Prolonged implantable electrocardiographic monitoring indicates a high rate of misdiagnosis of epilepsy—REVISE study

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Aims
Syncope, epilepsy, and psychogenic psuedo-syncope are the most common causes of transient loss of consciousness (T-LOC or blackout). All can present with similar features, including abnormal limb movements. It is reported that somewhere between 13 and 42% of patients with ‘epilepsy’ may be misdiagnosed. A UK Parliamentary working group found that at least 74 000 English patients are misdiagnosed with epilepsy, and taking antiepileptic drugs. The likely alternative diagnosis is ‘convulsive’ syncope, mimicking an epileptic seizure. We hypothesized that many patients misdiagnosed with epilepsy have convulsive reflex syncope, and that prolonged electrocardiographic (ECG) monitoring with an implantable ECG recorder (ILR) would show reflex cardioinhibition during T-LOC. This would respond to permanent pacing and allow antiepileptic drugs to be withdrawn. We also aimed to evaluate tilt testing and other tests done in these patients.

Methods and results
We included patients previously diagnosed with epilepsy, but considered to have a definite or likely misdiagnosis of epilepsy after specialist neurological review. All received an ILR (Reveal Plus⁶/Reveal DX®, Medtronic Inc.), and tilt-table testing. One hundred and three patients were included, mean age of 46 ± 17 years, with 58 of 103 (56%) female patients. A diagnosis of epilepsy was previously made by a neurologist in 69%, but definite tonic-clonic seizures were only noted in the history in 4%. In 22 patients (21%), the ILR recorded profound bradyarrhythmia or asystole with convulsive features, and they were offered pacemaker implantation. After pacing and withdrawal of antiepileptic drugs, 60% of these patients were asymptomatic. Only 14% of patients had a positive tilt-table test. In these, there was no correlation with the ECG findings of a spontaneous blackout during ILR recording.

Conclusion
This study shows a high incidence of the cardioinhibition of reflex syncope in patients with convulsive T-LOC previously diagnosed as epilepsy and treated with antiepileptic drugs. We believe that reflex syncope with convulsive features mimics generalized epilepsy, leading to a misdiagnosis. This may be a widespread problem accounting for many wrong diagnoses of epilepsy. There was also poor correlation in ECG findings between tilt testing and ILR recording.

Keywords
Epilepsy • Convulsive syncope • Misdiagnosis • Cardioinhibition • Implantable ECG monitoring (ILR)

Introduction
Syncope, epilepsy, and psychogenic psuedo-syncope are the three most common causes of transient loss of consciousness (T-LOC/blackout).¹–³ All three can present with similar clinical features, including abrupt T-LOC without warning, abnormal limb movements such as myoclonic jerks or tonic-clonic activity,⁴–⁸ and incontinence. Establishing a diagnosis is a clinical challenge, based on the
history and eye-witness accounts. Abnormal movements are easily equated to a ‘seizure’, leading to a misdiagnosis of epilepsy, but also occur frequently with cerebral anoxia during syncope. In order to confirm a clinical diagnosis objectively, an episode of T-LOC has to be captured during physiological recording, as few clues exist between attacks. The surest method available to do this is videotelemetry, where patients are admitted for long periods under video surveillance during continuous electroencephalography (EEG) and electrocardiographic (ECG) monitoring. This is very costly, with very limited availability, and many patients thought to have epilepsy are treated on the basis on the clinical features alone. Clinical review and supplementary tilt testing in some cases disclose that between 13 and 42% of patients with epilepsy are misdiagnosed. The alternative diagnosis is syncope, by far the most likely cause of T-LOC. Elsewhere, it has been noted that patients with reflex syncope with abnormal movements have a higher rate of cardioinhibition during tilt table testing than those without abnormal movements. This serves to suggest that many patients with a diagnosis of epilepsy could have reflex syncope with abnormal limb movements, or ‘convulsive syncope’. We believed that prolonged electrocardiographic monitoring with an implantable ECG recorder (ILR) would show that many patients would have cardioinhibition during T-LOC. We anticipated that these patients would respond to permanent pacing and allow antiepileptic drugs (AEDs) to be withdrawn.

