Electroconvulsive Therapy in Patients With Skull Defects or Metallic Implants: A Review of the Literature and Case Report

Shabbir Amanullah, MD, DPM, MRCPsych, FRCPC; Nicholas Delva, MD, FRCPC; Harold McRae, BSc; Laura A. Campbell, PhD; and Julie Cole, BA, MLIS

ABSTRACT

Context: Head injury is often associated with psychiatric morbidity. While it is well understood that the loss of critical areas of the brain may play a role in cognitive dysfunction and change in personality, head injury can also have profound effects on mood and cognition. The role of medications in the treatment of mood disorders associated with brain injury is well documented, and there is also evidence favoring the use of electroconvulsive therapy (ECT) in this context. However, data are limited on the use of ECT in patients with skull defects or metallic head implants.

Evidence Acquisition: First, a review of the literature on use of ECT in patients with metallic head implants is provided. Electronic databases and online sites, including PubMed, Cochrane Library of Systematic Reviews, and UpToDate, were used to search for relevant articles and case reports on the use of ECT in patients with and without metallic implants in the head (1964 to 2009). The search terms *electroconvulsive*, *electroconvulsive therapy*, *ECT*, *electroshock therapy*, *EST*, *head injury*, *brain injury*, *metallic plates*, *metallic implants*, *skull prosthesis*, and *depression* were used interchangeably. The search produced 7 articles discussing exclusively the use of ECT in patients with a metallic skull plate. Second, the case of the successful and safe use of ECT in an individual with a previous history of brain trauma and metallic plate implantation is described.

Results: Most cases of head injury are managed by neurologists and rehabilitation consultants; the more severe cases of depression and other mood disorders tend to be referred for specialist psychiatric care. With greater degrees of deficit following head injury, management becomes more complicated. Our patient showed positive results with ECT, including improvement in depressive features and resolution of suicidal ideas/plans.

Conclusion: ECT is an effective and safe alternative in patients with a history of brain trauma and metallic plate implantation who subsequently develop treatment-resistant depression and associated suicidal ideas or plans refractory to management with medications.

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Corresponding author: *Shabbir Amanullah, MD, Hillsborough Hospital, PO Box 1929, Charlottetown, Prince Edward Island, Canada C1A 7N5 (shabbir.amanullah@gmail.com).*

Brain injury is common. In the United States, about 1.4 million people suffer from brain injury resulting from various causes.[1] Individuals older than 75 years of age have the highest rates of traumatic brain injury–related admission to the hospital and mortality from brain injury.[1] Medical complications are varied and include seizures,[2] deep venous thrombosis,[3] stress ulcers, urinary incontinence, and normal pressure hydrocephalus.[4] Given the financial difficulties, stress on relationships, organic mood disorders, and possible personality changes that an individual faces after head injury, the availability of effective treatments is crucial for these patients.

Head injury is often associated with psychiatric morbidity, and the rate of mood disorder may be up to 40%.[5] While the loss of critical areas of the brain may play a direct role in cognitive dysfunction and change in personality and mood, brain injury can also affect the brain's neurochemistry and thus secondarily affect mood[5] and cognition.[6] Subtle cognitive deficits may erroneously be subsumed under the "functional" category.[6] Atrophy of the hippocampus and frontal cortical areas may have particularly significant consequences.[7] Most cases of head injury are managed by neurologists and rehabilitation consultants, and the more severe cases of depression and other mood disorders tend to be referred for specialist psychiatric care. With greater degrees of deficit following head injury, management becomes more complicated.[8]

The report of the National Institutes of Health consensus developmental panel on rehabilitation of persons with traumatic brain injury itemizes the common behavioral deficits in such individuals and lists among others agitation, aggression, sexual dysfunction, mood disorders, and anxiety disorders.[9] This report highlights the role of psychotherapy and psychopharmacologic agents but makes no mention of electroconvulsive therapy (ECT).[9]

The role of medications in the treatment of mood disorders associated with brain injury is well documented,[10,11] and there is evidence of benefit from ECT in this context.[12] Data are, however, sparse on the use of ECT in patients with skull defects or metallic head implants. Theoretical concerns about the use of ECT in patients with skull defects or metallic implants pertain to the possibility of the passage of excessive amounts of electricity with consequential damage to brain tissue and could account for its infrequent use in practice and the lack of much description in the medical literature. The hypothetical neuronal injury attributed to prosthetic heating during ECT was successfully refuted in 1 case study, with the caveat that equidistant electrode placement from the prosthesis would be beneficial.[13]

