High-sensitivity Cardiac Troponin Elevation after Electroconvulsive Therapy

A Prospective, Observational Cohort Study

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ABSTRACT

Background: While electroconvulsive therapy is widely regarded as a lifesaving and safe procedure, evidence regarding its effects on myocardial cell injury is sparse. The objective of this investigation was to determine the incidence and magnitude of new cardiac troponin elevation after electroconvulsive therapy using a novel high-sensitivity cardiac troponin I assay.

Methods: This was a prospective cohort study in adult patients undergoing electroconvulsive therapy in a single academic center (up to three electroconvulsive therapy treatments per patient). The primary outcome was new high-sensitivity cardiac troponin I elevation after electroconvulsive therapy, defined as an increase of high-sensitivity cardiac troponin I greater than 100% after electroconvulsive therapy compared to baseline with at least one value above the limit of quantification (10 ng/l). Twelve-lead electrocardiogram and high-sensitivity cardiac troponin I values were obtained before and 15 to 30 min after electroconvulsive therapy; in a subset of patients, an additional 2-h high-sensitivity cardiac troponin I value was obtained.

Results: The final study population was 100 patients and a total of 245 electroconvulsive therapy treatment sessions. Eight patients (8 of 100; 8%) experienced new high-sensitivity cardiac troponin I elevation after electroconvulsive therapy with a cumulative incidence of 3.7% (9 of 245 treatments; one patient had two high-sensitivity cardiac troponin I elevations), two of whom had a non–ST-elevation myocardial infarction (incidence 2 of 245; 0.8%). Median high-sensitivity cardiac troponin I concentrations did not increase significantly after electroconvulsive therapy. Tachycardia and/or elevated systolic blood pressure developed after approximately two thirds of electroconvulsive therapy treatments.

Conclusions: Electroconvulsive therapy appears safe from a cardiac standpoint in a large majority of patients. A small subset of patients with preexisting cardiovascular risk factors, however, may develop new cardiac troponin elevation after electroconvulsive therapy, the clinical relevance of which is unclear in the absence of signs of myocardial ischemia. **(ANESTHESIOLOGY 2017; 126:643-52)**

ELECTROCONVULSIVE therapy (ECT) is used in the treatment of severe or otherwise refractory psychiatric conditions, such as bipolar disorder, refractory psychosis, and treatment-resistant major depression.[1] ECT involves administration of an electrical current to the head of the patient to initiate a generalized seizure. In spite of general anesthesia, ECT results in significant cardiovascular stress and carries the rare risk of more serious adverse cardiac events, including myocardial infarction (MI)[2–8] and stress-induced cardiomyopathy (Takotsubo).[9–12] While serious adverse cardiac events are rare, a recent report showed that isolated cardiac troponin elevations after ECT may occur as frequently as 1 in 10 patients.[13]

Until recently, a systematic evaluation of cardiac risk after ECT was hampered by the relative insensitivity of contemporary cardiac troponin assays and predominantly relied

What We Already Know about This Topic

- Previous studies have demonstrated that while electroconvulsive therapy (ECT) is widely regarded as a lifesaving and safe procedure, evidence regarding its effects on myocardial cell injury is sparse
- This study determined the incidence and magnitude of new cardiac troponin elevation after ECT using a novel high-sensitivity cardiac troponin I assay

What This Article Tells Us That Is New

- This prospective cohort study of 100 patients undergoing electroconvulsive therapy (ECT) demonstrated that (1) most patients did not develop a high-sensitivity cardiac troponin I (hscTnI) elevation after ECT; (2) median hscTnI values did not change after ECT, both when measured immediately and 2 h after ECT; and (3) a small subset of patients developed new hscTnI elevation after ECT, indicative of myocardial injury

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on clinical observations.[14] The recent introduction of high-sensitivity cardiac troponin (hscTn) assays[15,16] offered an opportunity to determine a better estimate of incidence and magnitude of cardiac troponin release after ECT because these assays allow the detection of baseline cardiac troponin values in most adult patients and thus a quantification of before and after changes. hscTn assays—currently not available in the United States, but approved in many other countries—measure the same cardiac troponin (I or T), but with markedly increased sensitivity. Indeed, the definition of high-sensitivity troponin assays is that the assay can detect circulating levels of cardiac troponin above the limit of detection in more than 50% of healthy subjects.[15] Numerous studies have shown that previously undetectable elevations of cardiac troponins are predictive of future cardiovascular risk.[16]

Materials and Methods

Study Design and Oversight

We conducted a prospective cohort study in 100 evaluable patients who underwent ECT at Barnes-Jewish Hospital, St. Louis, Missouri. The study was approved by the Institutional Review Board of Washington University, St. Louis, Missouri, and written informed consent was obtained from each patient.