Aims

The aims of this study were to (i) determine the incidence of cardioinhibition during T-LOC/blackout using ILRs in patients with a previous diagnosis of epilepsy; (ii) correlate the results of tilt testing with the findings of the ILR; (iii) determine the value of other tests in this group of patients; and (iv) implant pacemakers in patients with cardioinhibition, stop their antiepileptics and assess their progress.

Methods

We describe our experience of 103 patients previously diagnosed with epilepsy by neurologists and generalists, from two subgroups, one retrospective (n = 62) and the other prospective (n = 41). Both subgroups presented with T-LOC with convulsive movements and were evaluated in very similar ways. Patients with T-LOC but without any abnormal limb movements were excluded.

Retrospective group

The retrospective group came from 335 patients who underwent an ILR (Reveal™/Reveal Plus™; Medtronic Inc.), for T-LOC at the Manchester Heart Centre, Manchester Royal Infirmary, UK, between 1996 and 2006. One hundred fifty-seven (47%) of these patients had been referred by the neurologists, out of which 62 of 157 (40%) of the referrals were for ‘epilepsy’. The neurologists had made a ‘possible’ diagnosis of epilepsy in 45 of 62 (73%) and a ‘confirmed’ diagnosis in the remainder [17 of 62 (27%)]. Patients were referred if either they were unresponsive to AEDs or a clinical review indicated that the diagnosis might not be secure. All patients had a 12-lead ECG. Further cardiac investigations were undertaken as appropriate. In those patients who underwent a tilt test, a Finapres (Finapres Medical Systems BV, Paasheuvelweg 34a NL-1105 BZ Amsterdam ZO, The Netherlands) machine was used. Patients were tilted on a bed with footboard support for 45 min at a 60° angle, while monitoring their heart rate, blood pressure, and symptoms. No drug provocation was used. The tilt test was considered positive if hypotension and/or bradycardia were accompanied by reproduction of the patient’s symptoms. Decisions about treatment were dependant on the treating cardiologist. Follow-up was in the cardiology and neurology departments at the Manchester Heart Centre, Manchester Royal Infirmary and the Greater Manchester Centre for Neurosciences, Hope Hospital, Salford, respectively.

Prospective group

The prospective group consisted of patients who were recruited into Reveal in the Investigation of Syncope and Epilepsy (REVISE), between 2007 and 2009 at the Manchester Heart Centre, Manchester Royal Infirmary, UK. The protocol was passed by the local ethics committee. All 41 patients had previously seen a neurologist, and they were reviewed by a neurologist with a special interest in epilepsy. Patients could be enrolled if he deemed that epilepsy had clearly been misdiagnosed, or that there was a significant doubt about a diagnosis of epilepsy, based on clinical features or a lack of response to AEDs.

Prospective patients were recruited from a total of 484 new patients with T-LOC seen during the period of prospective recruitment in an arrhythmia clinic, or a specialist nurse-lead Rapid Access Blackouts Triage Clinic. At enrolment, epilepsy was thought to be misdiagnosed in 28 patients, and there was a significant doubt about epilepsy in 13 patients. Most patients had received AEDs.

Other inclusion criteria for the prospective study were (i) three or more than three episodes of T-LOC in the last 12 months and a normal, equivocal or non-diagnostic 12-lead ECG, echocardiogram, 24 h ECG, standard unprovoked EEG and brain computed tomography (CT)/magnetic resonance (MR) scan. After recruitment, all patients underwent an ILR (Reveal Plus™/Reveal DX™; Medtronic Inc., Minneapolis, USA) and tilt-table testing. Patients underwent follow-up every 3 months till at least 1 year after ILR implantation.

Tilt testing was undertaken using the Task Force Monitor (APC Cardiovascular Ltd, Cheshire, UK), using the same protocol for tilt testing as in the retrospective group. The protocol allowed for treatment to be given, if necessary, during the course of the study. Decisions about treatment were taken by the principle investigator. Patients who had symptomatic pauses of ≥3 s on the ILR or a decrease in heart rate below 40 beats/min for 30 s were offered a permanent pacemaker (PPM). If patients were on AEDs at the start of the study, they could continue, but AEDs could also be withdrawn or initiated during the study on the advice of the neurologist with a special interest in epilepsy.

