Generalized Epileptic Seizure Induced by the Stroboscopic Effect of Helicopter Blades

Laëtitia Corgie; Nicolas Huiban; Laetitia Quesnel; François-Xavier Brocq; Jean-François Boulard; Marc Monteil

BACKGROUND: The stroboscopic effect made by helicopter blades passing through rays of sunlight is known as a factor that can induce an epileptic seizure.

CASE REPORT: We report a case of inaugural tonic-clonic generalized seizure while refueling an NH 90 helicopter by an aeronautical technician standing under the rotating main rotor on a sunny day at a South of France naval air station. The stroboscopic effect of the helicopter blades was identified as one of the factors involved in the induction of this seizure.

DISCUSSION: This aeronautical factor identified here during ground hot refueling must be considered for patients predisposed to epileptic seizures who are being evacuated by helicopter, but also for the medical screening of flight members. This is even more important within the military aeronautical environment, justifying electroencephalogram testing implementation on initial aeronautical medical evaluation in France.

KEYWORDS: epilepsy seizure, stroboscopic effect, helicopter blades.

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The stroboscopic effect is often cited as a factor that can induce a comitial seizure.[13] This can be produced by rotating the blades of a helicopter through rays of sunlight. It is associated with a risk sometimes described as anecdotal, but should be especially considered in a person predisposed to seizure occurrence such as in the case of epileptic disease. We present here the observation of an aeronautical technician without significant previous medical history who suffered from an inaugural generalized seizure induced by the stroboscopic effect of the rotating blades in the context of sleep debt while servicing an NH 90 helicopter with engaged main rotor.

CASE REPORT

The patient was a 26-yr-old "*Porteur*" specialized aeronautical technician assigned to a squadron located at a South of France naval air station (NAS). A "*Porteur*" is a technician specialized in engine maintenance, hydraulic or electrical systems, and mechanical components of rotary naval aircraft such as the NH 90 "Caiman" helicopter in service in French Naval aviation (**Fig. 1**).

During an afternoon of a summer day in 2018, with strong sunshine on the NAS, the technician was participating in a refueling operation of an NH 90 under the rotating main rotor. In the anamnesis he said he felt a feeling of unease as he viewed flashes of light at each passage of the blades of the helicopter. A generalized tonic-clonic comitial seizure with loss of consciousness followed, but without further accident, as the refueling operation was immediately stopped by the aircraft captain, who shut down the engines. The patient was then taken care of by emergency services and transferred by the fire brigade to the local emergency department. He regained consciousness in the firefighter's vehicle 15 min after the symptoms onset and evoked the visualization of repeated light flashes just before the seizure.

The technician had no particular medical-surgical past, especially no history of febrile seizure in childhood. He was born to term without neo-natal suffering and had no developmental delay. He has a very good lifestyle, practices mostly

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Fig. 1. National Navy NH 90 "Caiman" helicopter.

endurance sports 10 h/wk, does not smoke, and does not consume alcohol or illegal products. The patient reported some fatigue correlated with a poor quality of sleep and a sleep debt of 2 h/night (5 sleep hours a night instead of the usual 7) due to the hot and noisy atmosphere of his neighborhood. There was also a recent increase in physical activity in terms of intensity, but no change in frequency, and some stress in anticipation of his moving. The heat index was 82°F (28°C) and the patient was perfectly acclimated to living in this area and properly hydrated. Dehydration did not play a role in this observation.

The rest electrocardiogram had no particularity. The biological examinations revealed moderate rhabdomyolysis with a high rise in creatine phosphokinase at 360 IU · L^{-1} and myoglobinemia at 34 μg · L^{-1}, with no renal dysfunction or ionic disorder. Cerebral computed tomography performed before and after contrast medium injection found no abnormality.