ECT has been used effectively in patients with metastatic brain cancer without raised intracranial pressure.[14] Similarly, ECT has been utilized in patients with normal pressure hydrocephalus without raised intracranial pressure.[4] The status of recent and open head injury as a relative contraindication to ECT was negated by several reports describing individuals who developed severe major depression refractory to medical therapy after sustaining gunshot wounds and who were then successfully

Clinical Points

- Head injury and metallic plate implantation with subsequent severe depression is a challenging clinical problem, and a high suicide risk makes effective treatment imperative.
- A course of electroconvulsive therapy (ECT) in such patients and, if needed, maintenance ECT is a safe and effective option.

treated with ECT.[15–17] Mania following head injury has also been successfully treated with ECT.[18]

We hereby provide a review of the relevant literature on the use of ECT in patients with metallic head implants. Also, the successful and safe use of ECT in a patient with a previous history of brain trauma and metallic plate implantation is described.

REVIEW OF THE LITERATURE

Method

Electronic databases and online sites, including PubMed, Cochrane Library of Systematic Reviews, and UpToDate, were used to search for relevant articles and case reports on the use of ECT in patients with metallic implants in the head. The terms *electroconvulsive*, *electroconvulsive therapy*, *ECT*, *electroshock therapy*, *EST*, *head injury*, *brain injury*, *metallic plates*, *metallic implants*, *skull prosthesis*, and *depression* were used interchangeably to ensure the greatest range of returns. Literature consistent with the topic of ECT use in patients with metallic head implants was drawn from a variety of journal sources using MeSH subject headings.

An initial review of the literature of the past 10 years (July 1989 to July 2009) on the use of ECT in patients with metallic skull plates yielded only 3 relevant articles in PubMed. The literature search was then broadened to include all brain-injured patients, including those with and without metallic skull plates, and the date limits of the literature review were modified to include all relevant literature written from the first discussions of the use of this procedure on such patients, originating back to 1964. These adaptations to the scope of brain injuries and the timeline allowed a scan of over 45 years of relevant data and research on the use of ECT in this subgroup of patients, for a total of 58 studies. Of these 58 articles, we found 4 more relevant articles, for a total of 7 articles in PubMed discussing exclusively the use of ECT in patients with a metallic skull plate.

Results

Table 1 lists the studies that described patients with metallic head implants and/or skull defects. These studies were selected on the basis of information provided about the parameters used. Studies that gave no clear indications of parameters used were not included. Studies involving spinal Harrington rods and maxillofacial repairs without skull defects were also excluded.

CASE REPORT

Mr A is a 54-year-old man with a history of traumatic brain injury at the age of 4 years, when he was hit by a car and lost consciousness for 2 weeks. Surgical treatment included the placement of a metallic clip in the left parietal region for a vessel tear (patient recall). Mr A had academic difficulties related to poor concentration and difficulty processing information and dropped out of school after grade 8 at the age of 13 years. As an adolescent, substance abuse was significant (lysergic acid diethylamide, cannabis, and alcohol) prior to Mr A suffering a generalized tonic-clonic seizure just before his 18th birthday. Since then, he has received anticonvulsant medication, with no established recurrences.

Mr A went on to work and later married and settled down to family life. Over the ensuing years, however, he suffered from bouts of low mood that fulfilled *DSM-IV* criteria for major depressive disorder with a recurrent pattern. Some of the bouts of depression were severe, with 2 attempted suicides by overdoses with prescribed medications. Mr A had a history of lapses in memory dating back 20 years. Various antidepressants from different groups were prescribed in adequate doses for adequate durations, with inadequate to poor response. It was during this phase that Mr A's son died by suicide, and his depression worsened. Mr A was preoccupied, with poor appetite and sleep.

At presentation to our mental health service, Mr A had low mood, lack of energy, sadness (with no diurnal pattern), lack of interest, guilt, irritability, and suicidal ideas with plans. His Global Assessment of Functioning (GAF) score was 40. His medications included phenytoin 100 mg bid; carbamazepine controlled release 1,000 mg po daily; dimenhydrinate 50 mg po daily; lorazepam 1 mg po daily as needed; sertraline 150 mg po daily; clonazepam 2 mg po 1–2 tablets daily; and risperidone 2 mg po daily. A consultant neurologist concluded that Mr A had epilepsy with partial and secondarily generalized tonic-clonic seizures. There were 2 types of seizures, the first characterized by a sensation of his tongue getting thicker and speech becoming slurred, with full recall of these events, and a second type characterized by loss of consciousness and tongue biting, with no recall, headache, and feeling sleepy on recovery. There was a positive family history of suicide and alcohol dependence, with a first-degree relative dying by suicide and another with alcohol dependence syndrome.

