A comparative study of the cognitive side effects of bitemporal and bifrontal electroconvulsive therapy

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Received 22 December 2016
Accepted 23 April 2017

Middle East Current Psychiatry
2017, 24:109–115

Background
Several previous studies have shown that unilateral electrode placement produces relatively fewer cognitive adverse effects during electroconvulsive therapy (ECT). There are a few reports comparing bifrontal (BF) and bitemporal (BT) electrode placements during ECT.

Objectives
The objectives of the present study were to detect and compare cognitive impairment in patients receiving BT-ECT and BF-ECT.

Patients and methods
In a parallel, double-blind, randomized clinical trial, 40 patients with schizophrenia, bipolar disorder (mania), and major depressive disorder admitted to the psychiatric department of Al Menoufia University Hospital and Abbasia Mental Hospital (Egypt) were assigned randomly to BF ($n=19$) and BT ($n=21$) ECT groups. The primary outcome measures included the Montreal cognitive assessment (MoCA) scale. All patients were assessed with the ICD-10 checklist and the MoCA scale before receiving ECT. Patients were evaluated using the MoCA test after each even ECT session, and then monthly after the ECT course for 6 months.

Results
All patients received eight sessions of ECT. The two groups were matched with respect to their MoCA baseline scores. There was a significant difference between the MoCA scores of the BF compared with the BT group after the second ECT session until 3 months after the ECT course ($P>0.05$) with better cognitive functions in the BF-ECT group. This advantage of the BF-ECT in the cognitive profile was restricted to language and executive functions until the end of the ECT course as well as attention abilities and memory assessment until the second and third month, respectively, after the ECT course.

Conclusion
BF-ECT was associated with fewer cognitive side effects and early recovery than BT-ECT.

Keywords:
cognitive impairment, electroconvulsive therapy, electrode placement

Middle East Curr Psychiatry 24:109–115

2090-5408

Introduction

Electroconvulsive therapy (ECT) is a standard psychiatric treatment in which seizures are electrically induced in patients to provide relief from psychiatric illnesses. Usually, ECT is considered as a safe procedure with an estimated current mortality of about less than one death per 73 440 treatments [1].

Bifrontal (BF) electrode placement was initially described as a novel method for electrode placement by Abrams and Taylor [2]. The initial description of fewer cognitive side effects with BF in 1990 [3] has been replicated by several further studies [4–8].

ECT is a proven effective treatment for depression, especially those with high suicidal risk, severe psychomotor retardation and physical deterioration, and treatment-resistant depression. ECT is an effective treatment for acute mania. Recent reports suggest that ECT should be considered in mania cases that are acutely treatment refractory, delirious mania, or in rapid-cycling manic states. ECT is also recommended for schizophrenic patients, especially those with a history of a favorable response to ECT, abrupt psychotic exacerbations, catatonic schizophrenia, or schizoaffective disorder [9].

Cognitive adverse effect is arguably the most important concern regarding ECT. The degree of memory impairment depends on several factors. The number of ECT sessions, the width of the electrical pulse, stimulus dosage, and the lateralization of the electrodes greatly affect the degree of post-ECT cognitive impairment [10].

 DOI: 10.1097/01.XME.0000516721.16137.4a

Patients and methods

This study was scientifically and ethically discussed and approved by the Department of Neuropsychiatry, Faculty of Medicine, Al Menoufia University, in accordance with the ECT protocol of the general secretary of Mental Health in Egypt. The study was carried out over a period of 11 months, starting from May 2014 to April 2015.

Study population

All patients admitted to the El-Abbasia Mental Health Hospital with major depressive disorder, bipolar disorder, or schizophrenia, aged 18 to 60 years, and referred for ECT were eligible for inclusion. This age range was chosen on practical grounds, on the basis of the local service, to facilitate satisfactory participant flow and cooperation during testing. Additional inclusion criteria were the ability to co-operate during testing and to provide voluntary written informed consent (by the patient or a first-degree relative). Appropriateness for ECT was determined after consultation with an anesthesiologist and a psychiatrist, who were in charge of the ECT. The reasons for referral were failed medication trials, intolerance to drugs, urgency of illness, and the patient's preference or previous ECT response. The diagnosis was made by their treating consultant psychiatrist and confirmed with an ICD-10 symptoms checklist.