At each follow-up visit, a record was kept of patient symptoms, including the number and date of episodes of T-LOC. All patients had their ILR downloaded, and ECG findings correlated with symptoms.
Statistical methods
Normalized data are given, with mean, standard deviations and ranges. Results are presented for all patients and separately for the prospective and retrospective groups. Student's t-test was used to compare percentages and means between the prospective and retrospective groups using the GraphPad Prism statistical package.

Results

Demographics (Table 1)
The mean age of the whole cohort was 46.4 ± 17.4 years (range: 18–80 years) with slightly more number of female patients (58 of 103; 56.3%). Patients in the prospective group were younger than the retrospective (40.2 ± 16.2 vs. 50.5 ± 17.0, P = 0.0028). There was no difference in the age quartile or sex distribution.

Duration of symptoms
The mean duration of symptoms for the whole cohort was 126.8 ± 131.6 months (range: 4–780 months) with no significant difference between the subgroups.

Diagnosis at enrolment (Table 1)
Half of the patients (45 of 103; 43.7%) had a ‘confirmed’ diagnosis of epilepsy by neurologist [prospective 28 of 41 (68.3%), retrospective 17 of 62 (27.4%), P = < 0.001]. A ‘doubt’ about the diagnosis was noted in 13 of 103 (12.6%) patients (all prospective). Neurologists diagnosed ‘likely’ epilepsy in the remainder of the cohort (45 of 103, 43.7%, all retrospective). In a majority of cases, the treating neurologist was unable to diagnose the type of epilepsy (35 of 62, 56.5%). A diagnosis of partial epilepsy was made in 17 62 (27.4%) patients and generalized epilepsy in 10 of 62 (16.1%) patients.

Origin of the initial diagnosis of epilepsy
In most cases (64 of 103, 62.1%), the diagnosis of epilepsy was made by a neurologist, otherwise it had been by a family doctor or general physician. In 17 patients the origin of the diagnosis was unknown [prospective vs. retrospective 15 of 41 (36.6%) vs. 2 of 62 (3.2%), P = < 0.0001].

Antiepileptic drugs
Most (81 of 103; 78.6%) patients had taken AEDs. The mean number of drugs used per patient was 1.5 ± 1.3 (range: 0–10). Use of greater numbers of AEDs was higher in the retrospective than prospective group (57 of 62 (91.9%) vs. 24 of 41 (58.5%), P ≤ 0.0001).

Twelve different commonly used AEDs were prescribed, and most patients had been on more than one drug. More phenytoin had been prescribed in the retrospective group.

Baseline 12-lead electrocardiography
All patients in the study underwent a 12-lead ECG at baseline. Most (83 of 103; 80.6%) were normal. There were 20 of 103 abnormal ECGs, 9 of 20 (45.0%) had sinus bradycardia (45 to 60 bpm) [prospective vs. retrospective group, 12 of 41 (29.3%) vs. 8/62 (12.9%), P = 0.0395]. Most abnormalities were minor.

Transthoracic echocardiogram
Echocardiography was done in 76 patients (74%), including all prospective patients and half of the retrospective group. Few patients had structural heart disease and none had severe structural abnormalities.

External electrocardiographic recording
Ambulatory ECG recording was available in 74 of 103 (71.9%) patients. All prospective patients were monitored vs. 33 of 62 (53.2%, P ≤ 0.0001). No patient had T-LOC symptom/ECG correlation.

Implantable electrocardiographic recorder data (Table 2)
Patients were followed up for a mean of 874 ± 776 days after implantation of the ILR. Follow-up was longer in the retrospective group (1263 ± 749 vs. 239 ± 171, P = 0.0093). The mean number of downloads from the ILR was known for the prospective subgroup were 2.24 ± 1.88 (median: 2.00, range: 0–9).