The electroencephalogram (EEG) performed the day after the comitial seizure showed a background activity at 9 Hz, regular, symmetrical, and reactive at the eyes opening, with resting intercritical paroxysmal abnormalities (**Fig. 2**). In particular, during hyperpnea (PNH) (**Fig. 3**), a type of explosive, sharp, slow "theta/delta" waves with extremely steep fronts was described, but without a typical aspect of spike waves or polyspike waves. During intermittent photic stimulation (IPS), a physiological photic drive was observed, but did not constitute a real photoparoxysmal response (**Fig. 4**).

Given the importance of the EEG abnormalities, the patient was treated with levetiracetam (Keppra®) 500 mg twice a day and was given sick leave. Cerebral nuclear magnetic resonance imaging was unremarkable.

The control EEG carried out under treatment at 3 wk after the comitial seizure showed a background activity consisting of waves in the alpha band at 10–11 Hz, predominantly posterior,

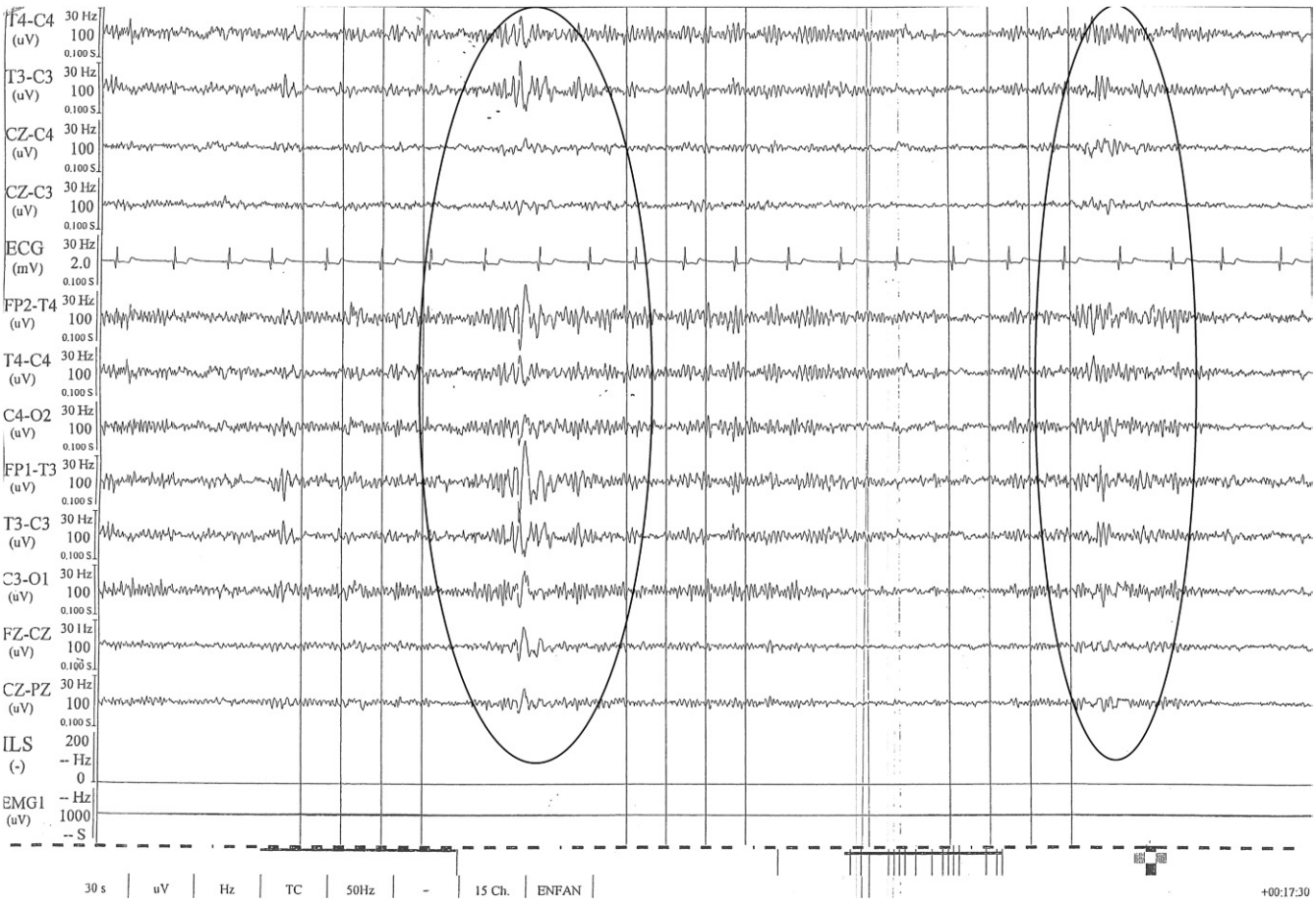

Fig. 2. EEG at D + 1 of the patient: puffs of paroxysmal activity at rest.

