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The clinical utility of qualitative electroencephalography during tilt table testing – A retrospective study

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HIGHLIGHTS

- Simultaneous EEG recording during tilt table studies does not have significant clinical impact.
- Not all patients with syncope have EEG changes at the time of the syncope.
- EEG changes are not seen in other symptomatic orthostatic syndromes.

ABSTRACT

Objective: To assess electroencephalography (EEG) changes during tilt table testing in syncope and other orthostatic syndromes.
Methods: We retrospectively reviewed consecutive tilt table studies with simultaneous EEG from April 2014 to May 2016 at our center. All patients had video EEG during tilt table. All patients had at least 10 min of head up tilt unless they had syncope or did not tolerate the study. Video EEG was interpreted by epileptologists.
Results: Eighty-seven patients met the inclusion criteria. Mean age was 45 years, and 55 were women. Seven patients (~8%) had syncope during tilt table, 11 patients (~12%) had significant neurogenic orthostatic hypotension and a separate group of 11 patients (~12%) had significant orthostatic tachycardia. Valsalva responses were abnormal in 7 of the 11 patients with orthostatic hypotension, suggesting an underlying neurogenic orthostatic hypotension. Visually discernable EEG changes were seen in only 3 patients (~43%) who had syncope and in 1 patient (~9%) with orthostatic tachycardia.
Conclusions: Qualitative EEG analysis based on visual inspection during tilt table study revealed abnormalities in less than half the patients with syncope and a very small fraction with orthostatic tachycardia.
Significance: Routine qualitative EEG recording might not be clinically useful during tilt table studies.

1. Introduction

Head-up tilt table testing (HUT) is often performed to aid in the diagnosis of patients with unexplained syncope (Task Force for the Diagnosis and Management of Syncope et al., 2009) or other disorders of orthostatic intolerance, such as orthostatic hypotension (OH) or postural tachycardia syndrome (POTS) (Freeman, 2008). It may also be performed to help rule out other diagnoses such as epileptic seizures, which can be difficult to differentiate from convulsive syncope, or myoclonus associated with syncope. In some patients, seizures may lead to bradycardia or sinus pauses and can lead to syncope (Britton and Benarroch, 2006; Nguyen-Michel et al., 2014). In these clinical situations, HUT with simultaneous video EEG monitoring may aid in the diagnosis of convulsive syncope, thereby avoiding inappropriate chronic antiepileptic therapy. Simultaneous video EEG monitoring during HUT may also help to differentiate other causes of transient loss of awareness or consciousness, such as functional or psychogenic non-epileptic seizures.

The benefits of HUT in clinical practice have been well documented (Kosinski and Grubb, 1994), however the additional value of continuous video EEG monitoring during HUT has not been consistently demonstrated. Prior studies have described multiple patterns of EEG changes with syncope (Van Dijk et al., 2014), however these findings have not been replicated and their clinical implications remain uncertain. In addition, we do not know if patients

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with other disorders of orthostatic intolerance, such as OH or POTS, exhibit EEG changes during periods of orthostatic stress. Orthostatic hypotension has been associated with orthostatic cognitive impairment (Centi et al., 2017) and many patients with POTS report cognitive slowing or "brain fog" when upright, presumably due to cerebral hypoperfusion. In this study, we attempted to assess the frequency of EEG changes during HUT in two groups of patients: those who had either neurocardiogenic syncope or presyncope during testing, and those with a diagnosis of OH or POTS who were symptomatic but did not have syncope during HUT.

2. Methods

We reviewed the charts of all patients who were referred for syncope or convulsive syncope that underwent simultaneous video EEG monitoring with HUT at the Stanford Autonomic Center during the period of April 2014 to May 2016. Medications that may influence autonomic study findings, such as anticholinergics, antidepressants or narcotics, were held for 24–48 h prior to testing, however anti-epileptic medications were continued. Patients were instructed to maintain adequate levels of hydration, and caffeinated beverages were avoided. EEG recording was performed using 24 disposable disc electrodes (Ag/AgCl) placed according to the international 10–20 system. EEG data was acquired using the Nihon Kohden Neurofax (Irvine, CA) recording system, sampled at 200 Hz, with simultaneous video recording. All patients had video EEG recording for at least 30 min prior to tilt. EEG recording continued during HUT and several minutes after returning to the supine position. All raw EEG traces were reviewed by trained epileptologists.