Exclusion criteria included illiterate and mentally retarded patients, patients with substance use disorder (except nicotine), patients with major medical or neurological disorders, those with a history of receiving ECT in the last 6 months, and patients with catatonia because of the difficulty in undergoing baseline cognitive assessment before starting the ECT course.

All patients were recruited from El-Abbasia Mental Health Hospital. It is located in eastern Cairo, serving as a catchment area for greater Cairo, with a population of 17.6 million. It serves both urban and rural areas including Cairo, Giza, and Kalyoubia governorates.

Procedures for randomization and blinding

All patients who met inclusion criteria were randomized, using a computer-generated random number table, to receive either BF or bitemporal (BT) ECT. The groups were matched for sex, age, and diagnoses to negate the possible impact of patients' clinical diagnosis or possible side effects of antipsychotic drugs on cognitive functions. The patients and their family members were blinded to the randomization status throughout the study. Electrode gel was applied to all four positions on the skull, to ensure that the participants were unaware of which electrode-placement method was used. The designated electrode position was implemented when the patient was under adequate anesthesia. Raters and ward nurses were not permitted to enter the ECT treatment room. Thus, neither patients nor raters were able to identify the actual electrode-placement approach.

Medication during electroconvulsive therapy treatment

It is a standard practice in the hospital to stop drugs that can alter seizure duration 12 h before the ECT session (benzodiazepine and antiepileptic used as mood stabilizers). Antipsychotic and other medications prescribed by the clinical team were not controlled.

Electroconvulsive therapy technique

ECT was administered two times a week with an ultrabrief-pulse, constant-current device (MECTA, Portlan, Oregon, USA). During first ECT session, the threshold was determined by the titration method. From the second session onwards, patients received ECTs with stimuli 1.5 times their threshold.

The number of treatments in the study was fixed at eight (twice weekly for 1 month) based on the ECT unit protocol in El-Abbasia Mental Hospital.

Anesthesia was induced with propofol, and muscle relaxation was induced with succinylcholine. The initial dose was 1.5 mg/kg of propofol and 0.5 mg/kg of succinylcholine. If the seizure threshold was determined, patients were pretreated with 0.5-mg atropine. At subsequent treatments, the doses of anesthetic medications were adjusted individually on clinical grounds.

Patients were ventilated with 100% oxygen until resumption of spontaneous respiration. Physiological monitoring included pulse oximetry, blood pressure, and ECG. Electroencephalogram and electromyography could not be monitored because of technical malfunction in the ECT device.

The criterion for adequate generalized seizure duration was at least 20 s of motor response. During the treatment course of ECT, the dosage was increased if needed to maintain adequate seizure duration.

For BT-ECT, electrodes were placed on the perpendicular line 3 cm above the midpoint of the line joining the outer canthus of each eye with the ipsilateral external auditory meatus. For BF-ECT, electrodes were placed bilaterally 5 cm above the outer angle of orbit.

During the first ECT session, the threshold was determined by titration. From the second session onward, patients received ECTs of stimuli 1.5 times their threshold.

Clinical evaluations

Diagnostic procedures

Using all available information from patient interviews and observations from next of kin, the diagnosis according to ICD-10 criteria was confirmed, with consensus between two independent and experienced senior consultants in psychiatry. In addition, the diagnosis was supported by the ICD-10 checklist interview.

Clinical evaluations

A psychologist, blinded to electrode placement, measured the side effects of using the Montreal cognitive assessment (MoCA) test version 7.1 before starting the ECT course (baseline), 24 h after the second, fourth, sixth, and eighth

ECT sessions, and then monthly for 6 months after the last ECT session for follow-up. The alternative/equivalent versions of the MoCA (version 7.2 and version 7.3) have been used to decrease possible learning effects as recommended by Nasereddine when the MoCA is administered repetitively (every 3 months or less).

Ethics

This study was scientifically and ethically discussed and approved by the Committee for Research Ethics at Al Menoufia University and the general secretary of Mental Health in Egypt. Eligible patients and their next of kin were given thorough written and oral information about ECT, the purpose of the trial, and the procedures that would be involved. Inclusion was strictly based on informed consent and the patient's signature. In all cases, ECT was prescribed by the treating clinical units. None of the patients was prescribed ECT solely for the purpose of this study.