Patients and Treatment

Adult patients scheduled to undergo ECT were eligible for recruitment. Patients with baseline cognitive impairment were excluded. ECT and anesthesia were provided according to departmental standards. For anesthesia, etomidate (0.1 to 0.2 mg/kg body weight) and succinylcholine (0.5 to 1 mg/kg body weight) were administered intravenously, and patients were ventilated with 100% oxygen. No β blockers or other antihypertensive drugs were administered per institutional practice. Typically, patients received either right unilateral, bifrontal, or bitemporal ECT treatment according to a standard institutional ECT regimen using a Thymatron System IV Electroconvulsive Therapy Unit (Somatics, LLC, Venice, Florida), and trains of 0.3-ms pulses at 6.0 times the seizure threshold for right unilateral (d'Elia position) and 1.0-ms pulses at 2.0 times the threshold for bitemporal and bitemporal treatments. Seizure thresholds were estimated at the initial treatment for all patients using a method of limits approach.

Assessment and Outcomes

The goal of this study was to quantify the incidence and magnitude of new cardiac troponin elevation after each ECT visit for a series of up to three treatments in each patient. Patient demographics, cardiovascular risks, and home medications were assessed at enrollment. For each treatment, high-sensitivity cardiac troponin I (hscTnI) and a 12-lead electrocardiogram were obtained within 2 h before and within 15 to 30 min after ECT in all patients. After study initiation, the study protocol was amended to allow the acquisition of an additional hscTnI sample 2 h after ECT to determine if hscTnI kinetics may reveal delayed troponin changes that were not present shortly after ECT. Electrocardiograms were analyzed for signs of ischemia (such as new ST-segment depression or elevation, T-wave inversion, presence of new Q waves or left bundle branch block) by a blinded expert. Periprocedural heart rate, blood pressure, and pulse oximetry were recorded in 2- to 5-min intervals, and clinical signs of myocardial ischemia were monitored until 2 h after ECT.

The primary outcome was the incidence of new hscTnI elevation after ECT, defined as an hscTnI increase greater than 100% combined with at least one value above the limit of quantification (LOQ; 10 ng/l). In addition, we determined new hscTnI elevations above the sex-specific 99th percentile upper reference limit (URL).[17] We investigated up to three ECT treatments per patient to determine the variability of hscTnI elevation after each ECT visit. Additional outcomes included MI defined as an hscTnI increase above the LOQ plus clinical or electrocardiographic signs of myocardial ischemia according to the Third Universal definition of MI,[18] hypertensive episode defined as periprocedural peak systolic blood pressure greater than 160 or greater than 200 mmHg, and tachycardia defined as a peak heart rate greater than 100 or greater than 150 beats/min.

Laboratory Analyses

Samples were collected in lithium heparin tubes and immediately put on ice, and were centrifuged within 30 min of collection. Plasma was transferred into cryogenic tubes and stored at −70°C. Biomarker measurements were performed in batches and by study personnel unaware of clinical outcomes. Grossly hemolyzed samples were excluded from analysis. hscTnI (reported as ng/l) was measured on an Abbott Architect STAT (Abbott Laboratories, USA) platform (limit of blank, 0.7 to 1.3 ng/l; limit of detection, 1.1 to 1.9 ng/l; LOQ, 10.0 ng/l; 99th percentile URL female 15.6 ng/l and male 34.2 ng/l).[19] Imprecision of the assay at the 99th percentile concentrations is less than 6% coefficient of variation.[15]

Statistical Analysis

Only ECT treatment visits with available before and after hscTnI levels were included for analysis. The cumulative incidence of new hscTnI elevation, as well as hypertensive episodes and tachycardia after ECT, was calculated per patient and per whole cohort. Sample size was not based on a formal sample size calculation but was chosen based on our previous experience using hscTn and its ability to reliably detect even small hscTn changes.[20] hscTnI values are presented as median and interquartile range. Friedman ANOVA for paired hscTnI data was used to test for statistically significant changes in hscTnI levels across three treatments for all patients and in the subgroup with an additional hscTnI sample available 2 h after ECT. Linear correlation was analyzed by calculation of Spearman correlation coefficient. All

P values are two sided, and $P < 0.05$ was considered statistically significant (IBM® SPSS® version 22; IBM, USA; JMP Pro 12.2; SAS Institute, USA). Plots were produced using GraphPad Prism® version 6.07 (GraphPad Software Inc., USA) and JMP 12.2. (SAS Institute).