Soon after Mr A's contact with our services, we noted a decline in his mood and worsening in his suicidal ideation. Mr A was admitted to the hospital on a reduced dose of antiepileptic medication and suffered what was thought to be an unwitnessed generalized tonic-clonic seizure, after which he claimed that his mood improved significantly and his suicidal ideas vanished. After discharge, intensive work was continued to help motivate Mr A, and a schedule was put in place for him to structure his day. Given his inadequate response to medications, Mr A was told that ECT would be an alternative intervention if he were to suffer a relapse. He consented to this treatment should it be needed.

Table 1. Cases Involving the Successful Use of Electroconvulsive Therapy (ECT) in Head Injury Patients With Skull Defects/Metallic Implants

Author	Age (y)	Gender	Lesion	MMSE (pre/post) ECT	ECT Machine	Electrode Placement	Current (mA)/ Stimulus Dosing	Frequency (Hz)	Pulse Width (ms)	Duration (seconds)	Total ECTs
Ruedrich et al, 1983[15]	21	Female	Cerebral cortical laceration	NR	NR	Bitemporal/brief pulse stimulation	NR	70	1.5	2.0	17
Tsuang et al, 1979[4]	35	Male	Skull defect, surgical clips, and bullet fragments	NR	MECTA SR-1	Right unilateral, brief pulse stimulation	800	70	1.4	1.0	8
Glezer et al, 2009[19]	53	Male	Cranial-facial titanium plate	NR	spECTrum 5,000	Right unilateral, brief pulse stimulation	800	60	1.0	4–6	9
Madan and Anderson, 2001[13]	74	Male	Metallic skull plate	27/30 pre-ECT; 30/30 post-ECT	spECTrum 5,000	Bilateral, brief pulse stimulation	NR	50	NR	3.0	8
Hartmann and Saldivia, 1990[20]	59	Male	Skull defect, shrapnel in zygoma	27–28/30 midway and post-ECT	MECTA SR-1	Bilateral, brief pulse stimulation	700	80	1.6	1.25	12
Everman et al, 1999[21]	79	Male	Skull defect	29/30 post-ECT	THYMA-TRON DGx	Bilateral, brief pulse stimulation	10%–50%	NR	NR	NR	7
Everman et al, 1999[21]	67	Female	Skull defect	30/30 post-ECT	THYMA-TRON DGx	Right unilateral, brief pulse stimulation	50%–100%	NR	NR	NR	9
Singh and Morley, 2008[17]	72	Female	Intracranial lead	NR	NR	Right unilateral	NR	NR	NR	NR	8

Abbreviations: MMSE = Mini-Mental State Examination, NR = not referenced.

Figure 1. Computed Tomography Scan Image of the Metallic Implant 1: Superficial Cut/Section

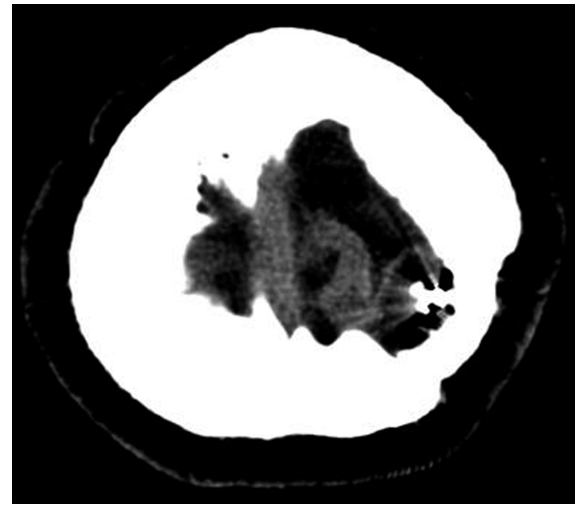
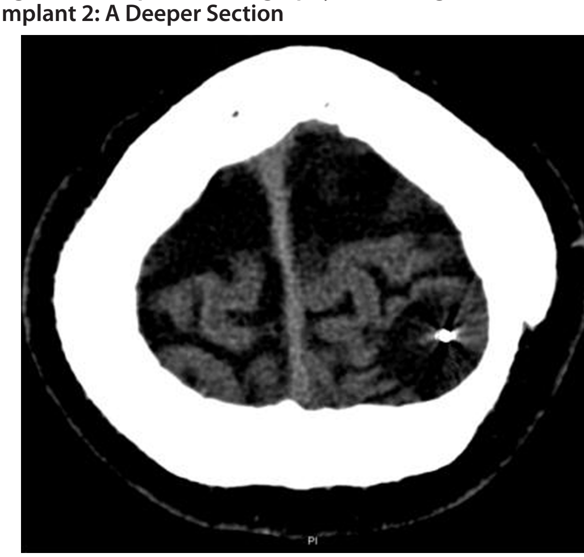