Symptom/electrocardiography correlation by implantable electrocardiographic recorder (Table 2, Figures 1 and 2)
Sixty-seven percent (69 of 103) of patients had T-LOC symptom/ECG correlation by ILR recording, at 35% of each subgroup. Sinus arrest was recorded in 13 of 103 (12.6%). The mean duration of asystole was 25.4 ± 30.3 s (range: 4–89 s) for patients in the prospective group. Fifteen patients in the retrospective group had asystole > 6 s recorded. In 43 of 103 (41.8%) patients with T-LOC symptom/ECG correlation there was normal sinus rhythm. Muscle artefact suggestive of tonic-clonic seizures were recorded in a further four (3.9%) patients, while the underlying ECG appeared normal (Figure 2). All of these patients were in the prospective group.

Further treatment
On basis of the results of the symptom/ECG correlation achieved by ILR, a pacemaker was offered to 22 of 103 (21.4%) patients and 21 (20.4%) consented (6 prospective, 15 retrospective). One prospective patient refused. Eleven (50%) of the patients offered pacemakers had confirmed epilepsy at baseline (prospective group: 6 of 18, 33.3%, retrospective group: 5 of 17, 29.4%). Seventeen patients (81%) who received a pacemaker were asymptomatic on follow-up (5 prospective, 12 retrospective). Four paced patients remained on AEDs. In 13 of 103 (12.6%) patients with a previous diagnosis of epilepsy, a pacemaker abolished symptoms. The mean duration of follow-up was 42 ± 25.6 months (range: 15–91). All other patients in the prospective group continued to have episodes of T-LOC. This was despite treatment with AEDs in 7 of 41 (17.1%), midodrine in 6 and no active treatment was given in 15. Of the nine patients with a resting bradycardia on their initial
ECG, only one patient had an asystolic pause on ILR and received a pacemaker.

**Antiepileptic drugs on follow-up**

In the prospective group 18 out of 41 patients were on AEDs at follow-up which was similar to enrolment. Indeed, two of the prospective group started AEDs during the course of the study. Both of these patients had muscle artefact suggestive of tonic-clonic seizures recorded on the ILR at the time of symptoms. One of them has subsequently been asymptomatic for 24 months. In the retrospective group, AEDs were withdrawn in 60% of patients after pacemaker implantation.

**Tilt testing**

Tilt-table testing was undertaken in 81 of 103 (78.6%) patients, and was positive in a minority—14 of 103 (13.6%). Ten patients (10%) had a vasodepressor response and four patients had a cardioinhibitory response. The percentage of patients who had a positive test and the type of response was similar in the two subgroups.

### Table 1  Numbers of patients in each group, age and diagnosis at enrolment

|                     | Whole cohort, N = 103 (%) | Prospective group, N = 41 (%) | Retrospective group, N = 62 (%) | P value, prospective vs. retrospective |
|---------------------|---------------------------|-----------------------------|--------------------------------|--------------------------------------|
| Age: mean ± standard deviation, range | 46.4 ± 17.4 | 40.2 ± 16.2 | 50.5 ± 17.0 | 0.0028* |
| Diagnosis at enrolment |                           |                             |                                |                                      |
| ‘Confirmed’ epilepsy | 45 (43.7)                  | 28 (68.3)                  | 17 (27.4)                      | <0.0001* |
| ‘Doubt’ regarding the diagnosis of epilepsy | 13 (12.6)                  | 13 (31.7)                  | 0 (0)                          | <0.0001* |
| ‘Possible’ diagnosis of epilepsy | 45 (43.7)                  | 0 (0)                      | 45 (72.6)                      | <0.0001* |

*P value significant.

### Table 2  Implantable electrocardiographic recorder data

|                     | Whole cohort, N = 103 (%) | Prospective, N = 41 (%) | Retrospective, N = 62 (%) | P value, prospective vs. retrospective |
|---------------------|---------------------------|-------------------------|----------------------------|--------------------------------------|
| Duration of follow-up after ILR (days): mean ± standard deviation, range | 874 ± 776, 6–3360 | 239 ± 171, 6–616 | 1263 ± 749, 120–3360 | 0.0093* |
| ECG symptom correlation achieved in Findings | 69 (67.0) | 29 (70.7) | 40 (64.5) | NS |
| Sinus arrest | 13 (12.6)                  | 4 (9.8)                  | 9 (14.5)                      | NS |
| Sinus arrest with AV block | 5 (4.9) | 3 (7.3) | 2 (3.2) | NS |
| Tachy-brady syndrome | 2 (1.9) | 0 | 2 (3.2) | NS |
| Severe symptomatic sinus bradycardia | 2 (1.9) | 0 | 2 (3.2) | NS |
| Normal sinus rhythm | 43 (41.8) | 18 (43.9) | 25 (40.3) | NS |
| Muscle artefacts S/o TCS | 4 (3.9) | 4 (9.8) | 0 (0) | 0.0119* |