Results

Patients

Between June 2011 and September 2012, one hundred fifteen patients were recruited into the study. After withdrawal of 15 patients, the final study population was 100 patients (fig. 1), of whom 58 patients had three ECT visits, 29 patients had two ECT visits, and 13 patients had one ECT visit analyzed. In total, complete before and after hscTnI data were available for 245 ECT treatment visits ($58 \times 3 + 29 \times 2 + 13 \times 1 = 245$). In the final 14 of 100 (14%) patients (35 of 245 ECT treatments), an additional hscTnI level was obtained 2 h after ECT. Table 1 presents patient characteristics. The majority of patients received ECT for major depressive disorder or bipolar disorder. Table 2 provides details about the ECT treatments. In 38% (n = 38), the first study ECT visit coincided with the first ECT treatment the patient received during which initial seizure threshold determination was made.

Study Outcomes

Figure 2 shows the absolute and relative changes in hscTnI after ECT. hscTnI levels did not change significantly after ECT treatments both immediately after ECT (n = 72; $P = 0.4$) and as in the subgroup with an additional hscTnI sample available 2 h after ECT (n = 10; $P = 0.6$; fig. 3). Most patients did not experience an increase in hscTnI after ECT, but a subset had a marked increase (maximum hscTnI, 731.6 ng/l). Patients who developed new hscTnI elevation after ECT tended to be older and had more cardiovascular risk factors.

Eight patients (8 of 100; 8%) experienced new hscTnI elevation after ECT with a cumulative incidence of 3.7% (9 of 245 treatments; one patient experienced two hscTnI elevations after separate ECT visits; table 3; fig. 4). A detailed description of the eight patients who developed a new hscTnI increase is provided in table 3. Two patients (patients A and C in table 3 and fig. 4) met definitive criteria for non–ST-elevation MI (NSTEMI; incidence 2 of 245; 0.8%). In a total of 10 ECT visits (10 of 245; 4.1%) of six patients (6/100; 6%), hscTnI was already elevated greater than 99th percentile URL before ECT, and they did not experience a subsequent new hscTnI elevation.

Patients who had their initial ECT treatment with seizure threshold determination did not experience significantly different absolute or relative hscTnI change after ECT compared to patients who had subsequent ECT treatments (median [interquartile range]: absolute difference, −0.1 ng/l [−0.9 to 0.8] *vs.* −0.1 [−1.1 to 0.9]; $P = 0.74$; relative difference, −1.8% [−16.9 to 9.8] *vs.* −2.4% [−16.9 to 14.4]; $P = 0.95$). Four patients with initial ECT and seizure threshold determination experienced an hscTnI increase greater than 100% (4 of 37; 10.8%) compared to four patients undergoing subsequent ECT treatments (4 of 62; 6.5%); this corresponded to a nonsignificant unadjusted odds ratio of 1.68 (95% CI, 0.40 to 7.11; $P = 0.48$). Neither central seizure duration nor convulsion duration was correlated with absolute hscTnI change after ECT (r = −0.10 and −0.13, respectively). Among the eight patients with hscTnI elevation, seven received right unilateral and one bifrontal ECT treatment.

In approximately two thirds of ECT visits patients developed tachycardia (heart rate greater than 100 beats/min) and/or a hypertensive episode (systolic blood pressure greater than 160 mmHg) (table 4). In approximately 17%

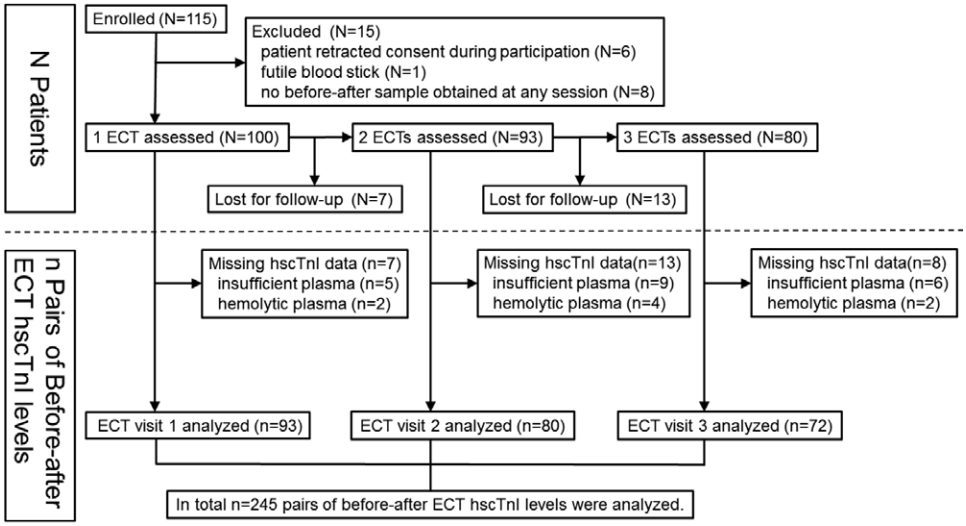

Fig. 1. Consolidated Standards of Reporting Trials (CONSORT) diagram: study flow. Of 115 patients enrolled, 100 patients had at least one pair of analyzable high-sensitivity cardiac troponin I (hscTnI) levels before and 15 to 30 min after an electroconvulsive therapy (ECT) treatment.

