Short report

Simple tics in Gilles de la Tourette's syndrome are not prefaced by a normal premovement EEG potential

J A OBESO, J C ROTHWELL, AND C D MARSDEN

From the University Department of Neurology, Institute of Psychiatry and King's College Hospital Medical School, London

Summary EEG events prior to simple tics have been examined in six patients with Gilles de la Tourette's syndrome, and compared to EEG changes occurring when the same subjects voluntarily mimicked their own tics. Voluntary jerks were prefaced by a premovement negative potential commencing about 500 ms prior to the muscle EMG discharge and reaching an amplitude of about 7 μV. No such premovement potential was evident in the EEG prior to spontaneous tics in five of the six patients; a very small event was seen in the sixth patient but it was only about one-tenth of the size of the premovement potential seen prefacing voluntary jerks in the same subject. These data indicate that simple tics in Gilles de la Tourette's syndrome are physiologically distinct from normal self-paced willed movements.

The diagnostic criteria for chronic multiple tic or Gilles de la Tourette's syndrome are the presence of tics with vocalisations persisting into adult life. The tics themselves are characterised by sudden, lightning-like muscle jerks occurring at irregular intervals independently in different muscle groups, but usually with some degree of stereotyped repetition. Most tics are simple movements such as a facial grimace, a shrug of a shoulder or a jump of an arm, but more complex movements such as touching, wiping or hitting may be seen.

Many authors consider such tics to be true automatic involuntary movements, but this is debated. The frequency and intensity of tics in Gilles de la Tourette's syndrome are increased in conditions of social stress; the tics can be suppressed to some extent by an effort of will; and the tics occasionally appear purposive. All these observations have been interpreted by others to suggest that the movements are not automatic or involuntary, and there still is uncertainty as to whether the condition should be regarded as due to neurological or psychological causes. In this report we present physiological evidence indicating that simple tics in Gilles de la Tourette's syndrome are automatic movements not employing the normal cerebral mechanisms responsible for voluntary willed movement.

Patients and methods

Six male patients aged from 14 to 38 (mean 24 yr) with a clinical diagnosis of Gilles de la Tourette's syndrome were studied. The main history and clinical details are summarised in the table. All were easily able to imitate their tics voluntarily after a little practice. Multi-channel EMG recordings were made of the involuntary tics of all six patients. Up to six pairs of silver/silver chloride surface electrodes were placed over the affected muscles and a PDP 12 computer was used to record the data continuously onto floppy discs for subsequent analysis. The muscle(s) showing the most frequent and abrupt jerks were chosen for further analysis. Six EEG electrodes were then placed on the scalp, usually with four over the contralateral sensorimotor cortex, one at the vertex, and one over the ipsilateral sensorimotor cortex with linked mastoid electrodes as reference. Both EMG and
EEG signals were preamplified (Devices 3160 amplifiers) with time constants 0·002 and 1·0 s respectively, 3 dB down at 2·5 kHz.

In the first half of the test session each subject was instructed to sit comfortably with his eyes closed in a reclined chair and to allow his tics to occur spontaneously without any voluntary interference. This required some practice in four of the subjects, who complained that they had spent most of their lives trying to inhibit or cover up the jerks. Nevertheless all six patients eventually co-operated extremely well. One well-defined repetitive tic was selected in each subject (see table). The EMG correlate of that selected movement was used to investigate the relationship between EMG and EEG events. Each jerk was recorded separately by the computer using the programme PASTIME (Mr HB Morton), triggering the computer from the EMG of the active muscle in order to observe EEG events before and after the trigger. Two-hundred and fifty-six data points per channel were collected in each 2 s sweep. Sixty to 200 individual jerks from each subject were averaged later (AV; Mr HB Morton); any record which showed movement artefact or EMG contamination of the EEG record was rejected. In the figure the average EEG records have been smoothed using a digital three-point moving average filter.

In the second half of the session, after a rest of 15–20 min, each subject was asked to imitate the particular tic chosen for study. They were asked to inform the experimenter if any unplanned, involuntary tics occurred. The EMG and EEG from the voluntary movements were recorded and averaged as above.

### Results

When the patients were instructed to relax and to avoid any voluntary interference with the tics, the EMG bursts producing each jerk were of short duration (less than 100 ms) and occurred independently in different muscle groups. Co-contraction of agonist and antagonist muscles was seen in the three patients who had jerks in the arms (see insert in figure (a)). The EEG events associated with spontaneous tics and voluntary jerks of biceps and triceps are shown for a single patient in the figure (a). When the subject imitated the tic voluntarily (even producing a slight co-contraction of biceps and triceps), the EEG showed a large bilateral premovement potential, represented by a negative wave beginning some 500 ms before the movement. Another negative wave (motor potential) of shorter duration preceded the EMG burst by some 70 ms and was followed by a positive post-movement potential. During spontaneous tics occurring in the relaxed subject, a similar but much smaller positive wave followed the jerks, but there was no change in the EEG activity preceding the contraction.