NS, not significant; s/o, suggestive of; TCS, tonic-clonic seizures.  
*P value significant.

**Electrocardiography correlation between patients with a positive tilt test and implantable electrocardiographic recorder (Table 3)**

In those with a positive tilt test, 12 out of 14 (85.7%) patients had a positive symptom/ECG correlation by means of the ILR (prospective six of eight, retrospective four of four). Findings on ILR were sinus arrest: two of four (50%), sinus tachycardia: one of four (25%), and slow atrial fibrillation: one of four (25%). Among the four patients with a cardio-inhibitory positive tilt test, ECG–symptom correlation was achieved by ILR in two (50%) patients. One patient had sinus arrest and the sinus rhythm. The ECG features of a tilt test correlated poorly with findings of T-LOC symptom/ECG correlation by ILR.

**Electroencephalogram**

Seventy-three of the 103 patients had an EEG, which was abnormal in 18 (17.5%) patients. However, in all but one patient, non-specific, non-diagnostic abnormalities were found. In the prospective group, 6 of 41 (14.6%) patients had a sleep-deprived EEG and 3
of 41 (7.3%) patients underwent EEG recording during video telemetry, but without any diagnostic findings.

**Brain imaging**

Brain imaging, by CT scan or MR imaging, was undertaken 82 of 103 (79.6%) patients. Ten scans were abnormal, but in the opinion of the neurologist none could explain the patients’ symptoms.

**Discussion**

A likely diagnosis in T-LOC is made by clinical evaluation of symptoms, supplemented where possible by an eye-witness story. Laboratory investigations are usually done when the patient is well, and have to be interpreted in the light of the clinical presentation. Essential knowledge about any of heart rate and rhythm, blood pressure and brain activity during an attack have usually been unavailable until the advent of the ILR. Epilepsy is generally characterized by recurrent seizures with asynchronous neuronal discharge, preserved cerebral perfusion, and preserved heart rate and rhythm. Syncope is characterized by T-LOC where the cause is transient global impairment of cerebral perfusion. Pathological changes in heart rate and rhythm may be the cause of failure to perfuse the brain, as may a pathological fall in blood pressure, or both. In psychogenic pseudosyncope, it is possible to provoke a blackout with tilt-table testing, but show that the ECG, blood pressure, and EEG remain apparently undisturbed. It is now possible to record heart rate and rhythm during TLOC using an ILR. However, it is much more difficult to acquire information on the role of blood pressure and brain activity during spontaneous T-LOC. This is partly because of current limitations in implanted technology. Facilities for external monitoring of the ECG and EEG do exist in centres with videotelemetry, but typically in these settings blood pressure is not measured continuously. Also, videotelemetry facilities are very costly and thus have limited availability.

Clinical evaluation is therefore dependent on the history from the patient, who may recall little of an episode of T-LOC, supplemented by an eye-witness account if available. Laboratory physiological data are typically absent or largely incomplete, and it is not surprising that there may be a delay in diagnosis or a misdiagnosis. According to the All Party Parliamentary Group on Epilepsy, there are 74 000 patients in the United Kingdom who are misdiagnosed and taking epilepsy drugs that they do not need. The direct cost of these misdiagnoses to the NHS £189m, and place a strain on patients and on families. For the individual, there may be important implications for education, work, and childbearing. Furthermore, if epilepsy is misdiagnosed, and the treatment is wrong, it raises the question, ‘what is the diagnosis?’

