

Supplementary Material

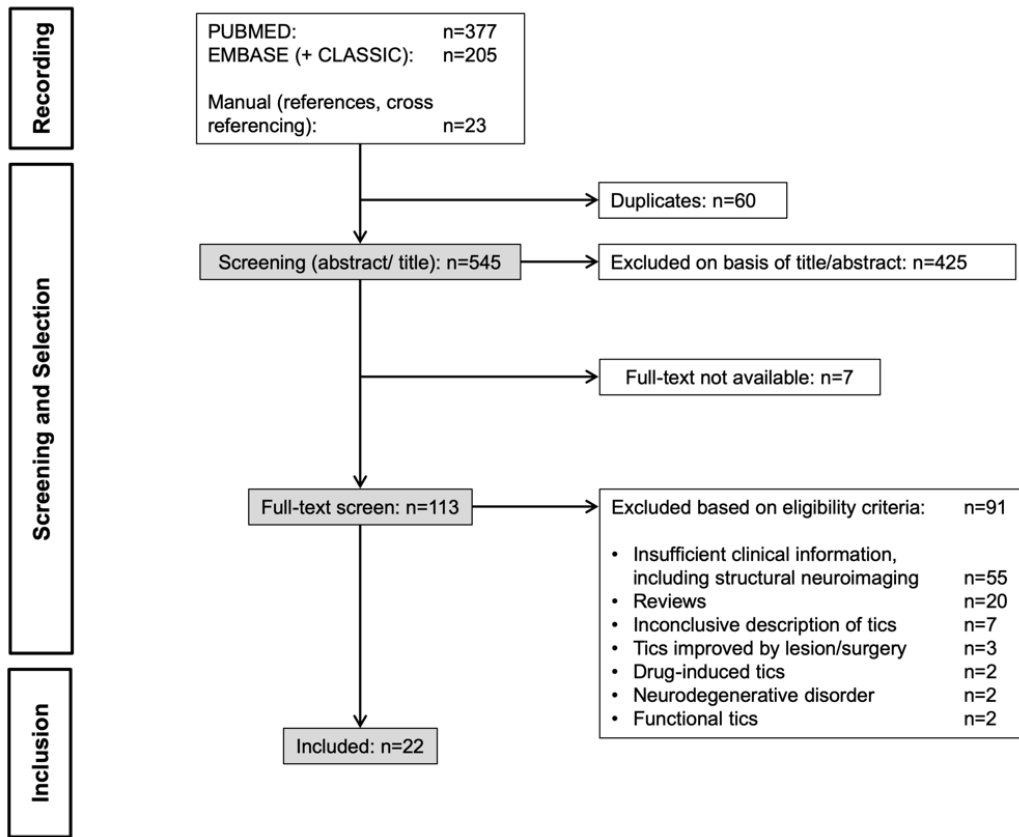
Electronic search strategy:

- Pubmed:
 - Date: 19.03.2020
 - Term: (*(Tics/etiology or Tics/pathology or Tourette Syndrome/etiology or Tourette Syndrome/pathology or tic disorders/etiology or Tic disorders/pathology or secondary tics or Tourettis*) AND (brain lesion or brain damage or white matter abnormalities or gray matter abnormalities or brain abnormalities or spinal injur* or spinal lesion* or brain injur* or head injur* or craniocerebral trauma or posttraumatic or post-traumatic or central nervous system infection or wounds and injuries or central nervous system neoplasms or brain metastasis or neurosurgical procedure OR multiple sclerosis or encephalitis or cerebrovascular disorder or intracranial hemorrhage or ischem* or apoplex* or insult* or stroke or nervous system malformation)*)
 - Limitations: none
 - Sorting: Best match
 - Results: 377