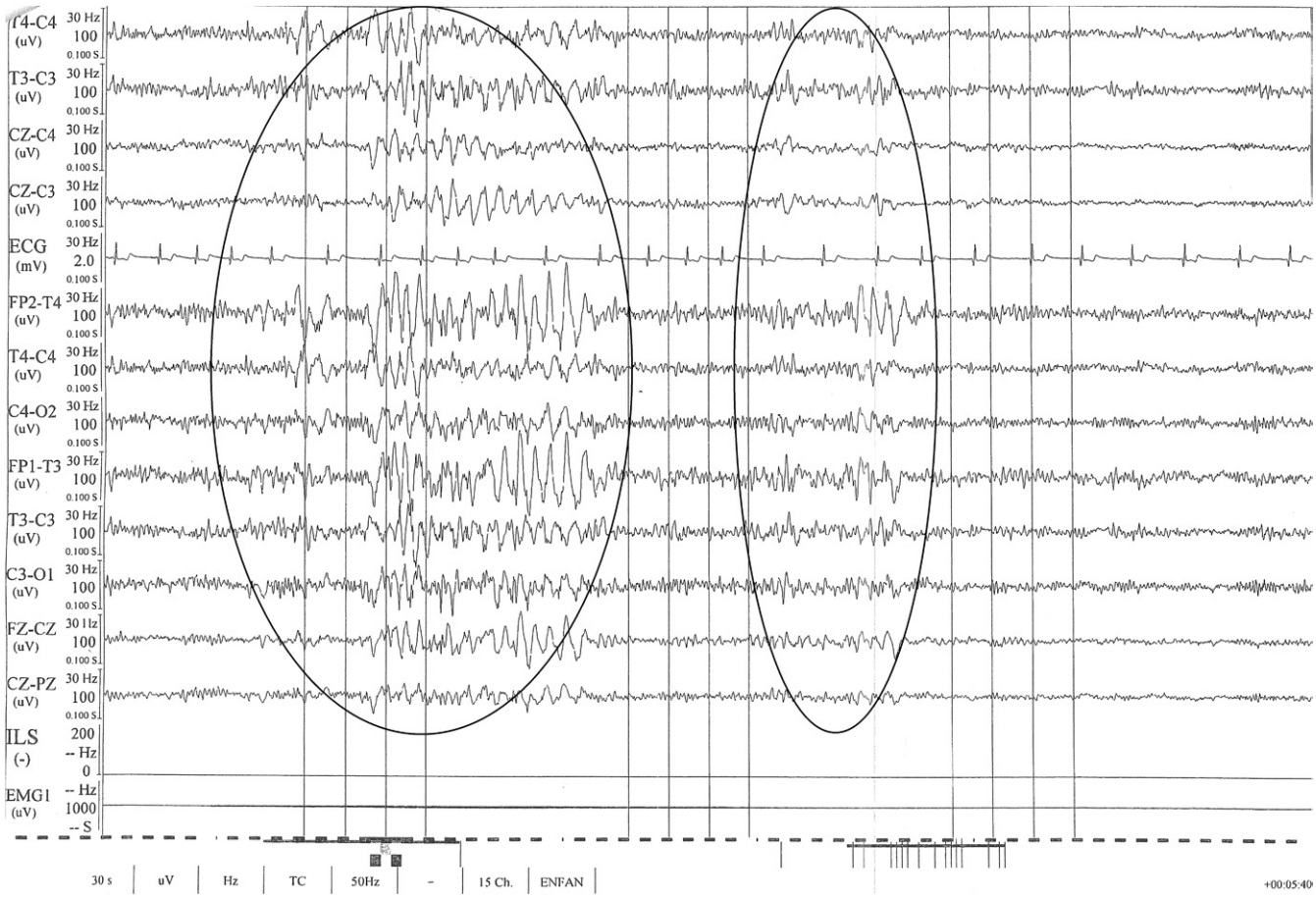

Fig. 3. EEG at D + 1 of the patient: flushes of paroxysmal activities during PNH.

reactive to the opening of the eyes, and symmetrical in appearance at the beginning of the recording. Intermittently, apart from any stimulation, this activity slowed down and became more irregular in the theta band, especially in the left hemisphere. These anomalies alternated with phases in which the trace was low voltage, indicating a probable phenomenon of drowsiness. During PNH, the plot slowed down and took on a slightly more irregular appearance. At the end of PNH, we noted a surge of pseudo-rhythmic delta waves of diffuse bilateral and symmetrical projection. IPS drives the track for frequencies between 8 and 10 Hz. In summary, the plot was within the normal range with fluctuating alertness, irregular rhythmic theta waves of diffuse projection at the end of PNH, and without the typical graphoelement of spike waves, polyspike waves, or other focused anomaly.

The military neurologist at Sainte-Anne military hospital (Toulon, France) was in favor of a contextual seizure rather than an epileptic disease. She advised a specialized follow-up that included an EEG at 6 mo. Engaging in high risk sport activities (aerial, parachuting, scuba diving, and mountaineering) and driving was restricted. The technician's driving license was suspended and will need to be renewed through the Motor Vehicle Administration's medical commission. Unsupervised swimming was not recommended. The patient was informed of the need for correctly following the treatment for effectiveness. On the military side, he is not fit for sea or overseas deployments, carrying weapons, or shift work.

DISCUSSION

EEG remains the gold standard for the electrophysiological study of epilepsy and the only examination involved in its positive diagnosis.[1] The occurrence of seizures in a context of flickering or variation of light intensity is now well known, with several series of patients recorded before IPS was reported.[4] Several articles dealing with photosensitive epilepsy have been published, including those of Kasteleijn-Noslt Trenite and Wilkins et al., which describe the stimuli likely to cause visually induced seizures, among which is the stroboscopic effect.[8,13]

Reflex epilepsies have a specific mode of seizure provocation, among which the most frequent is visual stimulus such as a variation of luminous intensity. Photosensitivity is a purely electroencephalographic characteristic, with the appearance of spikes or spike waves caused by a visual stimulus. Epilepsy with photosensitivity is associated with epilepsy, photosensitivity, and sometimes visually induced seizures. Pure photogenic epilepsy is a subgroup of the previous one with only visually induced seizures that can be generalized tonic-clonic seizures, absences, or myoclonus and sometimes partial occipital seizures.

