Highlights:

- The presenting ECG in Takotsubo is subtly different than the presenting ECG of myocardial infarction, by fewer total abnormal leads, lesser total magnitude of ST-elevation and lesser pathological Q waves.
- The 4-day evolution of the Takotsubo ECG compared to acute myocardial infarction is characterised by much more widespread and deeper T wave inversion. The mean QTc progressively increases in takotsubo whilst in MI decreases.

Abstract

Background: Takotsubo syndrome mimics acute myocardial infarction (MI) at presentation.

Objectives: To explore differences in ECG time-course that could further help distinguish the two conditions.

Methods: Serial ECG's (day 0-4) of 27 acute takotsubo and 37 MI patients, all presenting with anterior ST-elevation, were analysed for detailed morphology and timing of de/re-polarisation. All underwent cardiac magnetic resonance.

Results: The presenting ECG (day 0) showed significantly fewer total abnormal leads (p=0.001), comparable number of ST-elevation leads but lesser total magnitude of ST-elevation (p=0.003), smaller sum of positive T wave amplitude (p=0.006) and lesser number of pathological Q waves (p=0.005) in takotsubo *vs* the MI group. After day 0, takotsubo patients developed more widespread T wave inversion (p=0.001, day 3) and/or deeper T waves compared to MI, (sum of the T-wave amplitude slope of change between days 0-3: -43.1±9.6 *vs* -16.6±5.4 mm, p=0.02). Although there was no difference in mean QTc between the groups on any day, between days 0-3 there was a progressive increase in QTc in takotsubo vs a decrease in MI (34.1±12.2 vs -29.5±9.3 ms, slope of change p<0.001). There was significantly more myocardial oedema (native T1 mapping) in takotsubo vs MI (p=0.02), which resulted in increased left ventricular mass index in takostubo (p=0.04).

Conclusions: The differences in presenting (day 0) ECG between takotsubo and MI are significant but subtle, reinforcing the importance of acute cardiac catheterisation for accurate diagnosis. During the next 3 days there is progressive increase in the depth and spread of T-waves and QTc duration in takotsubo vs MI - these may aid

the diagnostic confidence in patients with bystander non-obstructive coronary disease.

The Early Dynamic of ECG in Takotsubo Syndrome presenting with ST-elevation: A comparison with age and gender-matched ST-elevation Myocardial Infarction

Caroline Scally MBChB MRCP[a],
WaiKah Choo MBBS MRCP[a]
Amelia Rudd RDCS, BSE[a],
Christopher Neil MBBS, FRACP[a]
Nishat Siddiqi MBBS MRCP[a]
Alice M Mezincescu MD MRCP[a],
Heather M Wilson PhD[a],
Michael Frenneaux MD, FRCP, FESC, FMedSci[a]
Graham Horgan, BA, MSc, PhD[b]
Paul Broadhurst MBBS, MD, FRCP FESC FHRS[a]
Dana K Dawson MD, FRCP, D.Phil, FESC[a]

[a] University of Aberdeen, Aberdeen, United Kingdom
[b] Biomathematics & Statistics Scotland, Aberdeen, United Kingdom

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Address for Correspondence:

Dana Dawson, Aberdeen Cardiovascular and Diabetes Centre, Polwarth Building, Foresterhill, University of Aberdeen, UK

Tel: +44 1224 559573, Fax: +44 1224 437971

Email: dana.dawson@abdn.ac.uk

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Abbreviations

MI = Myocardial Infarction

LV = Left Ventricular

CMR = Cardiac magnetic resonance

ECG = Electrocardiograph

LAD = Left anterior descending

TIMI = Thrombolysis in Myocardial Infarction

MVO = Microvascular Obstruction

HR= Heart rate

Introduction

Takotsubo syndrome has a dramatic clinical presentation, indistinguishable from acute myocardial infarction (MI)[1]. It is often triggered by an intense episode of emotional or physical stress, and is usually diagnosed when invasive cardiac catheterisation demonstrates unobstructed coronary arteries and typical ballooning of the left ventricle (LV).