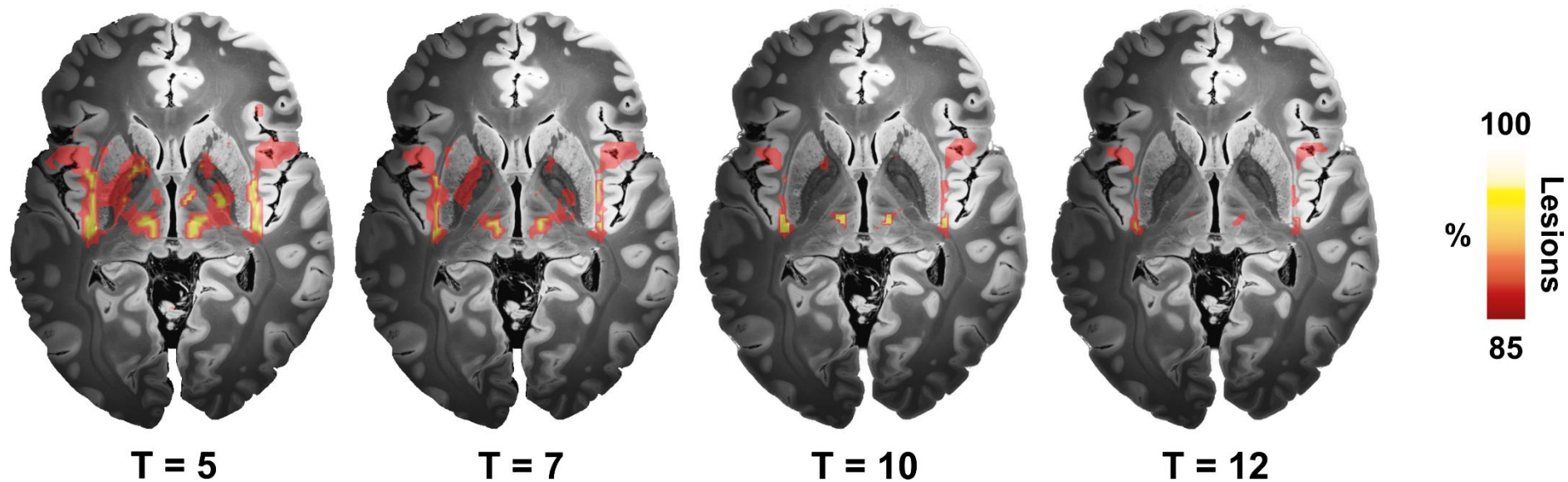
Included MeSH-Terms:

central nervous system infections; tourette syndrome/pathology; intracranial hemorrhages; tics/etiology; head; central nervous system neoplasms; tourette syndrome/etiology; neoplasm metastasis; brain injuries; neurosurgical procedures; multiple sclerosis; gray matter; tics/pathology; tic disorders/pathology; wounds and injuries; leukoaraiosis; congenital abnormalities; cerebrovascular disorders; craniocerebral trauma; brain; encephalitis; nervous system malformations; tic disorders/etiology; tics; stroke