Statistical analysis

Data were analyzed using statistical program for the social science (SPSS, version 18.0, Chicago, USA). Quantitative data are expressed as mean ± SD. Qualitative data are expressed as frequencies and percentages. Independent samples *t*-test of significance was used to compare two means. A one-way analysis of variance (ANOVA) was used to compare more than two mean values. The χ^2 test of significance was used to compare proportions between two qualitative parameters. A *P*-value less than 0.05 was considered significant, a *P*-value less than 0.001 was considered highly significant, and a *P*-value greater than 0.05 was considered insignificant.

Results

Participant flow

A total of 63 patients were prescribed ECT during the period from May 2014 to July 2014. All 63 patients were thoroughly screened, and 15 patients were excluded. The reasons for exclusion were history of receiving ECT in the past two months ($n = 1$), presence of neurological disorders (epilepsy, $n = 1$), mental retardation ($n = 1$), history of substance dependence ($n = 3$), illiteracy ($n = 4$), and catatonia ($n = 5$). The remaining 48 patients were randomized to receive BF-ECT ($n = 24$) or BT-ECT ($n = 24$).

In the BF-ECT group ($n = 19$), four patients were discharged before the eighth ECT session, and one patient underwent more than eight sessions. Data of these 5 patients were excluded from the study results. In the BT-ECT group ($n = 21$), three patients were discharged before the eighth ECT session, and their data were excluded from the study.

Demographic data of the sample showed no statistically significant difference between the two groups regarding age or sex. In addition, the clinical diagnoses were comparable among both groups, as they were matched previously by the research team. Our study included 40 patients (20 male and 20 female). Their ages ranged from 22 to 50 years with a mean ± SD of 34.6 ± 7 years. Patients were divided into two groups.

The BF-ECT group included 19 patients [10 (52.6%) female and nine (47.4%) males]. Their ages ranged from 22 to 46 years with a mean age of 34.5 years. The clinical diagnoses in this group were major depressive disorder ($n = 6$), bipolar disorder ($n = 6$), and schizophrenia ($n = 7$).

The BT-ECT group included 21 patients [10 (47.6%) female and 11 (52.4%) male]. Their ages ranged from 23 to 50 years with a mean age of 34.75 years. The clinical diagnoses in this group were major depressive disorder ($n = 7$), bipolar disorder ($n = 6$), and schizophrenia ($n = 8$).

Cognitive assessment during electroconvulsive therapy

Our study showed no statistically significant difference ($P > 0.05$) between the two groups with regard to cognitive functions assessed using the MoCA score before ECT treatment (baseline assessment). After the second session until the third month after the last session, there was a significant difference between the two groups ($P < 0.05$), with the BF group having better cognitive functions as shown in Table 1.

Regarding visuospatial abilities, abstraction, and orientation, our study showed no statistically significance difference ($P > 0.05$) between the two groups in pretreatment baseline scores and during the study period. Regarding language and executive function affection, our study showed no statistically significant difference ($P > 0.05$) between the two groups in pretreatment baseline scores; however, there was a statistically significant difference ($P < 0.05$) between the two groups from the second session until the end of the ECT course, with better performance in the BF-ECT group. This difference disappeared in the first assessment during the follow-up (1 month after the last session). As for attention abilities, our study showed no statistically significant ($P > 0.05$) difference between the two groups in pretreatment baseline scores. Moreover, there was no statistically significant difference ($P > 0.05$) between the two groups after the third month from the last session. However, there was a statistically significance difference ($P < 0.05$) between the two groups from the second session until the second month after the end of ECT, with better performance in the BF-ECT group. Regarding memory assessment, our study showed no statistically significance difference ($P > 0.05$) between the two groups in pretreatment baseline scores. Moreover, there was no statistically significant difference ($P > 0.05$) between the two groups after the fourth month from the last session; however, there was a statistically significant difference ($P < 0.05$) between the two groups from the second session until the third month after the end of ECT, with better performance in the BF-ECT group.