Unfortunately no acute ECG findings alone or in combination are specific enough to obviate or delay urgent coronary angiography in routine clinical care[2-4]. The most characteristic takotsubo ECG feature remains prolongation of the QT/QTc interval, seen at presentation and peaking 24-48 hours thereafter[5-7]. However, it remains unclear if this is a reliable differentiating feature from MI after correcting for gender differences in the QT interval since all published studies compared cohorts of takotsubo where most patients were women *versus* predominantly men in the MI groups.

Furthermore, there is a different resolution dynamic in the immediate aftermath of a takotsubo event compared to myocardial ischemia: in the classical stunning/hibernating myocardium following acute MI, the ECG and the wall motion abnormalities resolve in tandem, once the coronary blood flow is restored[8]. In contrast, in takotsubo, the ECG appears to continue to evolve despite rapid restoration of the wall motion and a relatively preserved coronary blood flow[9]. Whilst undoubtedly further data will be necessary to fully characterise the takotsubo coronary flow and microcirculation, there remains a gap in knowledge for the comparative description of the ECG evolution in takotsubo *versus* MI and the pathophysiology that can be inferred therein.

In this study we compare the progression of the 12 lead ECG in takotsubo patients presenting with ST-elevation *versus age and gender matched* anterior ST

elevation acute MI patients and draw a parallel between these ECG changes and the left ventricular morphological changes seen on cardiac magnetic resonance imaging (CMR).

Methods

Study population: This was an observational case-control study of 27 patients (25 women) admitted to the cardiology department with ST-elevation on their presenting ECG subsequently diagnosed with takotsubo syndrome and 37 (31 women) age and sex matched patients admitted with anterior ST-elevation MI. All takotsubo cases had a diagnosis fulfilling the Mayo Clinic[10] and the European Society of Cardiology - Heart Failure Association criteria[11], plus absence of any macroscopic fibrosis on CMR. All patients had emergency invasive coronary angiography and takotsubo patients had left ventriculography. All patients in the MI cohort underwent primary PCI at the time of diagnosis. Patients were enrolled through two separate studies, (NCT02897739 Pathogenesis of Acute Stress Induced (takotsubo) syndrome: Energy Shutdown or Intense Inflammation and NCT01388504 Nitrates in acute myocardial infarction) and all provided written informed consent. The studies were approved by the North of Scotland Research Ethics Committee 1 and Scotland Research Ethics Committee A. Both studies comply with the *Declaration of Helsinki.*

ECG Analysis

All subjects had a 12-lead ECG recorded on presentation (day 0) and daily for the subsequent 4 days. Due to the nature of the emergency, ECG's at presentation were obtained as soon as possible from the onset of symptoms at the first medical contact, and therefore from different ECG machines, however each ECG was

obtained at a sweep speed of 25mm/s and an amplitude of 10mV/mm. ECG analysis was performed by an experienced cardiac physiologist and a random sample of 10 were reanalysed by a cardiologist for inter-observer variability. A full list of ECG parameter measured can be found in Table 1.

The inter-observer variability for our ECG measurements was 4.5±10.5%. (mean±SD)

Cardiac Magnetic Resonance Imaging

CMR was performed as soon as possible after admission [median day 4 (range 0-9) in the takotsubo group and median day 9 (range 6-12) in the MI group]. All participants were scanned on a 3T Philips Achieva scanner (Best, The Netherlands). A 6-channel cardiac coil was used to acquire cine imaging, early and late gadolinium enhancement (Gadovist, 0.1 mmol/kg) with swap of the phase-encoding direction and pre-contrast Modified Look-Locker Imaging for T1 mapping[12]. Data for T1 mapping were acquired with 5(3)3 scheme. The CMR images were analysed in CMR Tools (Cardiovascular Imaging Solutions, London, UK) for computation of left ventricular volumes and mass and a wall motion score was calculated for each of the 16 myocardial segments (excluding the true apex). T1 maps were imported into Segment (Medviso, Lund, Sweden) and T1 values were generated for each of the 16 segments of the 17-segment model [13](omitting the true apex). Infarct size (IS) and microvascular obstruction (MVO) were measured as previously described[14]. Our inter-observer variabilities for CMR have been reported previously and ranged 1.5-2.7±0.5-1.5% for cardiac magnetic resonance inclusive of T1 mapping [15-17].