All patients underwent at least 10 min of HUT, unless they either lost consciousness or experienced symptoms that were too severe to continue the test. Tilt angle is 70° and we did not use any pharmacological agents or vasodilator medications (Fitzpatrick et al., 1991). Beat-to-beat blood pressure (BP) and heart rate (HR) were continuously monitored and recorded by finger arterial pulse contour analysis (Nexfin, Edwards Instruments). Most patients underwent other tests of autonomic function including measurement of heart rate variability with deep breathing and the BP and HR response to the Valsalva maneuver. Data was collected and analyzed using Testworks software (WR Medical Electronics), and all relevant orthostatic symptoms reported by the patients were recorded during the study. All studies were supervised and interpreted by autonomic specialists (SM, MM or SJ), and all video EEG recordings were interpreted by epileptologists at our institution.

Patients were divided into groups based on their clinical history and the results of HUT, in accordance with current consensus criteria for orthostatic syndromes (Freeman et al., 2011). A diagnosis of OH was defined as a sustained blood pressure (BP) fall of $\geq$20 mmHg systolic or 10 mmHg diastolic within the first three minutes of HUT. A diagnosis of POTS was defined as a sustained heart rate increase of $\geq$30 beats per minute, within the first 10 min of HUT, accompanied by symptoms of orthostatic intolerance without a significant drop in blood pressure. Symptoms of orthostatic intolerance must have been present for at least 6 months in the absence of prolonged bed rest and not explained by other conditions. A diagnosis of neurally-mediated syncope (NMS) was defined as an abrupt fall in blood pressure and heart rate on HUT, followed by syncope or presyncope. Syncope was defined as a loss of consciousness, and presyncope was defined as a sensation of near loss of consciousness. This retrospective study was approved by IRB committee at our institution and met the ethical standards to complete this analysis.

3. Results

Eighty-seven patients underwent tilt table testing with simultaneous video EEG monitoring. The mean age of patients was 45 years (range 16–82 years), and 55 were women. All patients were referred for the evaluation of syncope or convulsive syncope, and all patients were previously seen by a neurologist. Only two patients were previously diagnosed with epilepsy. Only 7 (8%) had syncope during head up phase out of the 87 who underwent HUT. The time from tilt up to syncope ranged from 3 to 23 min. Of these 7 patients, only 3 had visually discernable EEG changes during their syncopal event (Table 1). One had "flattened" EEG waveforms with syncope (Fig. 1), and the other two had background slowing with syncope onset. The remaining patients did not have any clear EEG changes, even though all had clinically observable loss of consciousness that resolved upon tilt back to the supine state. There was no clear relationship between the time to syncope and the EEG changes observed. We also reviewed maximum recorded drop in SBP with syncope or presyncope. The mean drop in SBP in the 3 individuals with EEG changes was 71 mmHg. Among 4 patients who did not have EEG changes at the time of syncope, one had profound drop in SBP and was briefly not recordable. The mean drop in SBP in others without EEG changes during syncope was 60 mmHg. There was no correlation between drop in diastolic BP and incidence of syncope or EEG changes.

Other abnormal findings during HUT included symptomatic OH and symptomatic orthostatic tachycardia. Eleven patients (12%) had symptomatic OH, with a mean drop in systolic BP of 40 mmHg (range 30–110 mmHg). There were no discernable EEG changes during periods of hypotension in these patients. Another eleven patients (12%) had exhibited an exaggerated postural tachycardia. Only one of these patients (9%) had reversible EEG changes on HUT, consisting in this particular case of diffuse slowing that resolved upon tilt back. Nineteen patients (21%) had an abnormal baseline EEG prior to tilt, with findings that included focal slowing in the temporal and frontal regions. These focal abnormalities remained unchanged during tilt. Patients with focal changes had imaging studies and none of the patients had any structural abnormalities. Neurologists evaluated all patients in our practice either before or after Tilt EEG studies. Additionally, one patient had a psychogenic non-epileptic event while supine prior to tilt. No patients exhibited psychogenic non-epileptic events during HUT.

4. Discussion

We retrospectively evaluated the clinical utility of simultaneous EEG monitoring during HUT and observed several notable findings in our practice: (1) Syncope occurred in only 10% of patients during HUT; (2) Only 43% of patients with syncope had observable changes in their EEG pattern during the syncopal event; (3) EEG patterns rarely changed in symptomatic patients with OH or POTS. (4) In our cohort of 87 patients, simultaneous EEG monitoring during HUT did not alter the eventual diagnosis or treatment plan.

HUT has proven to be a valuable diagnostic tool in the evaluation of patients with syncope (Kosinski and Grubb, 1994; Kaufmann, 1995) and should continue to be utilized for this purpose. While simultaneous EEG monitoring with HUT may prove useful in select cases, our data does not support its use in routine clinical practice. For example, simultaneous EEG during HUT may prove useful when a diagnosis of psychogenic syncope or psychogenic non-epileptic seizures is suspected, as it may be useful to document a normal BP and EEG response during an episode (Blad et al., 2015). In our cohort, only one patient had a psychogenic episode, and this occurred while in the supine position.