Figure 2. Computed Tomography Scan Image of the Metallic Implant 2: A Deeper Section



Over the next 6 months, there was improvement in Mr A's mood, and he then reduced his medications of his own volition. Four weeks later, Mr A's mood worsened significantly, and he was taken to the hospital on the anniversary of his son's death. At that point, his GAF score was 10 due to the persistent thoughts of self-harm and nondisclosure of plans. After discussion with Mr A and his partner about the risks and benefits of ECT, he consented to receiving bitemporal ECT.

A computed tomography (CT) scan of the head was reviewed by the physician (S.A.) and the radiologist on the morning of the procedure to reconfirm the final electrode placement. Two pictures of the clip are presented in Figures 1 and 2. The figures show the object in the superficial slices. Although there was a skull defect, it was not deemed to be significant, and a bitemporal placement was chosen over ultra brief placement to reduce any chance of the clip heating up

Table 2. Testing and Investigations Performed Before and After Electroconvulsive Therapy (ECT)

Test	Pre-ECT	Post-ECT
Electroencephalogram	Normal	Not indicated
Computed tomography scan of head	Old left parietal calvarial defect with small metal foreign body with small gliosis from old trauma accompanied by mild bifrontal cerebral atrophy; no evidence of acute brain injury	Not indicated
Mini-Mental State Examination[22]	30/30	30/30
Hamilton Depression Rating Scale[23,24]	24	2
Hamilton Depression Rating Scale, 2-wk follow-up	…	3

Table 3. Psychometric Testing Before Electroconvulsive Therapy

Test	Percentile Rank/Score	Qualitative Descriptor
Wechsler Adult Intelligence Scale[25]		
Verbal IQ	32	Average
Performance IQ	5	Borderline
Verbal Comprehension Index	37	Average
Perceptual Organizational Index	14	Low average
Working Memory Index	21	Low average
Processing Speed Index	9	Low average
Clock drawing		
Numbers correctly placed?	Yes	No impairments, well-drawn
Time correct?	Yes	…
Trailmaking test[26]		…
Part A	< 10th	
Part B	20th	
California Verbal Learning Test[27]		
Trials 1–5	T-score = 52 (58th percentile); standard score = 0.5	Average
Total learning slope trials 1–5		
Word fluency	20th–30th percentile	Average
Wisconsin Card Sorting Test[28]		Minimal deficit

Table 4. Psychometric Testing After Electroconvulsive Therapy

Test	Percentile Rank/Score	Qualitative Descriptor
Trailmaking test[26]		…
Part A	< 10th	
Part B	< 10th	
California Verbal Learning Test[27]		…
Trials 1–5	Did slightly worse overall, but the difference did not reach statistical significance	
Total learning slope trials 1–5		
Word fluency	< 10th	Borderline or lower
Wisconsin Card Sorting Test[28]	Same or slightly worse	…
Rey Complex Figure Test[29]	Some minor improvement on the memory portion	…

with the increased duration of current application associated with ultra brief placement. Application of unilateral placement would have meant closer proximity of both electrodes to the clip, thus increasing the likelihood of a loop forming by which the current would likely be shunted and thereby reducing the chances of inducing a seizure. With ECT stimulus parameters of current 800 mA, pulse width 1 ms, frequency 90 Hz, and duration 4 seconds, Mr A had a well-modified seizure of adequate duration. There were no concerns post-ECT, and the following day, significant improvements were seen in his condition: an absence of suicidal ideas, better energy levels, better sleep, and a renewed interest in activities. By the sixth ECT treatment, Mr A was showing sustained positive changes and a marked renewal of interest in interacting with staff and some of the others on the unit and wanting to "get back to living." Over the next 2 ECT treatments, his subjective sadness reduced further, and a repeat Mini-Mental State Examination (MMSE)[22] was performed to ensure that there was no memory loss. In total, Mr A received 8 ECT treatments and consistently scored 30/30 on the MMSE, with no forgetfulness or lapses in concentration.

At the time of discharge, Mr A was doing very well. Neuropsychological testing performed before and after ECT treatments and results are shown in Tables 2–4.[22–29] At review after discharge, Mr A displayed an interest in activities that he had been avoiding such as reading the paper and going into the garden. Prior to his admission, Mr A's partner had rated him at 2/10 (10 equals well) on a visual analog scale, and at review, she rated him at 7/10. There were no hypomanic or manic features.