We believed that convulsive syncope mimics an epileptic seizure in many cases. When the only clinical evidence available is a limited patient story supplemented by the eye-witness account of a relative or other lay person, ‘having a fit’ easily gets identified as epilepsy. We used ILRs to gather limited but reliable physiological data at the time of a spontaneous event, capturing symptom/ECG correlation. However, we had previously observed convulsive features accompanying syncope with asystole recorded by ILR, and postulated that this would be a common phenomenon among the population with a misdiagnosis of epilepsy. This is the first study to systematically use the implantable ECG loop recorder (Reveal Plus®/Reveal DX®) in the evaluation of patients suspected to be misdiagnosed with epilepsy or in those in whom the diagnosis of epilepsy was in doubt. We showed that one in eight (13 of 103, 12.6%) patients with syncope were misdiagnosed as epilepsy. On the basis of treatment responses, the true diagnosis in these patients was reflex syncope. The convulsive movements noted during spontaneous episodes of T-LOC were manifestations of ‘convulsive syncope’. These patients were asymptomatic after implantation of a PPM and withdrawal of AEDs. In some patients it was also possible to infer generalized epilepsy, manifesting as tonic-clonic seizures, by the pattern of muscle artefacts found on the loop recorder during an episode of T-LOC in 4 of 103 (3.9%) patients.

The principle achievement of this study was to gather spontaneous physiological data, albeit limited to symptom/ECG correlation.
during a spontaneous convulsion, and then be able to diagnose cardioinhibitory reflex syncope. The diagnosis could then be changed, permanent pacing could be instituted, and AEDs stopped. The subsequent benefits of pacing were convincing. ECG/symptom correlation was achieved by ILR in 69 of 103 (67%) patients in this study. This rate of ECG/symptom correlation is higher than the 35% for patients presenting with unexplained syncope and 27% for patients with possible neurally mediated syncope,16 but comparable to the 88% when used in highly selected patients.16 In one other study,17 the ILR been used to investigate patients with suspected misdiagnosis of epilepsy. However, in that study only10 of 74 (13.5%) patients had an ILR.

The second difference between this study and previous evidence is in the results of tilt testing. Zaidi et al.9 used tilt testing to arrive at a diagnosis of syncope, being positive in 25.7% of patients. Tilt testing was positive in only 14 of 103 (13.6%) of our patients. Moreover, there was poor correlation between the results of the tilt test and the ILR findings. None of the patients in the studies by Smith et al.,11 Josephson et al.,12 and Scheepers et al.13 were tilted. Tilt testing relies on provocation to acquire evidence, rather than acquiring spontaneous data during T-LOC. There is a wide variation in the sensitivity and specificity of the tilt test,1 probably accounting for the difference between this study and that of Zaidi et al.9 Tilt testing is currently a class IIb indication for differentiating syncope from epilepsy in the latest European Society of Cardiology guidelines on syncope.1 Also notable in this study is the apparent diagnosis of generalized epilepsy by the pattern of rhythmic skeletal myopotential artefacts noted in 4 of 103 (3.9%) patients during a spontaneous T-LOC (Figure 2). It has also been shown to correlate with EEG findings18 in a small study of 12 patients elsewhere. Two of the four (50%) patients with this pattern on the ILR were started on AEDs, and one of the two patients was asymptomatic after 18 months.

This study also provides some insight into the value of other tests in these patients. Seventy-three (70.9%) patients had an EEG. From the prospective group, 6 of 41(14.6%) patients

| Table 3 Correlation between patients with a positive tilt test and implantable electrocardiographic recorder |
|---------------------------------------------------------------|
| Positive tilt test result | ECG–Sx correlation whole cohort, N = 14 (%) | ECGSx correlation prospective group (findings), n = 6 | ECG–Sx correlation retrospective group (findings), n = 8 |
|----------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| Vasodepressor response     | 10 (71.4)                                       | 6 (sinus rhythm: 6)                              | Four of four (sinus arrest: 2, sinus rhythm: 1, slow atrial fibrillation: 1) |
| Cardioinhibitory response  | 2 (14.3)                                        | 0                                               | Two of four (sinus arrest: 1, sinus rhythm: 1) |