Table 1. Baseline Characteristics

	No Elevated hscTnI (n = 92)	Elevated hscTnI (n = 8)	Total (n = 100)	Standardized Difference
Patient characteristics				
Age, yr, mean (SD)	45 (14)	53 (19)	46 (14)	0.55
Male, n (%)	49 (53)	4 (50)	53 (53)	0.05
Race, n, white/black/other	82/7/3	8/0/0	90/7/3	0.34
Smoking history, n (%)	53 (58)	6 (75)	59 (59)	0.25
Primary indication for ECT, n (%)				
Major depressive disorder	75 (82)	7 (88)	82 (82)	0.17
Bipolar disorder	14 (15)	1 (13)	15 (15)	
Posttraumatic stress disorder	1 (1)	0	1 (1)	
Severe eating disorder/obsessive compulsive disorder/depression	1 (1)	0	1 (1)	
Comorbidities, n (%)				
Hypertension	37 (40)	1 (13)	38 (38)	0.46
Hypercholesterolemia	20 (22)	4 (50)	24 (24)	0.75
Atrial fibrillation	3 (4)	0	3 (3)	0.30
Coronary artery disease	3 (3)	1 (13)	4 (4)	0.84
Previous myocardial infarction	2 (2)	1 (13)	3 (3)	1.23
Congestive heart failure	2 (2)	0	2 (2)	0.26
Diabetes	11 (12)	2 (25)	13 (13)	0.51
Insulin-dependent diabetes	4 (4)	0	4 (4)	0.34
Chronic kidney disease	4 (4)	0	4 (4)	0.34
Stroke/transient ischemic attack	2 (2)	0	2 (2)	0.26
Medication, n (%)				
Aspirin	14 (15)	2 (25)	16 (16)	0.31
β Blocker	16 (17)	0	16 (16)	0.52
Clopidogrel	1 (1)	0	1 (1)	0.19
Warfarin	2 (2)	0	2 (2)	0.26
Angiotensin-converting enzyme inhibitor	11 (12)	0	11 (11)	0.47
Statin	11 (12)	3 (38)	14 (14)	1.09
Angiotensin II receptor blocker	4 (4)	0	4 (4)	0.34
Calcium channel blocker	10 (11)	0	10 (10)	0.46
Diuretics	14 (15)	1 (13)	15 (15)	0.09

ECT = electroconvulsive therapy; hscTnI = high-sensitivity cardiac troponin I.

Table 2. ECT Treatment Details

Treatment Details	Count
At ECT visit 1	
Initial ECT titration and treatment #1	38
Treatment #2–#5	38
Treatment #6–#10	10
Treatment > #10	13
Unknown	1
Lead placement	
Right unilateral	89
Bilateral	6
Bifrontal	4
Unknown	1
Required > 1 stimulus	2
Duration of convulsion, s, median (IQR)	37 (27–50)
Duration of central seizure, s, median (IQR)	57 (37–80)

Count equals percent. Electroconvulsive therapy (ECT) data were missing for one patient.

= number of patient's ECT treatment; IQR = interquartile range.

of ECT visits, peak systolic blood pressure was elevated greater than 200 mmHg with the maximum reaching up to 250 mmHg. Neither peak heart rate (r = −0.06) nor systolic blood pressure (r = 0.19) was correlated with absolute hscTnI change.

Discussion

This prospective cohort study of 100 patients undergoing ECT demonstrated that (1) most patients did not develop an hscTnI elevation after ECT; (2) median hscTnI values did not change after ECT, both when measured immediately and 2 h after ECT; (3) a small subset of patients developed new hscTnI elevation after ECT, indicative of myocardial injury. Because we obtained hscTnI values in up to three ECT treatments per patient, we were able to determine if some patients always develop hscTnI elevation after ECT. Unexpectedly, there was no consistency between ECT treatments, *e.g.*, patients may develop hscTnI elevation after one ECT treatment but not after another treatment.