Mr A was advised maintenance ECT due to the severity of his depression and suicidal ideas. He had 15 ECT treatments as an outpatient. While the advice was for weekly and then biweekly treatments, due to transportation issues, Mr A had treatments initially weekly, then biweekly, and then monthly. On review at 1 year, following transfer to the outpatient psychiatrist, it was noted that Mr A was engaged in activities and feeling well with no concerns about depressive features and suicidal ideas or plans. He discontinued follow-up toward the 2-year follow-up period of his own volition, as he had to rely on a friend for the commute to receive outpatient ECT.

DISCUSSION

ECT is equal or superior to pharmacologic treatments in treatment-resistant depression.[30] Previous studies have found that the incidence of depression for which the criteria

for major depressive disorder were met ranges from 18%–61% in individuals with head injury.[31] The role of ECT was addressed in a case series by Kant et al,[12] and all patients showed improvement after ECT. The authors noted no adverse significant cognitive or physical sequelae.[12] Concerns about the flow of current were addressed by Weaver et al,[32] who studied current flow patterns and elucidated that the current density is highest beneath the electrodes and the areas close to the electrode axis. While bilateral ECT provides a more diffuse distribution of current, the current density is greatest along the anterior part of the electrode axis and in the frontal lobes. Cognitive tolerability has been addressed by Martino and colleagues,[33] who examined the use of ECT in individuals with head injury who were responsive to antidepressants prior to the head injury but treatment refractory after the injury. The authors concluded that there were no concerns with regard to cognitive tolerability of ECT after head injury as evidenced by neuropsychological testing.[33] Modern ventriculoperitoneal shunts use medical-grade silicone elastomers, and, therefore, electric conductance should not be a major concern. However, even with metallic components or content, ECT could also safely be used.

In summary, we advise the following before proceeding with ECT in patients with skull defects:

1. Complete a thorough history with full medication and physical health review;
2. Complete a CT scan of the head to confirm the existence of the implant (discussion with the radiologist may be helpful in deciding on electrode placement);
3. Discuss with the anesthetist the possibility of the need for restimulating if there are subthreshold seizures;
4. Map the planned electrode placement on the patient's head;
5. Discuss with the patient and next of kin the advantages and disadvantages of the treatment and potential complications;
6. Complete baseline psychometric assessment and rating on the Hamilton Depression Rating Scale[23,24] and MMSE[22]—alternatively the Montgomery-Asberg Depression Rating Scale[34] or the Beck Depression Inventory[35] could be used;
7. Place the electrodes as far away from the metallic implant as possible;
8. Consider that use of ultra brief stimuli and unilateral electrode placement may be an option in order to minimize cognitive deficits, but one will have to weigh issues such as increased duration of stimulus and potential heating of the clip and shunting of current;
9. Use of hyperventilation with oxygen or the administration of caffeine (pre-ECT) may be useful options;
10. Consider that the number of ECT treatments will depend on the severity of the depression and the response during the course of ECT (an average of 8–10 treatments seems to be adequate, with some patients going onto maintenance ECT); and
11. Conduct post-ECT reviews every 2 weeks for the first month by the psychiatrist and/or nurse in the community and repeat the MMSE and Hamilton Depression Rating Scale at each visit.

Implications

In the foreseeable future, head injuries will remain common, as will the associated mood disorders. The option of ECT will be an effective alternative in patients who have not responded to pharmacotherapy. Rapid advances in stroke interventions could mean an increased use of stents as a preventive mechanism in individuals at risk for cerebrovascular events, and ECT may become a common mode of intervention in those with severe treatment-resistant poststroke depression. The field of psychiatry will need to be prepared for this and other advances including deep-brain stimulation with intracranial "pacemakers." The steps outlined above will be a helpful guide to the administration of ECT in patients with head injury and implants with severe depression and suicidal risk. Finally, it should be noted that cochlear implant manufacturers have cautioned against the use of ECT due to the risk of damaging the device,[21] but the pros and cons of ECT will have to be weighed carefully in each case.

Drug names: carbamazepine (Carbatrol, Equetro, and others), clonazepam (Klonopin and others), lorazepam (Ativan and others), phenytoin (Dilantin, Phenytek, and others), risperidone (Risperdal and others), sertraline (Zoloft and others).

Author affiliations: Departments of Psychiatry (Drs Amanullah and Delva) and Medicine (Mr McRae), Dalhousie University, Halifax, Nova Scotia; and Departments of Psychiatry (Dr Amanullah) and Psychology (Dr Campbell), Hillsborough Hospital, and Queen Elizabeth Hospital (Ms Cole), Charlottetown, Prince Edward Island, Canada.

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