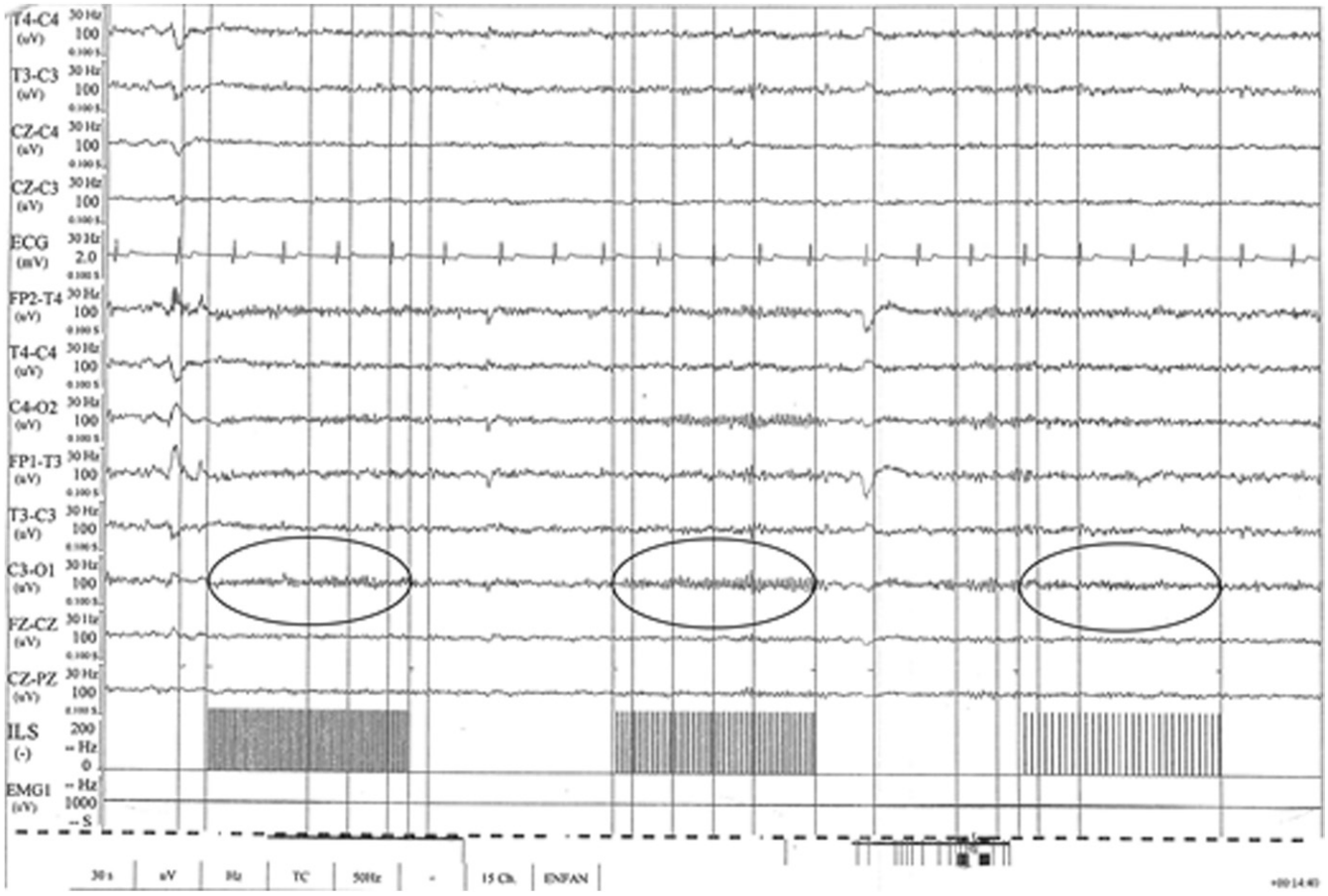

Fig. 4. EEG at D + 1 of the patient: training of occipital rhythms during IPS.

IPS during EEG is performed using a photostimulator placed 30 cm from the patient in a normal light environment. It must be performed between 2 and 60 Hz by 4-s flash trains in three different situations: eyes closing, closed eyes, opened eyes. The lower and upper limit of the sensitivity window is progressively sought while avoiding stimulation inside this window so as to avoid triggering seizures. Frequencies between 15 and 18 Hz have the most epileptic potential.[8]

Photosensitivity is defined by the existence of spike waves during IPS. The prevalence of photosensitivity in epilepsy is 5.5% and is mainly found in idiopathic generalized epilepsy.[8] The photoparoxysmal response is classified into four categories according to its topography (**Table I**). Only type 4 is correlated with the presence of idiopathic generalized epilepsy, but only 60% of these patients have visually induced seizures.[11]

Photosensitive epilepsies with or without visually induced seizures involve several syndromes and do not constitute a homogeneous group. The seizures are spontaneous and may or may not be associated with photosensitive seizures if triggered by television, strobe, sun reflection on the water, or sunlight through a row of trees.