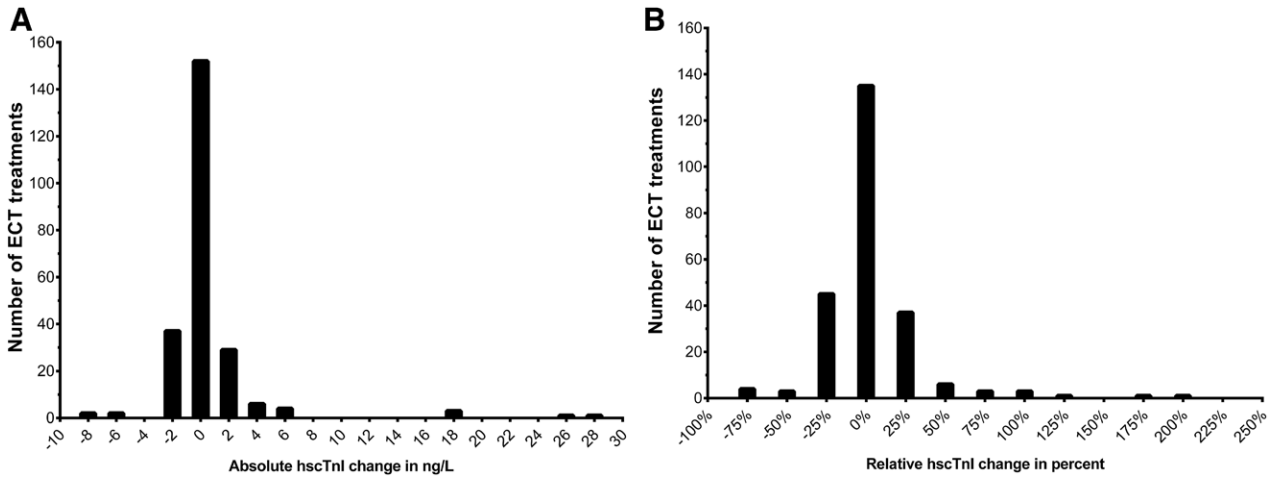

Fig. 2. Histogram of absolute (*A*) and relative (*B*) changes in high-sensitivity cardiac troponin I (hscTnI) after electroconvulsive therapy (ECT).

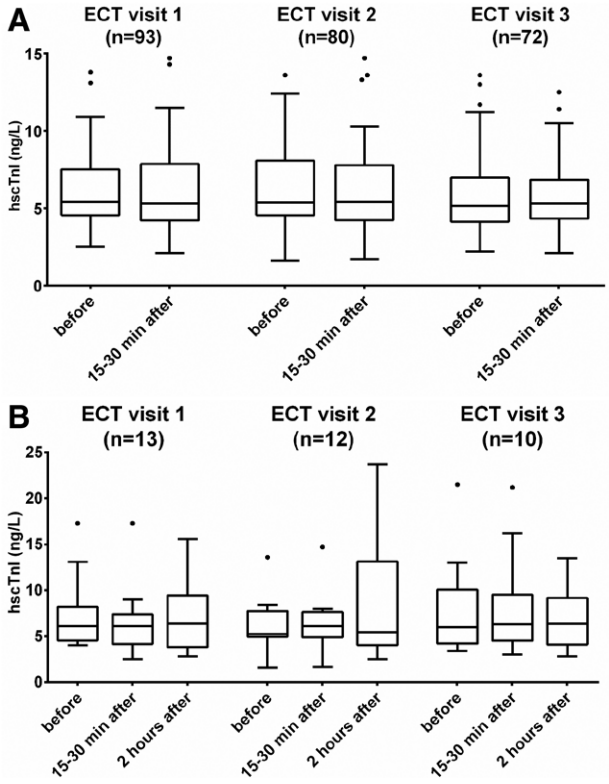

Fig. 3. High-sensitivity cardiac troponin I (hscTnI) before and after electroconvulsive therapy (ECT) visits. Boxplots with Tukey whiskers represent hscTnI levels (median [IQR]) at ECT visits 1, 2, and 3. (*A*) hscTnI levels before and 15 to 30 min after ECT of all patients: Before ECT 1: 5.4 (4.6 to 7.5); 15 to 30 min after ECT 1. (*B*) hscTnI levels before, 15 to 30 min, and 2 h after ECT of the subgroup with an additional blood sample obtained 2 h after ECT.

New Cardiac Troponin Elevation

Cardiac troponin, a myocardial protein, is a very sensitive and specific cardiac and standard biomarker for the diagnosis of MI.[18] Cardiac troponin is released when myocardial cells are injured and the magnitude of cardiac troponin elevation correlates with the damaged or necrotic myocardial cell mass. The newly developed hscTn assays (not available in the United States at present) measure the same cardiac troponin molecule but have significantly increased analytic sensitivity that allows detection of circulating cardiac troponin in more than 50% of healthy subjects.[15]

