N2–3: phenobarbitone, phenytoin, N4–17: NM,
Kim	NM	FLE or TLE		NM	1. Murder (6 pts) 2. Attempted murder (3 pts) 3. Rape (3 pts) 4. Assault (2 pts) 5. Robbery (2 pts) 6. Arson (1 pt)	NM
Rantakallio	NM	NM		NM	Juvenile delinquency	NM
Tittensor	NM	NM	NM	NM	Acquisition (69%) Sexual (15%) Violence (12%) Drugs (4%)	carbamazepine, lamotrigine, phenytoin or valproate
Kanemoto	Complex partial seizures	TLE	NM	NM	"Well-directed and well-organized attacks against human beings"	NM

Legend: NM: not mentioned, TLE: temporal lobe epilepsy, FLE: frontal lobe epilepsy, AEM: antiepileptic medication, MRI: magnetic resonance imaging, EEG: electroencephalography, CPS: complex partial seizure, SGTCs: secondarily generalized tonic–clonic seizures; PGE: primarily generalized epilepsy, SGE: secondarily generalized epilepsy, TCS: tonic–clonic seizures, IED: intermittent explosive disorder; NE: not established.

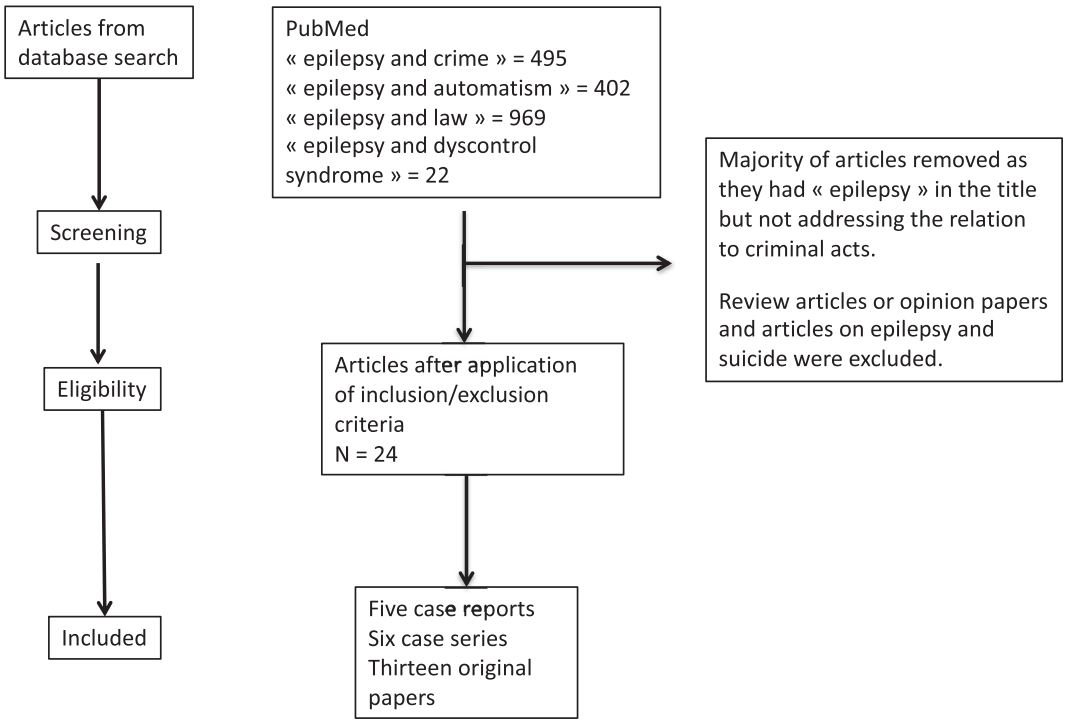

Fig. 1. Search strategy.

hippocampal sclerosis) was the most common "organic" condition associated with "explosive" rage or aggressive behavior during the ictal or postictal phases. A possible relationship with criminal behavior during or after a seizure was not analyzed in more detail.

The so-called EDS was also extensively studied by Bach-y-Rita et al. [33]. These authors split their whole EDS group into five different subpopulations: patients with TLE (7 patients), patients with seizure-like outbursts (30 patients), patients with diffuse violence (57 patients), patients with pathological intoxication (25 patients), and patients with repetitive violence (11 patients). They did not state whether the manifestations of EDS included criminal acts.

Solomon et al. [34] described eight cases of intermittent violent behavior: One case described was that of a 17-year-old young man who killed his mother with an ax "following an episode of wild rage". Later this patient was diagnosed with "psychomotor epilepsy". Treatment with phenytoin improved his behavior. There was no information about the temporal relationship between this criminal act and any epileptic seizure.

Girgis [35] investigated the social implications of dyscontrol syndrome and stated that mesial temporal sclerosis was commonly found at necropsy in the brains of aggressive patients (42 patients) who have died a natural death. The author believed an underlying malfunction of the limbic system was causally related to poor impulse control and violent behavior. He pointed out that TLE may be associated with sociopathic behavior or delinquency but did not provide any new original data to back up this claim. He reported the case of one 18-year-old male with violent behavior and grand mal seizures. During his hospital stay, he attempted to strangle another patient. Histopathological examination of brain tissue excised during an anterior temporal lobectomy revealed a grade I astrocytoma. After surgery the patient was seizure-free and his behavior improved "dramatically". The case description does not specify the temporal relationship between the attempted strangulation and any seizures.