Sx, symptom.
underwent a sleep-deprived EEG and 3 of 41 (7.3%) patients underwent a 5 day video-EEG telemetry monitoring. The EEG was abnormal in 18 of 103 (17.5%) patients but nearly all showed non-specific, non-diagnostic abnormalities. An interictal EEG or an ambulatory EEG, with or without brain imaging reported only in 23 of 186 (12.4%) of patients by Smith et al.\textsuperscript{11} Scheepers et al.\textsuperscript{13} also used the same tests in their study, although in unclear numbers. All patients in the study by Zaidi et al.\textsuperscript{9} and 90% of patients in the study by Josephson et al.\textsuperscript{12} had an EEG. However, like tilt table testing, the EEG has variable sensitivity and specificity for epilepsy,\textsuperscript{4} and because of its limitations it is recognized that an EEG should not be used to make a diagnosis of epilepsy. It may be useful in under 35s to support a diagnosis and to help define an epilepsy syndrome where epilepsy is likely.\textsuperscript{4} An EEG should be avoided in suspected syncope because of the possibility of false-positive results.\textsuperscript{4} Patients in this study were considered to have a misdiagnosis based on a clinical review by a neurologist with special interest in epilepsy. Where the results of the EEG were not used in the clinical evaluation. Misinterpretation of EEG findings is known to be a common reason for the diagnosis of epilepsy was in doubt. The most likely diagnosis in these patients was convulsive cardio inhibitory reflex syncope. Poor correlation between the results of tilt testing and ILR were found. In a small number of patients, rhythmical skeletal myopotential artefacts on the ECG suggested a diagnosis of tonic-clonic epileptic seizures. An ILR represents the only readily available tool for the investigation of patients whose seizures may accompany T-LOC caused by convulsive cardio inhibitory reflex syncope or generalised epilepsy, and the diagnosis is in doubt. Given the high incidence of the misdiagnosis of epilepsy, and the profound effects that the diagnosis has on patients and their families, an ILR should be considered whenever a diagnosis of epilepsy is uncertain but being considered.

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**References**

1. Moya A, Sutton R, Ammirati F, Blanc JJ, Brignole M, Dahn JB et al. Guidelines for the diagnosis and management of syncope (version 2009) The task force for the diagnosis and management of syncope of the European Society of Cardiology (ESC). *Eur Heart J* 2009;30:2631–71.

2. National Institute of Clinical Excellence Transient loss of consciousness in adults: final scope. http://www.nice.org.uk/nicemedia/pdf/TLOCscopeFinal0708.pdf (29 September 2009, date last accessed).

3. Brignole M, Albani P, Bentditt DG, Bergfeldt L, Blanc JJ, Thomsen PEB et al. Guidelines on management (diagnosis and treatment) of syncope e update 2004. The task force on syncope, European society of cardiology. *Eur Heart J* 2004;25:467–517.

4. Lempert T, Bauer M, Schmidt D. Syncope: a videometric analysis of 56 episodes of transient cerebral hypoxia. *Ann Neurol* 1994;36:233–7.

5. Stokes T, Shaw EJ, Guernica A E et al. Clinical guidelines and evidence review for the diagnosis of syncope: and consequences of its misdiagnosis as epilepsy. *Seizure* 2007;16:336–40.

6. Mellers JDC. The approach to patients with ‘non-epileptic seizures’. *Postgrad Med J* 2005;81:498–504.

7. Grubb BP, Gerard G, Roukh K, Temeszy-Armos P, Elliot L, Hahn H et al. Differentiation of convulsive syncope and epilepsy with head-up tilt testing. *Ann Intern Med* 1991;115(11):871–6.

8. Passman R, Horvath G, Thomas J, Kruse J, Shah A, Goldberger J et al. Clinical spectrum and prevalence of neurologic events provoked by tilt table testing. *Arch Intern Med* 2003;163:1945–8.

9. Zaidi A, Clough P, Cooper P, Scheepers B, Fitzpatrick A. Misdiagnosis of epilepsy: many seizure like attacks have a cardiovascular cause. *J Am Coll Cardiol* 2000;36(1):181–4.