Coronary Angiography

Coronary angiography was performed as part of the clinical investigations as soon as possible at presentation in keeping with guidance for treatment by the clinical cardiology team. Coronary blood flow was estimated using the TIMI frame count method[18]. As all MI's were in the left anterior descending (LAD) territory we used the LAD TIMI frame count in the takotsubo group as a comparison; as we assessed LAD only we did not correct for vessel length.

Statistical Analysis

Data are presented as the mean±SEM, or as the median with range if not normally distributed. Comparisons between groups were made using *t* tests or equivalent non-parametric tests for non-normally distributed data. Data examining changes over time were analysed by analysis of variance of the absolute values, and of changes from day 0. Variabilities were calculated as mean±SD of the percentage ratios between differences and means of each 2 independently measured variables.

Results

Baseline characteristics of patients are summarised in **Table 2**. The age of the two cohorts was comparable, whereas the MI patients had a significantly higher body mass index. The majority of the takotsubo patients had apical variant (85%) and most had an emotional stressor (55%). All patients with of Caucasian ethnicity.

All ECG's were in sinus rhythm. ECG data is shown in **Table 3**. On the presenting ECG (day 0) there was no difference in the HR, PR interval, QRS duration or corrected QTc. There were however a number of significant differences: 1) there were fewer abnormal leads (defined as a lead with pathological ST elevation, T wave inversion , ST depression or Q waves) in the takotsubo vs MI group (p=0.001), albeit a comparable number of leads with ST elevation (p=0.1); 2) a lower total magnitude of ST elevation in the takotsubo *vs* MI group (p=0.003); and 3) a significantly smaller sum of T wave amplitude in the takotsubo group when compared to the MI group (p=0.006). By day 1 the difference in the T wave amplitude between takotsubo and MI groups increased (p=0.003) and grew further apart on day 2 (p=0.009) and on day 3 (p=0.007). By day 3 the T wave inversion had become more widespread in the takotsubo group compared with MI (number of leads with abnormal T wave inversion 8.2±0.6 vs 3.4±1.0 p=0.001) **Table 3.** When the progression of the sum of T wave amplitude was analysed in each individual cohort, it was noted that it decreased significantly after presentation (between day 0 and day 3) in both the takotsubo and MI groups, but this change was greater in the takotsubo group when compared to the MI group (-43.1±9.6mm *vs* -16.6±5.4mm, takotsubo *vs* MI slope of change, p=0.02), **Figure 1a and Table 3.** There was no significant difference in the rate of change between the two groups in any other time periods. The differences in the sum of T wave inversion were driven by either the more progressive deepening of T waves in

takotsubo, or the more widespread pattern (sometimes developing in leads that had normal morphology on presentation ECG), or both (**Figure 1c**).

The was no significant difference in the QTc between the groups at any stage, however QTc increased between day 0 and day 3 in the takotsubo group (by 34.1±12.2 ms) but fell in the MI group (by 29.6±5 ms) with a significant difference between takotsubo vs MI, slope of change p<0.001, **Figure 1b and Table 3.**

Takotsubo patients had fewer Q waves across all leads and generally these were less deep than in patients with MI, albeit the latter did not reach statistical significance except in day 3 after acute presentation (**Table 3**).