Comparison between the different diagnoses (schizophrenia, bipolar, and major depressive patients) with

Table 1 Comparison between the bifrontal electroconvulsive therapy group and the bitemporal electroconvulsive therapy group with regard to the Montreal cognitive assessment test before starting electroconvulsive therapy, during eight electroconvulsive therapy sessions, and through 6 months of follow-up

ECT session	BF-ECT (mean ± SD)	BT-ECT (mean ± SD)	*t*-Test	*P*-value
Before ECT	18.15 ± 3.00	16.7 ± 2.52	1.43	>0.05
After the 2nd session	17.55 ± 3.14	14.75 ± 2.27	2.08	<0.05*
After the 4th session	17.4 ± 3.15	14.75 ± 2.22	1.99	<0.05*
After the 6th session	17.4 ± 3.13	14.55 ± 2.16	2.11	<0.05*
After the 8th session	17.35 ± 2.89	14.45 ± 2.28	2.13	<0.05*
1 month after the last session	17.75 ± 2.88	15.85 ± 2.39	2.27	<0.05*
2 months after the last session	18.1 ± 2.86	16.35 ± 2.30	2.07	<0.05*
3 months after the last session	18.12 ± 2.81	16.5 ± 2.31	2.03	<0.05*
4 months after the last session	18.13 ± 2.81	16.73 ± 2.28	1.97	>0.05
5 months after the last session	18.13 ± 2.81	16.85 ± 2.39	1.57	>0.05
6 months after the last session	18.16 ± 2.81	16.85 ± 2.39	1.57	>0.05

BF-ECT, bifrontal electroconvulsive therapy; BT-ECT, bitemporal electroconvulsive therapy; ECT, electroconvulsive therapy; *t*, independent sample *t*-test.
*$P<0.05$, significant.

regard to cognitive functions using the MoCA test in the BF-ECT group showed no statistically significance difference in the pretreatment baseline score. In addition, there was no statistically significant difference during the study period ($F = 1.4$–1.9, ANOVA) in the BT-ECT group when comparing the MoCA scores for different diagnoses. It showed no statistically significant differences in the pretreatment baseline scores; moreover, there was no statistically significant difference during ECT treatment and follow-up ($F = 0.15$–0.4, ANOVA).

Follow-up assessment

As for the follow-up assessment of the cognitive functions, patients in the BF-ECT group showed statistically significant differences between baseline assessment and cognitive assessment after the second, fourth, sixth, and eighth ECTs. This cognitive affection also appeared in the first-month follow-up after the ECT treatment. Assessment during the second to the sixth months after ECT treatment showed no statistically significant differences between the baseline assessment and the cognitive assessment in this period as shown in Table 2.

The BT-ECT group showed statistically significant differences between the baseline assessment and the cognitive assessment after the second, fourth, sixth, and eighth ECT. This cognitive affection also appeared in the first, second, and third month follow-up after the ECT treatment. Assessment during the fourth to the sixth month after ECT treatment showed no statistically significant difference between the baseline assessment and the cognitive assessment in this period as shown in Table 3.

Table 2 Paired difference between baseline cognitive assessment (before electroconvulsive therapy) and other cognitive assessments during the study period in the bifrontal electroconvulsive therapy group using the Montreal cognitive assessment test

	Mean ± SD	*t*-Test	*P*-value
Before ECT	18.15 ± 3		
After the 2nd session	17.55 ± 3.14	0.60	<0.05*
After the 4th session	17.4 ± 3.15	0.75	<0.05*
After the 6th session	17.4 ± 3.13	0.75	<0.05*
After the 8th session	17.35 ± 2.89	0.80	<0.05*
1 month after the last session	17.75 ± 2.88	0.40	<0.05*
2 months after the last session	18.1 ± 2.86	0.05	>0.05
3 months after the last session	18.12 ± 2.81	0.03	>0.05
4 months after the last session	18.13 ± 2.81	0.02	>0.05
5 months after the last session	18.13 ± 2.81	0.02	>0.05
6 months after the last session	18.16 ± 2.81	0.01	>0.05

BF-ECT, bifrontal electroconvulsive therapy; ECT, electroconvulsive therapy; *t*, paired sample *t*-test.
*$P<0.05$, significant.

Table 3 Paired difference between baseline cognitive assessment (before electroconvulsive therapy) and other cognitive assessments throughout the study in the bitemporal electroconvulsive therapy group using the Montreal cognitive assessment test

	Mean ± SD	*t*-Test	*P*-value
Before ECT	16.7 ± 2.52	–	–
After the 2nd session	14.75 ± 2.27	1.95	<0.05*
After the 4th session	14.75 ± 2.22	1.95	<0.05*
After the 6th session	14.55 ± 2.16	2.15	<0.05*
After the 8th session	14.45 ± 2.28	2.25	<0.05*
1 month after the last session	15.85 ± 2.39	0.85	<0.05*
2 months after the last session	16 ± 2.3	0.35	<0.05*
3 months after the last session	16.1 ± 2.31	0.20	<0.05*
4 months after the last session	16.73 ± 2.28	−0.03	>0.05
5 months after the last session	16.85 ± 2.39	−0.15	>0.05
6 months after the last session	16.85 ± 2.39	0.15	>0.05

BT-ECT, bitemporal electroconvulsive therapy; ECT, electroconvulsive therapy; *t*, paired sample *t*-test.
*$P<0.05$, significant.