10. Zaidi A, Crampton S, Clough P, Fitzpatrick A, Scheepers B. Head-up tilting is a useful provocative test for psychogenic non-epileptic seizures. *Seizure* 1999;8(6):353–5.

11. Smith D, Defalba BA, Chadwick DW. The misdiagnosis of epilepsy and the management of refractory epilepsy in a specialist clinic. *Q J Med* 1999;92:15–23.

12. Josephson CB, Rahey S, Sadler RM. Neurocardiogenic syncope: frequency and consequences of its misdiagnosis as epilepsy. *Can J Neurol Sci* 2007;34(2):221–4.

13. Scheepers B, Clough P, Pickles C. The misdiagnosis of epilepsy: findings of a population study. *Seizure* 1998;7(5):403–6.

**Conclusions**

This study used ILRs to show a high incidence of bradyarrhythmias and asystole in patients previously diagnosed with epilepsy where the diagnosis of epilepsy was in doubt. The most likely diagnosis in these patients was convulsive cardio inhibitory reflex syncope.

**Limitations of the study**

The whole cohort contains patients studied retrospectively and prospectively, and this may have a bearing on the results, although the two groups were very similar in baseline characteristics, clinical features, and investigations. Patients with a true diagnosis of epilepsy are reported to have asystolic pauses during an episode of spontaneous T-LOC.\textsuperscript{17,18} It is possible that one patient in our study who did not respond to permanent pacing fell into this category. However, she continues to be symptomatic in spite of restarting AEDs and is now being considered for a vagal nerve stimulator as treatment for resistant epilepsy.\textsuperscript{19} The possibility of a psychogenic cause of T-LOC has not been investigated in this study. It is possible that some patients with normal sinus rhythm on their ILR during an episode of T-LOC suffer from psychogenic pseudosyncope or non-epileptic attack disorder. This could still represent a misdiagnosis, and demonstrates the limitations of currently only being able to monitor the ECG in T-LOC patients. Elsewhere, tilt-testing during monitoring of ECG, blood pressure, and EEG has been used to provoke psychogenic pseudosyncope,\textsuperscript{10} and more physiological data in long-term implanted monitors are needed.
Multiple morphologies of ventricular tachycardia assessed by implantable cardioverter-defibrillator electrograms in a patient with Chagas disease, successfully treated with catheter ablation: modern problems, old solutions

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A 60-year-old man with Chagas disease, implanted with an implantable cardioverter defibrillator (ICD) (Medtronic Maximo-VR7232) was hospitalized for electrical storm. Implantable cardioverter defibrillator interrogation revealed 62 episodes of monomorphic ventricular tachycardia (VT). Analysing implantable cardioverter-defibrillator electrogram (ICD-EG), a difference in morphology was seen only in the HVA/HVB electrogram (a QS complex in VT1 and a Qr complex in VT2; see Figure 1). During hospitalization, he experienced several VT episodes and surface-electrocardiogram (ECG) showed two different QRS configurations, confirming multiple morphology (MM)-VT. This difference in QRS morphology correlated to different ICD-EG, resembling those found before admission.

At electrophysiological (EP) study, performed under fluoroscopic navigation, VT1 was easily induced. With the use of conventional EP-mapping and entrainment techniques a reentry circuit in left ventricular (LV) posteroseptal zone (sites 4–6 from the LV mapping schema proposed by Cassidy and Josephson) was identified and successfully ablated. Repeated ventricular stimulation resulted in induction of VT2, originated from a widely separate circuit in the lateral LV (sites 8–10). Radiofrequency energy delivery at that position resulted in interruption of the VT without VT induction thereafter. There was no arrhythmia recurrence over a 9-month follow-up period.

Correlation between ICD-EG and surface-ECG has been suggested in patients with coronary disease. To the best of our knowledge, this is the first report showing MM-VT and correlation between ICD-EG and surface-ECG in a patient with Chagas disease.

The present case highlights the usefulness of ICD-EGs in identifying two different VTs and the need for a complete examination of ICD-EG from all VT episodes before VT ablation.

The full-length version of this report can be viewed at: http://www.escardio.org/communities/EHRA/publications/ep-case-reports/Documents/chagas-disease-vt-morphologies.pdf