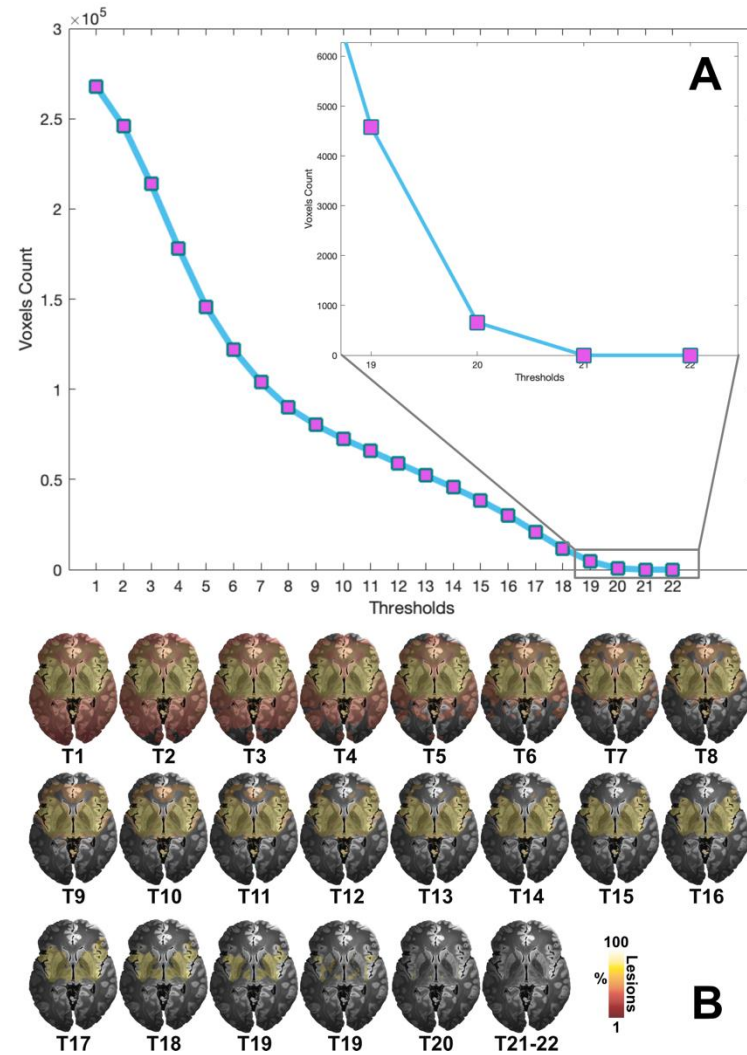
- Embase:
 - Date: 19.03.2020
 - Term: (*exp tic/et or exp tic/co or exp gilles de la tourette syndrome/et or exp gilles de la tourette syndrome/co or secondary tics.mp. or Tourettis*.mp.) AND ((exp brain damage/ or exp brain injury/ or exp head injury/ or posttraumatic.mp. or post-traumatic.mp. or (spinal injur* or spinal lesion*).mp. or exp white matter injury/ or exp white matter lesion/ or white matter abnormalit*.mp. or exp central nervous system infection/ or (gray matter lesion* or gray matter injur* or gray matter abnormalit*).mp. or exp brain malformation/ or exp wound/ or exp injury/ or exp central nervous system tumor/ or exp brain metastasis/ or exp neurosurgery/ or exp encephalitis/ or exp cerebrovascular accident/ or exp cerebrovascular disease/ or exp brain hemorrhage/ or (ischem* or stroke or apoplex*).mp. or exp nervous system malformation/))*
 - Limitations: none
 - Results: 205



Supplementary Figure 1 Flow diagram of data acquisition.



Supplementary Figure 2 Replication of lesion network map using different T-map thresholds. T indicates the T-score threshold used to generate different lesion network maps.



Supplementary Figure 3 (A) Lesion network map voxel count distribution in different thresholding levels indicated as number of lesions on the x axis. (B) Lesion network maps showing different distribution of voxels surviving the serial thresholding level (T).