On CMR, as seen from **Table 2**, there was no difference in the LV ejection fraction or indexed LV volumes between the two groups. However, there was a significantly higher indexed LV mass as well as higher native T1 in the apical and midcavity segments of the LV in the takotsubo group when compared with MI. None of the takotsubo patients had any evidence of late gadolinium enhancement. The infarct size as a percentage of LV mass and size of microvascular obstruction (MVO) in the MI group, as shown in **Table 2**, were typical of a primary percutaneous intervention treated cohort. There was no difference in the wall motion scores or TIMI frame counts between the takotsubo and MI groups (measured post-intervention).

Discussion

We describe for the first time a head to head comparison of daily ECG progression in the early convalescent phase post-acute takotsubo *versus* acute MI in age and gender matched subjects, which is especially relevant to the QTc interval which is gender dependent. Whilst LAD coronary blood flow (TIMI frame count) was comparable in resting conditions in all patients (post primary percutaneous intervention status in the case of the MI group) and the wall motion scores were also

comparable, there were distinctive differences in the evolution of the ECG's between these patients.

On the presenting (day 0) ECG, we observed a lesser number of total abnormal leads (most likely due to the lack of reciprocal changes as shown by Kosuge *et al*[7]), comparable number of leads with ST-elevation, less magnitude of ST-elevation and less Q waves in the takotsubo patients. Kosuge *et a*l reported more ST-elevation in the takotsubo patients, however, the two groups were not gender matched[7]. We believe that the lesser magnitude of ST-elevation and more frequent absence of Q waves in takotsubo suggest less myocardial necrosis, which is confirmed by the CMR finings of no late gadolinium enhancement present. Examining the subsequent evolution of the ECG, firstly, there appears to be a greater magnitude of T wave inversion in takotsubo which deepens further and/or becomes more widespread in the first 4 days post-acute event. Secondly, although there were no significant differences in the absolute mean QTc between groups at any time point, there was an obvious pattern of *opposite* directional change of daily *increasing* mean QTc in takotsubo contrasting with gradual shortening towards normal values in the MI group. This is the first study comparing age and gender matched populations, and since the normal QTc is different in women (≤450 ms) compared to men (≤440 ms) in those aged 40-69[19] this is an important finding. This suggests that the deeper T waves and longer QTc is indeed a feature of early convalescent takotsubo ECG compared to MI, and despite some overlap this characteristic can be used in the future to further add towards diagnostic certainty. These ECG abnormalities are seen in LV myocardial tissues which show different degrees of myocardial oedema, with a much higher amount of water-derived signal (native T1 mapping) in the takotsubo patients, to the extent that the calculated left ventricular mass becomes significantly increased in the acute phase in takotsubo *versus* MI. The striking oedematous

changes in takotsubo without significant myocyte death are most likely responsible for the differences in ECG findings, as a larger number of viable myocytes still undergo repolarization compared with MI. It is unclear whether the QT changes are a simple consequence of the thicker, oedematous myocardial wall or originate from specific abnormalities of the conductive system *per se*.

It has previously been hypothesised that there is a link between this oedema and the amount of T-wave inversion in takostubo. Migliore et al [20,21]described a number of patients with deep T-wave inversion in a takotsubo-like pattern associated with significant myocardial oedema and reversible LV dysfunction of different causes. Marra[5] then went on to demonstrate a correlation between regional myocardial oedema and T-wave inversion in patients with takotsubo syndrome. A further study by Lazzari et al[22] similarly demonstrated patients with myocarditis were more likely to have T-wave inversion on ECG if myocardial oedema was present on MRI and that the distribution of the T-wave inversion correlated with the area of myocardial oedema.

Study Limitations

There are some weaknesses to our study that we must acknowledge. We have only studied those patients with Takotsubo presenting with acute ST elevation, therefore these findings may not be applicable to Takotsubo patients presenting with other ECG changes; secondly due to the acute nature of the presentation it was not possible to standardise the intervals from onset of symptoms to 1st ECG and for the purposes of the presenting ECG we used that taken at 1st medical contact.