Discussion

BF-ECT, although researched less extensively than BT or right unilateral (RUL) ECT, has been suggested to be comparable with the other two electrode placements with respect to safety and clinical efficacy [11].

Our study showed statistically significant differences between the two groups with regard to cognitive functions after the second session until the third month after the last session, with the BF-ECT group having better cognitive functions. This is in agreement with findings of the recent studies comparing BF-ECT and BT-ECT regarding cognitive impairment [11–13].

These results are also consistent with the earlier study by Delva *et al.* [14], in which the BF group showed the least degree of treatment-induced cognitive dysfunction compared with the BT or RUL treatment groups. All the previous studies used a similar ECT protocol as our study.

This advantage of BF-ECT can be explained by the sparring effect on the temporal lobes, especially the hippocampal regions, which are known to be particularly important in mediating memory and learning [15]. Although previous studies have not found that ECT causes structural brain changes [16], one study found that BT-ECT caused an increase in bilateral hippocampal volume [17]. This suggests that ECT may affect the structure of the hippocampus, a key component of neural circuitry involved in mood. The effects of BT-ECT on the hippocampus may also underlie its effects on cognition, particularly memory [18]. An earlier study, using magnetic resonance spectroscopy, found increased hippocampal choline concentrations, a putative measure of membrane turnover after BT-ECT [19]. It has been proposed that the adverse cognitive effects of ECT are mediated through indiscriminate activation of glutamate receptors in the hippocampus at the time of the seizure [18]. However, most reviews have concluded that the most consistent finding is reduced anterior cingulate/prefrontal cortex anterior cingulate prefrontal cortex or cerebral magnetic resonance spectroscopy, possibly with some relationship with adverse cognitive effects of BT-ECT [20]. This advantage to the cognitive profile of BF-ECT can also be supported with an anatomically based model, which proposes that the prefrontal lobe, which is critically involved in the regulation of mood and cognition, must be stimulated. It emphasizes the direct and vigorous stimulation of the prefrontal lobe in contrast to the indirect action through the monoaminergic transmitters [21].

However, our study finding disagrees with Kellner *et al.* [22], who failed to find a substantial difference in cognitive effects of BF-ECT and BT-ECT in patients with major depressive disorder. Kellner and colleagues study was also unusual in that there were no consistent differences between cognitive effects of BT-ECT and RUL ECT too. About 30–55% of the data on cognitive effects had to be imputed because of missing data in this study. Possible differential rates of dropout in those with worst cognitive effects could have resulted in failure to detect consistent differences in this outcome [22].

As for the follow-up assessment of cognitive functions, the BF-ECT group showed early recovery compared with the BT-ECT group. Assessment at 2 months after the ECT treatment showed complete recovery to the pretreatment level in the BF-ECT group, whereas it took 4 months for the BT-ECT group after the end of ECT treatment to return to the pretreatment cognitive level. This is in agreement with Oremus *et al.* [23], who found complete recovery of cognitive impairment after ECT within 3 months. In addition, this is in agreement with an earlier study by Calev *et al.* [24], who found no cognitive impairment after 6 months from the last ECT session. However, this is inconsistent with the study by MacQueen *et al.* [25], who noted that cognitive impairment cannot be explained by patients' medical condition even after 6 months from the last ECT session.

This advantage of the BF-ECT regarding the cognitive profile was restricted to the language and executive functions during the ECT course, and attention abilities and memory assessment till the second and third months, respectively, after the ECT course. Visuospatial abilities, orientation, and abstractions showed no affection in both groups.

Visuospatial abilities were assessed using a clock drawing task and copying a three-dimensional cube. Our study showed no affection in both groups during the study. This is consistent with Rossi *et al.* [26], who noted that ECT does not affect visuospatial performance in both groups using the same tests; however, it is inconsistent with the study by Rami *et al.* [27], who tested visuospatial abilities before and 90 min after each ECT, and stated that ECT sessions may cause some acute, mild dysfunction of visuospatial function. Limitations of this study were the small number of patients (12 in each group) and there was no long-term assessment [27].