Supplementary Table 1 Clinical characteristics of tic-inducing lesion cases

Case Nr/Ref	Year	Age at lesion confirmation (y)/Age at tic onset (y)/Sex	Latency to tic onset* (months)	Lesion etiology	Lesion captured [imaging modality]	Clinical tic characteristics	Suppressibility / Urges	Concurrent Movement Disorders [#]	Neuropsychiatric comorbidities	Sources of Funding
1 ¹	2011	19/20/M	12	Traumatic brain injury	Scattered lesions in corpus callosum, right putamen capsule, dorsal aspect of mesencephalon and cerebral convexity (grey/white matter interface) [MRI]	Eyelid tics, facial grimacing, clenching fists; sniffing, grunting, throat clearing	Yes/Yes	Ataxia	Impulsivity, Attention and learning difficulties,	None reported
2 ²	2002	7/8/F	15	Traumatic brain injury	Lesion of the left putamen, globus pallidus, head of caudate, and internal capsule. [MRI]	Blinking, shoulder and arm jerks, trunk flexion, echopraxia; grunts, clicking noises, vocalisations, coprolalia, echolalia	Yes/NA	Ataxia	Short attention span, impaired short-term memory, disinhibited behavior	None reported
3 ³	2002	NA/8.5/M	6	Hemorrhagic stroke	Lesion of the right putamen and caudate nucleus [MRI]	Eye blinking, head jerking and shoulder shrugging, blowing air onto palm, compulsive scratching, head nodding, dystonic cervical tics, stretching and thrusting of neck; urge to sniff	Yes/Yes	Dystonia	ADHD, OCD, SIB (repetitive scratching)	NA
4 ⁴	2008	71/71/M	0.75	Ischemic stroke	Acute ischemic lesion of left caudate nucleus [MRI]	Vocalizations (“a”)	Yes/Yes	None	NA	NA
5 ⁵	2009	73/73/M	8	Ischemic lesions	Patchy ischemic lesions in the basal ganglia, periventricular white matter, centrum semiovale [MRI]	Nose picking, touching his nose, jerks on the legs, jumping up, blowing nose into handkerchief; shouting, startling	NA/Yes	None	Anxiety, Depression	NA
6 ⁶	2004	12/12/M	0.4	CO-Intoxication	Caudate nucleus and putamen bilaterally [MRI]	Repetitive smiling, speech arrest, shoulder shrugging, arm jerking, foot dorsiflexion, throat clearing, humming, lip	NA/NA	None	NA	NA

						smacking				
7 ⁷	2003	4.5/4.7/M	2	VZV encephalitis	Changes of caudate nucleus head and putamen bilaterally, midbrain [MRI]	Head extension and flicking, upward eye deviation, nose twitching, shoulder shrugging; grunting, palilalia	NA/NA	Tremor	ADHD	Support from Action Research and the Barnwood House Trust
8 ⁸	1991	6/6/F	0.5	Herpes encephalitis	Extensive changes of right temporal lobe, basal ganglia and thalamus [CT, MRI]	Eye rolling, facial grimacing, head twitching, shoulder shrugging, jumping, touching objects and body parts, making obscene gestures; grunting, sniffing, snorting sounds	Yes/NA	Possibly dystonia (overflow movements)	Personality changes with emotional lability, anxiety and hyperactivity	Public Health Service Grant Support (NIH NS 27327; HD 25806)
9 ⁹	2020	28/35/M	84	Nail gunshot injury	Focal encephalomalacia of left parietal lobe [MRI]	Head turning; vocalisations (“me”, “boo”), coprolalia	Yes/Yes	None	NA	None reported
10 ¹⁰	2012	52/52/M	10	Osmotic demyelination syndrome	Bilateral lesions of caudate nucleus and putamen, central pons and cortical areas, including insular and precentral cortex [MRI]	Dystonic tics of neck and shoulders; throat clearing	Yes/Yes	Parkinsonism	None	NA
11 ¹¹	1997	33/26/M	NA	Traumatic brain injury [@]	Bilateral subcortical and periventricular leukoencephalopathic changes particularly of the frontal and the right temporoparietal white matter [MRI]	Nose rubbing, mouth opening, wringing hand movements, sniffing	No/No	None	Irritability, Distractibility, OCD, Depression	None reported
12 ¹²	2000	16/16/M	0.07	Arteriovenous malformation	Left frontal arteriovenous malformation [MRI]	Dystonic head turning, vocalisations (“yeah”)	Yes/Yes	None	NA	NA
13 ¹³	1996	2/8/F	NA	Grade II astrocytoma [^]	Tumor involvement of optic chiasm, the hypothalamus and thalamus, internal capsule, ventral striatum, fornix,	Blinking, mouth-opening and other facial tics, throat clearing, lyrical vocal tic, adjusting glasses on nose until	NA/NA	None	Aggression	Grant support (MH 49351; MH 18268; MH 30929; NIH