5. Discussion

Many of the reports analyzed lacked the data necessary to allow a clear conclusion about a possible relationship between epileptic seizures and criminal acts. Forensically relevant information (e.g., the temporal association between crime and epileptic seizures) was not systematically provided. In addition, potential genetic or psychosocial factors were rarely reported, although these, as well as comorbid conditions, could play a particularly important role in the generation of behavioral disturbances in people with epilepsy. Methodological diversity and quality in data gathering and reporting rendered a meaningful comparison between studies difficult. For example, since EEG data were not always reported [12,14–17,19,23], it was often impossible to distinguish securely between postictal states and nonconvulsive status epilepticus. Both conditions could, conceivably, cause abnormal or violent behavior and confusion. Another concern is that the diagnostic criteria for epilepsy were not specified in many studies and not uniformly applied across studies. This means that some patients described as having epileptic seizures may actually have experienced epileptic seizure mimics [26].

Great variations in study sizes, ranging from case reports to large cohorts with approximately 23,000 subjects, made a meaningful pooling and comparison of results largely impossible. Although violence related to epileptic seizures was reported as a feature of epilepsy and classified as ictal, interictal, and postictal violence [27], the main limitation in the reviewed studies related to the difficulty of establishing accurately if a subject had experienced a seizure close to the time of the criminal act (Table 2). The majority of authors of publications captured by our literature search argued for an association between epileptic seizures and crime [5–11,13–16,36]. Criminal behavior appeared to be observed most commonly during the postictal phase (Table 2). A previous review by Pandya et al. [13] arrived at similar findings: in 39 patients (78%) no temporal relation between violent behavior and epileptic seizure was found. However, in those patients (22%) were a temporal relation could be established, the criminal or violent behavior occurred during the postictal period.

Treatment was not always mentioned; there was insufficient detail about whether patients were taking AEDs at the time of the criminal act. Information on absence or presence of pharmacological treatment at the time of the crime is, however, of critical importance. There is a longstanding debate about the effects of AEDs on levels of aggression.

A 2010 Cochrane Review and meta-analysis based on 14 studies and 672 subjects [24] examined the efficacy of five AEDs, i.e., valproate, carbamazepine, phenytoin/diphenylhydantoin, levetiracetam, and oxcarbazepine on reducing aggression and associated impulsivity. The authors did not arrive at any conclusive findings. A more recent review did not arrive at any definitive conclusions either [25]. However, the authors conceded that, based on current evidence, some AEDs appear to be associated with a higher risk of adverse behavioral effects including clobazam, clonazepam, levetiracetam, perampanel, phenobarbital, tiagabine, topiramate, vigabatrin, and zonisamide.

The analysis of a relationship between epilepsy and criminal acts is rendered even more difficult if we consider that once a criminal act has occurred, the normal procedure at the crime scene focuses on legal rather than medical matters (such as a detailed immediate clinical evaluation of the perpetrator, including the recording of an EEG or measurement of antiepileptic drug levels). It is rarely possible to make reliable diagnoses retrospectively. Epilepsy was used by way of an example in court as a defense for Jack Ruby who, in 1963, shot Lee Harvey Oswald, who had allegedly murdered US President John F. Kennedy. Ruby's EEG was judged abnormal by the US neurologist Gibbs ("psychomotor variant") who argued that Ruby was suffering from a rare form of epilepsy. However, the pattern described by Gibbs is now considered as "rhythmic temporal theta bursts of drowsiness" and is not considered to be associated with epilepsy [37]. What is more, a temporal association of criminal behavior and an epileptic seizure does not prove a causal relationship. None of the reviewed study provided proof of a causal association.

Further analysis of the literature on the association between EDS, epilepsy, and crime [30–35] only provided tangential evidence of a potential relationship. This literature suggests that a number of neurobiological factors, in particular dysfunction of temporal lobe circuits, may play a role in the development of behavioral changes like intermittent explosive disorder or episodic dyscontrol. However, in general, there is no clear evidence in the literature that seizures in patients exhibiting EDS may be associated with criminal acts.

6. Conclusion

The reviewed literature suggests that criminal acts may rarely occur in association with epileptic seizures. In accordance with the findings of Reuber et al., such acts are most likely to be committed during an ictal or postictal confusional state [14]. Most of the criminal or violent acts described occurred in association with focal seizures of temporal lobe origin. However, criminal behavior is complex and related to multidimensional and interrelated factors including social, religious, political, and cultural aspects, which interact with psychological and neurological mechanisms [21,28]. These aspects are subject to change over time. The fact that criminal behavior is defined within a specific social and historical context increases the difficulties associated with making meaningful comparisons of heterogeneous studies reporting epilepsy and criminal behavior. A minimal data set (epilepsy and seizure type, medication/compliance, comorbidity, temporal relationship between seizure and criminal act, and interictal EEG) needs to be included in future studies/reports of violent or criminal acts in the periictal phase, in order to allow a more meaningful comparison between reports on epilepsy and crime.

Declaration of Competing Interest

Nothing to declare.

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