Our study showed no affection in orientation in both groups. This is in agreement with the study by Phutane *et al.* [28], who also excluded patients with severe cognitive impairment from their study and assessed patients 24 h after the ECT session to avoid acute disorientation effects of ECT. However, this is inconsistent with an old study carried out by Sackeim *et al.* [29], who found similar significant affection of orientation with both BF-ECT and BT-ECT, which may be explained by the only 7-h interval between the ECT session and the orientation assessment.

Regarding abstraction using the similarity task test, there was no affection in both groups during treatment. This is in agreementwith Hiremani *et al.* [30], who found no evidence of creativity and abstract reasoning affection in both BF-ECT and BT-ECT groups using Paired Associate Learning Test, and their results are consistent with our study. However, this is in disagreement with an earlier study by Calev *et al.* [24], who examined abstraction using similarity task test 7 h after each session and reported affection in abstraction immediately after the first session, which improved beyond the baseline level within 1–6 months. Calev *et al.* [24] found clinical improvement in the study sample, which included severely depressed patients.

Executive functions were assessed using an alternation task drawing a line from a number to a letter in an ascending order. Our study showed restricted advantage for the BF-ECT group during the ECT session only, which is consistent with Kellner *et al.* [22], who evaluated executive functions in patients using the Trail Making Test, Category Fluency, the Stroop Color Word Test, the Controlled Oral Word Association Test, and the Delis–Kaplan Executive Function System. Kellner *et al.* [22] found significant differences between the electrode placement groups regarding these measuring instruments. However, this is inconsistent with Hiremani *et al.* [30],

who used the Trail Making Test to assess executive function in both groups before and after ECT and found no significant difference between the BF-ECT and BT-ECT groups. Hiremani *et al*. [30] also disagreed with our study with respect to the timing of assessment (8 h after each ECT session).

Language was assessed through repetition of two syntactically complex sentences and a fluency task. Our study showed better performance in the BF-ECT group during ECT sessions only. This is consistent with Phutane *et al*. [28] who investigated the cognitive effects of ECT using the same tests and their results showed language affection immediately after treatment, which remitted by follow-up; however, it is inconsistent with the study by Calev *et al*. [31], who found no language affection in both groups. Although Calev *et al*. [31] noted verbal fluency affection, he explained it by psychomotor slowing and recent memory affection rather than language affection.

Attention abilities were evaluated by repeating a list of digits in a forward and backward order, by using a target detection task, as well as a serial subtraction task. Our study found better performance in the BF-ECT group starting from the second session of ECT until the second month after ECT. This is in agreement with Phutane *et al*. [28], who evaluated attention using mental balance by counting letters of the alphabet backwards, and found more decrease in attention abilities in BT-ECT than BF-ECT. Phutane *et al*. [28] are in agreement with our study with regard to the timing of cognitive assessment [assessment tools were used before initiating ECT (baseline) and the day after every second ECT]. Our results are not in agreement with Hiremani *et al*. [30], who used 7 serial subtractions to assess attention in both groups before and after ECT. Although they found affection in attention abilities in both groups, they failed to find a significant difference between the two groups.

Memory was assessed using naming of three animals (lion, camel, and rhinoceros) and five objects recall test. BF-ECT patients showed better memory scores after the second session until the third month after ECT. This is consistent with the results of Phutane *et al*. [28]; however, this was not in agreement with the study by Kellner *et al*. [22] who assessed anterograde memory using the Rey Auditory Verbal Learning Test and retrograde amnesia using the Autobiographical Memory Interview – Short Form and mini mental state examination and found that BF was statistically significantly inferior to BT placement.

Limitations

Although this study fulfilled its aims, there were some unavoidable limitations. First, this study was conducted only on a small group of patients. Second, some patients were unable to complete the study because of the bad ECT stigma and false public fears about it, and some patients were discouraged by the long period of assessment, especially after being discharged from the hospital. Finally patients' medications were not controlled through the study, which makes studying the role of ECT in remission of symptoms impossible.

Conclusion

Regardless of efficacy, which was not included in our study, BF electrode placement showed better cognitive profile during the study than BT electrode placement. Although both electrodes showed complete recovery of cognitive side effects within the 6-month follow up period, BF electrode placement showed remarkable early recovery than BT electrode placement.

Conflicts of interest

There are no conflicts of interest.

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