Cardiac troponin elevations in the absence of clinical symptoms, such as chest pain or ischemic electrocardiographic changes, have recently been referred to as myocardial injury or myocardial damage.[21,22] However, there are currently no accepted guidelines as to which absolute or relative cardiac troponin elevations and changes constitute myocardial injury.[21] Short-term within-individual biologic variability of cardiac troponin concentrations in healthy subjects has been reported to be 4 to 14%, and when combined with analytic variability, the positive reference change value for hscTnI is 45 to 52%.[23–25] The biologic and analytic variability of hscTnI levels may therefore result in intraindividual increases and decreases of up to 52%. The reference change value is the change that exceeds normal biologic variability and analytic variability and represents a physiologic change. Thus, in the rapid rule-in/rule-out diagnosis of MI in patients with chest pain, a relative increase of greater than 50% is often interpreted as a positive test.[15] Little evidence is available for clinical scenarios in which a true baseline can be obtained, such as patients undergoing ECT or cardiac stress test. Taking into account the uncertainty around what is considered a significant cardiac troponin elevation, as well as analytic and biologic variabilities, we opted for a conservative cutoff of greater than 100% hscTnI increase compared to the pre-ECT sample to identify patients with a new significant cardiac troponin elevation after ECT in order to decrease the likelihood of false-positives.[17,24,26–28]

Clinical Relevance

New cardiac troponin elevations without definitive signs of myocardial ischemia have recently been referred to in the cardiology literature as myocardial injury or myocardial

Table 3. Patients with Events of New hscTnI Elevation after ECT

Panel in Fig. 4	Sex, Age (yr)	ECT Visit 1 hscTnI, ng/l; Treatment n, #		ECT Visit 2 hscTnI, ng/l; Treatment n, #		ECT Visit 3 hscTnI, ng/l; Treatment n, #		With New hscTnI Elevation after ECT			
		Before	After	Before	After	Before	After	Adverse Events	Ischemic Electrocardiographic Signs	Adjudication	Other Findings
A	Female, 40	2.5 #2	**19.7**	2.7 #3	2.9	2.5 #4	2.1	Bradycardia, bigeminus, hypertensive episode	ST-depression	NSTEMI	She developed bradycardia and new RBBB during ECT #2. Clinical cTnI peaked at 1.04 μg/l and she received emergent CAG that showed stress-induced CMP (acute heart failure, LVEF 40%, no CAD), which resolved over a few days. After a pause of 3 months, an uneventful course of 28 ECTs followed with previous β blocker
B	Female, 55	4.6 #1	**22**	n/a		n/a		None	Negative	Negative	She had no adverse events or clinical symptom of MI at ECT #1 and an uneventful course of 28 ECTs
C	Male, 29	8.8 #1	**34.7**	**189.8** #2	**173.9**	n/a		Chest pain	Negative	NSTEMI	He had chest pain with unspecific electrocardiographic changes after ECT #1, brief new atrial fibrillation during ECT #2, and urgent cardiology consult. Psychiatrist decided to discontinue ECT treatment
D	Male, 62	4.4 #4	10.2	10.8 #5	10.2	11.2 #6	12.5	Hypertensive episode	Negative	Negative	He had no clinical symptom of MI at ECT #4 and an uneventful course of 49 ECTs
E	Male, 83	10 #1	27.6	7.5 #2	9.7	32.7 #3	**166.9**	Bradycardia, hypertensive episode	Negative	Negative	He had no clinical symptom of MI at ECT #3 and an uneventful course of 31 ECTs
F	Female, 29	5.1 #1	10.5	**18.7** #2	**17.4**	13.6 #3	11.4	Hypertensive episode	Negative	Negative	She had no clinical symptom of MI at ECT #1 and an uneventful course of 13 ECTs
G	Male, 73	8.8 #1	9.8	8.4 #2	15.2	13.0 #3	**365.0**	None	Negative	Negative	He had no clinical symptom of MI at ECT #3 and an uneventful course of 10 ECTs. He had a history of MI and coronary stent (CAG before ECT showed patent stent and no obstructive CAD)
H	Female, 51	6.1 #2	**33.9**	13.6 #3	15.1	6.2 #5	6.7	None	Negative	Negative	She had no clinical symptom of MI at ECT #2 and an uneventful course of 10 ECTs

Data in boxes show events of hscTnI increase greater than 100% combined with greater than limit of quantification (10 ng/l) compared to before the respective electroconvulsive therapy (ECT) visit. Numbers in boldface are high-sensitivity cardiac troponin I (hscTnI) values greater than 99th sex-specific percentile upper reference limit (female 15.6 ng/l and male 34.2 ng/l). Patients were followed for up to three visits. hscTnI data of cases are plotted in the corresponding panels A to H of figure 4.

= of patient's ECT treatment; CAD = coronary artery disease; CAG = coronary angiography; CMP = cardiomyopathy; LVEF = left ventricular ejection fraction; MI = myocardial infarction; n/a = not available; NSTEMI = non–ST-elevation myocardial infarction; RBBB = right bundle branch block.