Table I. Categorization of the Photoparoxysmal Response at IPS.[11]

TYPE	DESCRIPTION
Type 1	Spikes in occipital background activity
Type 2	Parieto-occipital spikes
Type 3	Parieto-occipital spikes with diffusion on the frontal regions
Type 4	Spikes waves or polypoints generalized waves

Pure photogenic epilepsy accounts for nearly 30% of photosensitive seizures. The trigger mode is most often by watching television or playing video games. Seizures are generalized from the outset or sometimes limited to the occipital lobe with possible secondary diffusion.[5] IPS can be negative, or there may be pattern sensitivity.[6] An English multicenter study emphasizes the importance of photosensitivity or pattern sensitivity in triggering seizures.[12] A French study has attempted to determine the physical parameters of the pictures that trigger the most spike waves.[2] This study showed that several types of images are in question, either a slow-moving animation or a strong luminance. Faced with pure photogenic epilepsy, the prescription of antiepileptic drugs is often unnecessary. Some precautions for watching television or playing video games should be offered. Patients sensitive to flickering at 50 Hz (high sensitivity to IPS) should not approach within 2 m of the screen and a bright light atmosphere is recommended. Patients sensitive to alternating bands (low IPS sensitivity, only around 20 Hz) should not approach the screen at less than 1.50 m in a low light environment.[11]

A strobe is defined as a source of jerky light from a mechanical or electronic device that alternates between dark phases and

light phases or flashes. It is characterized by the intensity and duration of the flashes as well as the time that elapses between two flashes.

The stroboscopic effect is generated by the cutting of light rays like those of the sun by the recurrent passage of an obstacle between the light source and the subject exposed to this source. The obstacles can be, as in this case, rotating helicopter blades, but also wind turbine blades or rows of trees along a road. The rotor of the NH 90 helicopter measures 16.30 m in diameter, consists of four blades, each performing at a nominal speed of 256 rpm, which gives a computed frequency of a strobe of 17 Hz (17 flashes per second), close to what can be experienced in a night club. In addition, it is in the range of the most epileptic frequencies at IPS (15 to 18 Hz). The stroboscopic effect of helicopter blades is, therefore, able to provoke an epileptic seizure.

There is also a risk of epileptic seizure in predisposed patients with a low epileptic threshold because of the blades' stroboscopic effect during helicopter evacuations.[9] This is why it is recommended to protect the eyes or interpose an opaque protection between the porthole and the predisposed patient to prevent exposure.

Finally, this rarely described observation illustrates the ground consequences of an aeronautical factor and reinforces the French position of the practice of an EEG for medical screening of military aviation applicants.[7] Indeed, the discovery of EEG abnormalities disqualifies applicants given the prospect of professional constraints which risk lowering the epileptic threshold (stress, fatigue, hypoglycemia, hypoxia, night work ...). Functional abnormalities documented in this way may be at risk of sudden or subtle in-flight incapacitation, thus potentially jeopardizing flights and mission safety.[3] However, there are unusual physiological activities that are physiological variants of cerebral electrogenesis. In an EEG, their morphology and characteristics must be well known in order not to erroneously conclude they are of an epileptic origin.[10]

The stroboscopic effect of helicopter blades is a factor that can induce a comitial seizure as illustrated here. This one was judged situational in this observation of a patient without a medical history and whose control EEG does not reveal paroxysmal anomaly. The frequency (17 Hz) of the stroboscopic effect of the NH 90 blades operating at rated speed corresponds to the most epileptic frequency range at IPS (15 to 18 Hz).

This rarely described observation, which highlights the stroboscopic effect in the aeronautical environment as a risk factor for epilepsy seizure, reinforces the French position of requiring an EEG for any military aeronautical initial medical evaluation. Moreover, during a helicopter medevac, the risk of comitial seizure induced by this effect must be prevented if the patient is known as predisposed to the occurrence of an epileptic seizure.

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