The results from all six patients are shown together in the figure (b), where the EEG records from one electrode placed on C3 or C4 (10–20 International System) during both spontaneous tics and voluntary jerks have been superimposed for each subject. For willed jerks mimicking the tics,
Simple tics in Gilles de la Tourette's syndrome

the normal premovement potential started, on average, 510±68 ms before the voluntary muscle contraction, and had a mean maximum amplitude of 7 μV. The premovement potential was unclear in the EEG record in only one subject (WC), in whom it was difficult to record a normal negative potential when he voluntarily attempted to mimic his neck tic. However, transforming the data from WC using the CUSUM technique showed that a small premovement potential did precede the voluntary jerks but not the spontaneous tics. The raw records and CUSUM transformation of the EEG data for the spontaneous tics in the other five patients showed no evidence of a premovement potential in all but BN in whom there was a small event of very low amplitude compared to that seen prior to voluntary brachioradialis jerks.

Discussion

The results reported in this study provide the first evidence that the simple type of tics observed in Gilles de la Tourette's syndrome can be distinguished physiologically from normal voluntary movements. In the past few years strong evidence has appeared that this syndrome should be classified as a true involuntary movement disorder. Thus, tics are three times more common in boys than girls, they have been reported in cases of encephalitis lethargica and in a few cases of previously unaffected patients after taking chlorpromazine or amphetamine, and an unusually high incidence of minor neurological signs and EEG abnormalities have been found in Gilles de la Tourette's syndrome. The usually good response to treatment with haloperidol also has been used as an argument to favour an organic basis for tics in Gilles de la Tourette's syndrome.

The absence of a premovement potential before the involuntary tics cannot be attributed to a high rate of tiquing cancelling out the potentials associated with individual jerks. The rate of voluntarily-produced tics was chosen to be no more or less than that of the spontaneous tics, and spontaneous tics continued during the period of voluntary activity. The spontaneous tics therefore appear to be produced by a neural mechanism different from that involved in willed self-paced movements, which are preaced by changes of EEG activity over large areas of the cortex some hundreds of milliseconds prior to each movement. The brain structures and pathways mediating the spontaneous tics are unknown. Bilateral thalamotomy has been reported to lead to a marked reduction of jerks in four patients. In an epileptic patient

Figure (a) Average EEG recordings from six sites (1–6 referred to a linked mastoid reference) in 100 spontaneous tics consisting of elbow flexion due to brief biceps contraction, with some co-contraction of triceps (the EMG bursts producing a single such tic are seen in the middle insert), and in 128 voluntary self-paced willed biceps contractions mimicking the same tic, in patient AS. The bottom two traces show the rectified EMG from biceps (used to trigger the back-averaging programme) and triceps. The dotted line refers to the onset of activity in biceps.

(b) Average (between 30 to 128 trials) EEG records from the electrode at C3 point contralateral to the muscle involved in the tic (SCM = sternoclidomastoid, Bic = biceps, Bra = brachioradialis, Tra = trapezius, EDC = extensor digitorum communis) in six patients with Gilles de la Tourette's syndrome. The dotted line is at the onset of EMG activity in the muscle involved in the tic. The lighter trace is of EEG activity related to spontaneous tics. The heavier line is of EEG activity related to voluntary self-paced willed jerks aimed to mimic that patient's particular tic.
tic-like hyperkinesia was produced during stimulation with deep electrodes of a zone just lateral to and above the medial part of the lateral ventricle, probably corresponding to the corpus callosum and caudate nucleus.\textsuperscript{18} Our results also suggest a subcortical origin for the tics in Tourette's syndrome since most patients had no cortical activity preceding and time-locked to the spontaneous jerks.

In conclusion, the observations reported here show that the simple muscle jerks of Gilles de la Tourette's syndrome are physiologically distinct from normal self-paced willed movements. On the basis of this study we cannot deny that some patients may have some prior knowledge of the occurrence of each jerk, as claimed by Bliss\textsuperscript{6} after several years of close self-observation, nor can we extend our conclusion to the complex types of tics and sounds observed in some patients with Gilles de la Tourette's syndrome. We do believe, however, that our finding allows simple tics to be classified as true abnormal automatic movements, which reinforces the idea of a neurological basis for Gilles de la Tourette's syndrome.

References

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