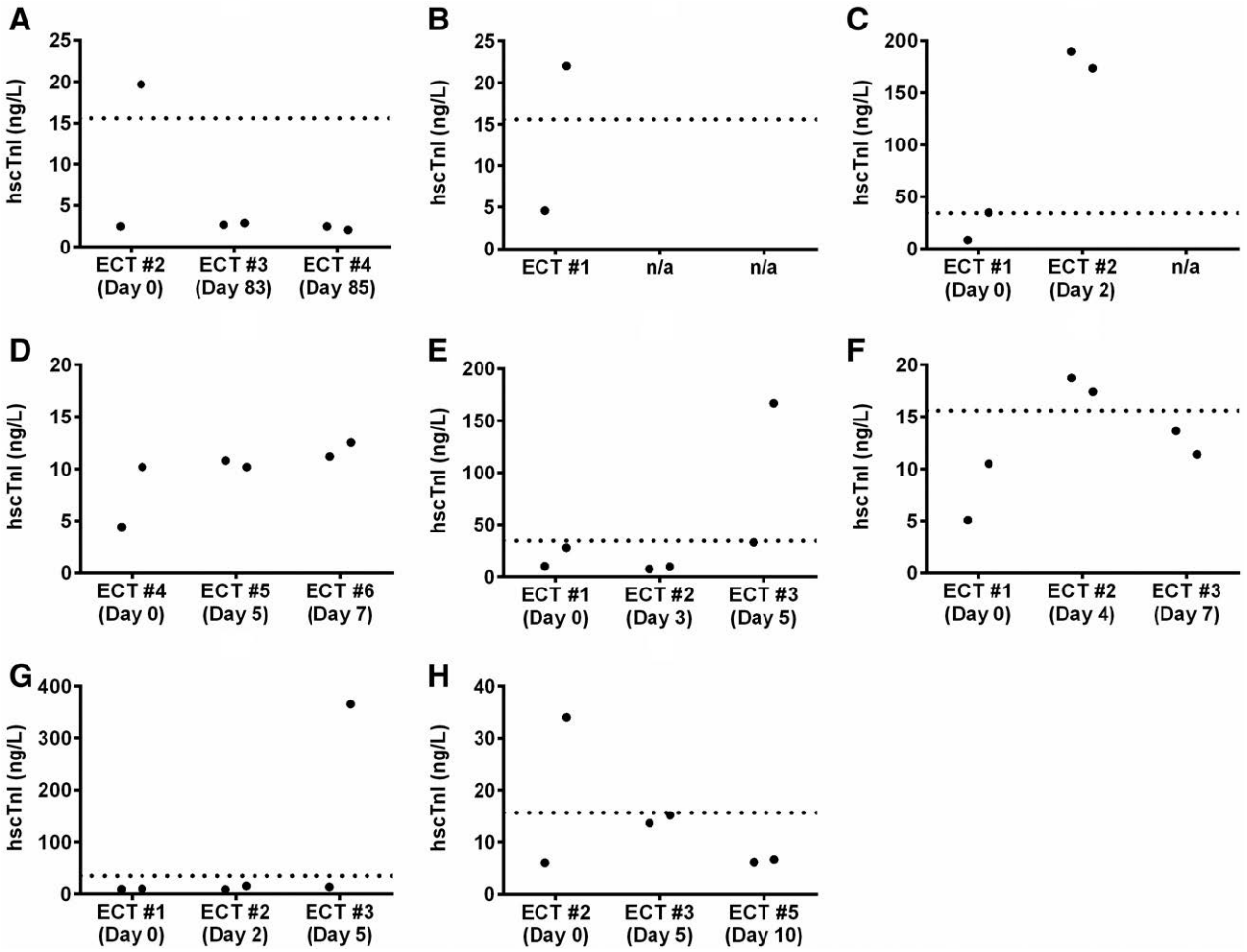

Fig. 4. Patients with new high-sensitivity cardiac troponin I (hscTnI) elevation after electroconvulsive therapy (ECT). The *dotted lines* indicate the greater than 99th sex-specific percentile upper reference limit. Individual patients (*A–H*) were followed for up to three visits. Clinical and numeric hscTnI data are shown in table 3. # = number of patient's ECT treatment.

damage.[22] Although the criteria for defining and diagnosing myocardial injury or damage are lacking, there is evidence that even small cardiac troponin elevations after major stress may have prognostic significance for subsequent cardiovascular morbidity and mortality.[29] The cause for the observed new hscTnI elevations in our patient population is unclear: in some patients, particularly those with preexisting coronary artery disease, the cause may be stress-induced myocardial ischemia *via* supply-and-demand mismatch. In other patients, stress-induced catecholamine release may directly cause myocardial cell damage. The latter mechanism is possibly related to stress-induced cardiomyopathy (Takotsubo), which has been described in patients undergoing ECT.[9–12] Investigations focused on electro- and echocardiographic evidence for ECT-induced myocardial ischemia found incidence rates of new regional wall motion abnormalities (indicative of ischemic myocardium in the distribution of a coronary artery) in 4 to 45% of patients.[4,30] The largest population-based study of mortality after ECT found 78 deaths within 30 days after ECT among 99,728 ECT treatments in the Danish National Patient Register (mortality rate, 0.08%). Six of these deaths occurred on the day of ECT treatment. The most prevalent attributed cause of deaths was cardiopulmonary.[31]