Conclusion

In this study we show that despite comparable coronary artery blood flow and degree of left ventricular systolic dysfunction, the ECG changes seen in the early convalescent takotsubo significantly contrast with those seen after acute MI. Takotsubo patients develop widespread and progressive deepening of T wave inversion across the 12 lead ECG and although there are no significant differences in the QTc between the two groups on each individual day, there is a progressive increase in the QTc in takostubo contrasting with a decrease in QTc post MI. These changes may further add in the diagnostic algorithm between these groups of patients in the early convalescent phase, especially in the presence of by-stander coronary artery disease, as well as reinforce the need to appropriately monitor the QTc in Takotsubo and avoid prescription of QT-prolonging drugs. Although subtle ECG differences are present, these are not specific enough to obviate the need for cardiac catheterisation in the acute setting.

References:

1. Prasad A, Lerman A, Rihal CS. Apical ballooning syndrome (tako-tsubo or stress cardiomyopathy): A mimic of acute myocardial infarction. *Am Heart J*. 2008;155(3):408-417.

2. Zorzi A, Baritussio A, ElMaghawry M, et al. Differential diagnosis at admission between takotsubo cardiomyopathy and acute apical-anterior myocardial infarction in postmenopausal women. *European Heart Journal: Acute Cardiovascular Care*. 2016;5(4):298-307.

3. Frangieh AH, Obeid S, Ghadri J, et al. ECG criteria to differentiate between takotsubo (stress) cardiomyopathy and myocardial infarction. *J Am Heart Assoc*. 2016;5(6).

4. Parkkonen O, Allonen J, Vaara S, Viitasalo M, Nieminen MS, Sinisalo J. Differences in ST-elevation and T-wave amplitudes do not reliably differentiate takotsubo cardiomyopathy from acute anterior myocardial infarction. *J Electrocardiol*. 2014;47(5):692-699.

5. Perazzolo Marra M, Zorzi A, Corbetti F, et al. Apicobasal gradient of left ventricular myocardial edema underlies transient T-wave inversion and QT interval prolongation (wellens' ECG pattern) in tako-tsubo cardiomyopathy. *Heart Rhythm*. 2013;10(1):70-77.

6. Kurisu S, Inoue I, Kawagoe T, et al. Time course of electrocardiographic changes in patients with tako-tsubo syndrome: Comparison with acute myocardial infarction with minimal enzymatic release. *Circ J*. 2004;68(1):77-81.

7. Kosuge M, Ebina T, Hibi K, et al. Simple and accurate electrocardiographic criteria to differentiate takotsubo cardiomyopathy from anterior acute myocardial infarction. *J Am Coll Cardiol*. 2010;55(22):2514-2516.

8. Kloner RA. Inverted T waves. an electrocardiographic marker of stunned or hibernating myocardium in man? *Circulation*. 1990;82(3):1060-1061.

9. Eitel I, Stiermaier T, Graf T, et al. Optical coherence tomography to evaluate plaque burden and morphology in patients with takotsubo syndrome. *J Am Heart Assoc*. 2016;5(12):10.1161/JAHA.116.004474.

10. Madhavan M, Prasad A. Proposed mayo clinic criteria for the diagnosis of tako-tsubo cardiomyopathy and long-term prognosis. *Herz*. 2010;35(4):240-243.

11. Lyon AR, Bossone E, Schneider B, et al. Current state of knowledge on takotsubo syndrome: A position statement from the taskforce on takotsubo syndrome of the heart failure association of the european society of cardiology. *Eur J Heart Fail*. 2016;18(1):8-27.

12. Messroghli DR, Radjenovic A, Kozerke S, Higgins DM, Sivananthan MU, Ridgway JP. Modified look-locker inversion recovery (MOLLI) for high-resolution T1 mapping of the heart. *Magn Reson Med*. 2004;52(1):141-146.

13. Cerqueira MD, Weissman NJ, Dilsizian V, et al. Standardized myocardial segmentation and nomenclature for tomographic imaging of the heart. A statement for healthcare professionals from the cardiac imaging committee of the council on clinical cardiology of the american heart association. *Int J Cardiovasc Imaging*. 2002;18(1):539-542.