					nucleus accumbens, septal nuclei, amygdala, and midbrain, including the substantia nigra and red nuclei [MRI]	they felt “just right”					RR 06022; HD 03008; 1K20MH012 32-01; Tourette Syndrome Association)
14 ¹⁴	2009	30/30/F	NA	Multiple sclerosis	Lesions in white matter of both cerebral hemispheres, and the right cerebral peduncle, as well as the middle cerebellar peduncles and both thalami [MRI]	Blinking and other facial tics, throat clearing, palilalia, coprolalia	NA/Yes	Stereotypies	Restlessness, hyperactivity, mannerisms and stereotypies, poor impulse control, SIB (repetitive scratching)	NA	
15 ¹⁵	2016	NA/47/M	NA	Hypoxic brain injury	Bilateral pallidal lesions [MRI]	Blinking, forehead wrinkling and jaw deviation tics, as well as arm abduction, shoulder lifting and hip twisting tics	Yes/Yes	None	None	None reported	
16 ¹⁶	2003	12/NA/M	NA	Hypoxic-ischaemic damage	Bilateral lesions of thalamic and infrathalamic structures. Involvement of right midbrain. High-signal lesion in left dorsolateral caudate-putamen, with involvement of internal capsule [MRI]	Blinking, grimacing and other facial tics, head jerks, body rocking, sounds and noises, including throat clearing, whistling, reiterative speech, as well as echo- and coprolalia	Yes/NA	Dystonia	Restricted social interaction, unusual preoccupations, fixed interests and rigid insistence. Inattentive, impulsive, violent outbursts. SIB (scratching, punching himself on abdomen and legs). Compulsive masturbation.	NA	
17 ¹⁷	2002	34/34/F	NA	Multiple sclerosis	Lesions in the periventricular white matter, thalamus, basal ganglia and brainstem [MRI]	Throat clearing	Yes/No	None	Fatigue	NA	

18 ¹⁸	1999	11/6/M	NA	Cystic malformations	Multiple cystic areas in the left gyrus rectus and superior frontal gyrus [MRI]	Eye and facial tics, vocalizations	NA/NA	None	No	NA
19 ¹⁹	2007	NA/NA/F	NA	Autoimmune encephalitis	Abnormal signal change in striatum bilaterally [MRI]	NA	NA/NA	Parkinsonism, Dystonia	OCB, Anxiety, Dysthymia	Tourette Syndrome Association; Sophie Cameron Trust; Action Research; NHS Trust; Marie Curie Training Fellowship)
20 ²⁰	2004	34/27/F	1	CO-Intoxication	Bilateral pallidal changes [MRI]	Facial tics with mouth opening, lateral jaw movements, neck twisting and shoulder shrugging.	Yes/Yes	None	NA	NA
21 ²¹	1986	24/6/F	NA	Porencephalic cyst	Porencephalic cyst in right temporal lobe with involvement of basal ganglia structures [CT]	Tics of eyelids and mouth, and tongue protrusion tics. Head and shoulder tics. Diaphragmatic tics, coughs, grunting and vocalizations, including screams	NA/NA	None	NA	NA
22 ²²	2016	16/16/M	NA	Acute necrotizing encephalopathy	Symmetrical T2-hyperintense lesions involving the basal ganglia (caudate, putamen and globus pallidus) and the thalami. Additional highly symmetrical white matter changes in the centrum semiovale [MRI]	Motor and vocal tics. Palilalia	NA/NA	Parkinsonism	ADHD, OCD, Tachygraphia	None reported

* from lesioning event to tic onset; # = including cerebellar signs; @ = Case 3 of the 3 reported. ^ = Case 1 of 3 reported. NA = Not Available, ADHD = Attention Deficit Hyperactivity Disorder, OCB/D = Obsessive Compulsive Behaviour/Disorder

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