Using contemporary cardiac troponin assays, Martinez *et al.*[13] found an 11.5% incidence rate of new abnormal cardiac troponin elevations after ECT.[32] Integrating case report series, cardiac biomarker studies, and echocardiographic evidence, it appears that a small subset of patients—probably those with chronic heart and/or lung disease—are at higher risk of developing adverse cardiac events after ECT. It is beyond the scope of this article, but efforts have been made to use preventive strategies to mitigate the cardiac risk associated with ECT in high-risk patients, such as improved identification,[14] or therapeutic strategies, such as β blockers.[33,34] It should be pointed out that patients who did not develop new hscTnI elevation after ECT, but had already elevated baseline hscTnI values, may be at increased long-term cardiovascular risk even if they did not experience myocardial injury during ECT.

Table 4. Electroconvulsive Therapy Visits with Elevation of hscTnI, Blood Pressure, and HR

		hscTnI Elevation > 100% and > LOQ			
	No hscTnI Elevation	With Elevation > 99th Percentile URL	Without Elevation > 99th Percentile URL	Missing Blood Pressure and HR Data	Total
Count, n (%)	235 (95.9)	6 (2.4)	3 (1.2)	1 (0.4)	245 (100)
Hypertensive episode, n (%)					
Systolic blood pressure > 160 mmHg	152 (62.0)	5 (2.0)	2 (0.8)	1 (0.4)	159 (64.9)
Systolic blood pressure > 200 mmHg	42 (17.1)	3 (1.2)	1 (0.4)	1 (0.4)	46 (18.8)
Tachycardia, n (%)					
HR > 100 beats/min	152 (62.0)	3 (1.2)	2 (0.8)	1 (0.4)	157 (64.1)
HR > 150 beats/min	4 (1.6)	0 (0.0)	0 (0.0)	1 (0.4)	4 (1.6)

Hemodynamic data of individual ECT visits with complete before- and after-hscTnI values. Reported proportions are percent of the total N = 245. Periprocedural peak blood pressure and heart rate were used to calculate incidence of hypertensive episodes and tachycardia in ECT visits with and without new hscTnI elevation. Of nine electroconvulsive therapy visits with new hscTnI elevation greater than 100% and greater than LOQ (10 ng/l), six were with an elevation greater than 99th percentile URL (female 15.6 ng/l; male 34.2 ng/l) and three were not.

ECT = electroconvulsive therapy; HR = heart rate; hscTnI = high-sensitivity cardiac troponin I; LOQ = limit of quantification; URL = upper reference limit.

Strengths and Weaknesses

The use of a novel hscTn assay is a strength of the study for 2 main reasons. First, these novel assays have increased the sensitivity for detection of cardiac troponin by an order of magnitude over traditional cardiac troponin assays. The increased sensitivity allows for the detection of small cardiac troponin concentration differences with a high degree of precision. Second, the use of these hscTn assays allows for the detection of circulating cardiac troponin at baseline and in the absence of an acute cardiac event. Thus, they allow before and after measurements and thereby a rigorous quantification of Δ or change values, which correspond to the amount of injured myocardium. However, there is overwhelming evidence in other populations that increased cardiac troponin predict future cardiovascular risk.[15,16]

First, the fact that this study did not follow patients for long-term cardiovascular outcomes precludes the determination if observed cardiac troponin elevations had any long-term clinical relevance. Second, we were unable to obtain pre- and post-ECT hscTnI values for all patients and all three planned ECT treatment measurements, which limited the power of the study. Third, the study was not designed to obtain robust incidence rates for hard clinical outcomes, such as NSTEMI. Thus, the observed incidence rate of NSTEMI (2%) may substantially under- or overestimate the true incidence.

Conclusions

In the overwhelming majority of patients, ECT appears to be safe from a cardiac standpoint. A small subset of patients develops cardiac troponin elevation after ECT, suggestive of myocardial injury. Lacking long-term outcome data, however, the clinical relevance of an isolated new cardiac troponin elevation after ECT, in the absence of evidence of myocardial ischemia, is currently unclear and should be determined in a larger prospective study that follows cardiovascular outcomes.

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Competing Interests

Dr. Nagele has filed for intellectual property protection related to the use of nitrous oxide in major depression. Dr. Zorumski serves on the Scientific Advisory Board of Sage Therapeutics (Cambridge, Massachusetts). The other authors declare no competing interests.

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