14. Siddiqi N, Bruce M, Neil CJ, et al. Protocol: Does sodium nitrite administration reduce ischaemia-reperfusion injury in patients presenting with acute ST segment elevation myocardial infarction? nitrites in acute myocardial infarction (NIAMI). *J Transl Med*. 2013;11:116-5876-11-116.

15. Schwarz K, Ahearn TS, C, Srinivasan J, et al. Alterations in cardiac deformation, timing of contraction and relaxation and early myocardial fibrosis accompany the *apparent* recovery of acute stress-induced (takotsubo) cardiomyopathy: An end to the concept of transience. *Journal Am Soc Echo*. 2017.

16. Dawson DK, Neil CJ, Henning A, et al. Tako-tsubo cardiomyopathy: A heart stressed out of energy? *JACC Cardiovasc Imaging*. 2015;8(8):985-987.

17. Scally C, Ahearn T, Rudd A, et al. Right ventricular involvement and recovery after acute stress-induced (tako-tsubo) cardiomyopathy. *Am J Cardiol*. 2016;117(5):775-780.

18. Gibson CM, Cannon CP, Daley WL, et al. TIMI frame count. *Circulation*. 1996;93(5):879-888.

19. Rautaharju PM, Mason JW, Akiyama T. New age- and sex-specific criteria for QT prolongation based on rate correction formulas that minimize bias at the upper normal limits. *Int J Cardiol*. 2014;174(3):535-540.

20. Migliore F, Zorzi A, Perazzolo Marra M, Iliceto S, Corrado D. Myocardial edema as a substrate of electrocardiographic abnormalities and life-threatening arrhythmias in reversible ventricular dysfunction of takotsubo cardiomyopathy: Imaging evidence, presumed mechanisms, and implications for therapy. *Heart Rhythm*. 2015;12(8):1867-1877.

21. Migliore F, Zorzi A, Marra MP, et al. Myocardial edema underlies dynamic T-wave inversion (wellens' ECG pattern) in patients with reversible left ventricular dysfunction. *Heart Rhythm*. 2011;8(10):1629-1634.

22. De Lazzari M, Zorzi A, Baritussio A, et al. Relationship between T-wave inversion and transmural myocardial edema as evidenced by cardiac magnetic resonance in patients with clinically suspected acute myocarditis: Clinical and prognostic implications. *J Electrocardiol*. 2016;49(4):587-595.

Figure Legends

Figure 1. **a)** Sum of T wave amplitude by day post-presentation; **b)** Mean QTc in takotsubo vs MI patients.

p= takotsubo vs MI

**p= slope of change takotsubo vs MI*;

c) ECG examples of a patient with takotsubo syndrome (top) and anterior ST elevation MI (bottom) on days 0 and 3, demonstrating that takotsubo patients develop more widespread and deeper T-wave inversion compared to acute MI patients.

- Rhythm
- Heart Rate (HR, bpm)
- R Axis (°)
- P wave axis (°)
- PR interval (ms)
- QRS width (ms)
- Uncorrected QT (ms)
- QTc in each lead (ms) with Bazett correction (QT/√RR)
- Mean QTc across all leads
- QT dispersion (max-min QTc)
- Total number of abnormal leads
- Q wave depth in each lead (mm)
- R wave height in each lead (mm)
- Total number of leads with ST elevation
- Total ST elevation (mm)
- Total anterior ST elevation, leads V1-V4 (mm)
- Total lateral ST elevation, leads I, aVL, V5-V6 (mm)
- Total inferior ST elevation, leads II, III, and aVF (mm)
- T wave axis (°)
- Total number of leads with abnormal T wave inversion
- T wave amplitude in each lead (mm) (maximum height of the T wave, negative T waves were indicated by a negative number)
- Sum of the T wave amplitudes across all leads (the sum of the height of the positive T waves minus the depth of the negative T wave)

462 **Table 1. ECG Parameters measured in takotsubo and MI patients**.

	Takotsubo (n=27)	MI (n=37)	*P* value
Female n (%)	25 (92)	31 (84)	0.89
Age, years (mean±SD)	65±3	62±3	0.6
BMI (kg/m^2)	27±1	31±2	**0.02**
12 hour troponin (ng/L)	3877±860	94111±32450	**<0.001**
Takostubo Stressor			
Emotional	15 (56%)	-	
Physical	6 (22%)	-	
None	6 (22%)	-	
Takotsubo Variant			
Apical	23 (85%)	-	
Mid-cavity	4 (15%)	-	
LVEF (%)	53±3	49±3	0.4
LVEDV index (ml/m^2)	78±3	88±6	0.1
LVESV index (ml/m^2)	37±3	47±6	0.2
LV Mass index (g/m^2)	83±3	71±5	**0.04**
Native T1 (ms)			
Basal	1239±23	1245±37	0.5
Mid	1271±23	1194±17	**0.003**
Apical	1305±28	1180±31	**0.001**
Whole Heart	1301±40	1208±15	**0.02**
MI size (% of LV mass)	-	24±4	**-**
MVO (% of LV mass)	-	3.1±1.4	**-**
LAD TIMI Frame count	21	21	0.9
WMS			
Basal	1.4±0.5	2.0±0.2	**<0.001**
Mid	2.3±0.2	1.9±0.1	0.2
Apical	2.8±0.3	2.1±2.1	0.06
Whole Heart	1.9±0.1	1.9±0.1	0.7

463 **Table 2. Demographics and CMR data in takotsubo and MI patients**.

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Data shown as mean±SEM. BMI= body mass index; LVEF= Left ventricular ejection fraction; LVEDV=left ventricular end diastolic volume; LVESV= left ventricular end systolic volume; MVO= microvascular obstruction; LAD=left anterior descending; WMS= wall motion score.

	Takotsubo Patients (n=27)	**MI Patients (n=37)**	***P* value**
Heart Rate (bpm)	78±5	78±3	0.9
Total number of abnormal leads (n)	6.9±0.6	9.5±0.4	**0.001**
Number of leads with ST elevation	4.0±0.6	4.9±0.3	0.1
ST elevation Anterior (mm)	1.3±0.2	2.6±0.3	**0.001**
ST elevation Lateral (mm)	0.9±0.2	2.6±0.3	**<0.001**
ST elevation Inferior (mm)	0.6±0.2	0.4±0.2	0.6
Total ST elevation (mm)	2.7±0.4	4.0±0.6	**0.003**
Number of leads with T wave inversion			
Day 3	8.2±0.6	3.4±1.0	**0.001**
Sum of the T wave amplitudes across all leads (mm)			
Day 0	16.8±2.6	26.3±2.5	**0.006**
Day 1	-0.2±3.4	13.9±2.8	**0.003**
Day 2	-12.4±0.6	4.7±2.8	**0.009**
Day 3	-26.3±9.2	6±4.7	**0.007**
Day 4	-13.7±9.1	4.4±9.6	0.2
QTc (ms), Day 0	437±6.4	449±4.3	0.1
QT Dispersion (ms), Day 0	122±8	100±7	**0.04**
Change in T wave amplitude(mm)			
from day 0 to day 3	-43.1±9.6	-16.6±5.4	**0.02**

Change in QTc (ms)			
from day 0 to day 3	34.1±12.3	-29.6±5.7	**<0.001**
Number of leads with pathological Q waves	1.32±0.4	2.69±0.3	**0.005**
Sum of the Q wave amplitudes across all leads (mm)			
Day 0	-13.5±3.9	-22.6±3.8	0.09
Day 1	-10.1±3.3	-19.2±3.8	0.08
Day 2	-3.7±1.9	-17.7±4.5	**0.01**
Day 3	-2.4±2.0	-5.5±2.1	0.3

Table 3. ECG parameters in takotsubo vs MI patients.

All data from day of presentation unless stated otherwise. Data shown as mean ±SEM