Research Paper

Effect of Coexisting Hypertension, Blood Pressure Control, and Antihypertensive Treatment on QT Interval Parameters in Type 2 Diabetics: A Cross-Sectional Study

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Abstract

Objectives: To study the electrocardiogram (ECG) based QT parameters namely QTc (heart rate corrected QT), QTd (QT dispersion) in treated type 2 diabetics (T2D) and the effect of hypertension (HTN), blood pressure (BP) control, and antihypertensives used on the above parameters. **Materials and Methods:** We performed a cross-sectional study in a tertiary care hospital of Gujarat, India, on 199 T2D (67 males and 132 females). Standard 12-lead ECG was recorded to derive QTc (Bazett's formula), QTd, and ECG left ventricular hypertrophy (LVH). QTc >0.43 s in male and >0.45 s in female and QTd >80 msec were considered abnormal. **Results:** Hypertensives (n = 138) and normotensives (n = 61) were comparable for most confounders. Hypertensives had better profile of QTc and QTd than normotensives. T2D with controlled BP revealed slightly better, though insignificant; QTc, QTd than those with BP uncontrolled. QT parameters were not significantly correlated with age, heart rate, or BP. Qualitative differences exceeded quantitative difference in QTc and QTd evaluation. There was no significant effect of use or nonuse of preventive pharmacotherapy on QT parameters. **Conclusion:** Low-to-moderate prevailing cardiac repolarization abnormality in T2D with very low ECG LVH was unaffected by HTN as a disease, its control status, and treatment modalities suggesting primary preventive role of antihypertensive use without class difference.

Keywords: Antihypertensive, blood pressure, hypertension, QT interval, type 2 diabetes

Introduction

Noncommunicable diseases including type 2 diabetes mellitus (T2DM) and hypertension (HTN) are on high.[1] Both coexist in more than 60% cases[2] and share not only common risk factors but also risks imposed. Cardiac repolarization abnormality is one such aftermath threatening to lead to ventricular arrhythmia and sudden cardiac death.[3] Simple electrocardiogram (ECG)-based QT interval parameters can indicate it. It is prolonged by both HTN[4] and T2DM[5] individually. HTN not only adds an extra risk for the same as a disease[6] but also offers a protective effect of antihypertensive drugs. We studied the effect of HTN in terms of a disease, its control status, and therapy offered for it, on QTc and QTd in known type 2 diabetics (T2D).

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Materials and Methods

Study setup and subjects

We conducted a cross-sectional study in the Department of Medicine in association with Physiology Department of Government Medical College, Bhavnagar, Gujarat, India.

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After getting approval from the institutional review board and informed written consent from each patient, subjects were recruited for this study. Of total number of patients attending the Outdoor Clinic, we screened all the adult patients for the presence of type 2 diabetes. Patients coming to clinic with record of treatment of diabetes were also included in this screening for confirmation. Of the total number of T2Ds, observed during the recruitment period (n = 400), 199 patients were randomly selected for this study. We calculated sample size by Raosoft software (Raosoft, Inc. free online software, Seattle, WA, USA). A sample of 199 patients from a population of 6 lakh, having 7.33% prevalence of type 2 diabetes in our region, gave us confidence level 95%, leaving margin of error 5%.

Selection criteria

We included T2Ds, with duration of at least 1 year with known current glycemic control status, aged 30–70 years, male or female, with or without HTN, taking treatment (except insulin) regularly (through chart review), ready for written consent.

Exclusion criteria: Those patients with chronic dysentery, cancer, chronic kidney failure, type 1 diabetes mellitus and a past history of intervention and those on pacemaker and on drug therapy influencing the autonomic function other than beta-blockers were excluded.

Collection of data

After a 5-min rest in sitting position, blood pressure (BP) was recorded on the right arm using a standard mercury manometer. In accordance with the WHO guidelines, if BP was ≥140/90 mmHg, a repeat measurement was obtained after a 5-min rest, with the patient in a supine position.

QTc measurement

We used 12 channel ECG machine to record strip ECG with standard norms. Patients were asked to lie in the supine position and 12 leads ECG was recorded on ECG machine. We measured QT interval and RR interval manually from the ECG strip for ten successive readings. QT interval was measured using tangent method.[7] RR interval was measured from one R-wave peak to successive R-wave peak. QTc intervals were derived using Bazett's formula and an average of ten results was taken for each patient. We finally included 199 participants in our study with measurable QT intervals in ≥6 total leads (mean, 9.8 ± 0.8) and ≥3 chest leads (mean, 4.6 ± 0.3). Seven cases were discarded since lead II had artifact or shallow T-wave as well as difficult measurement of the QT.

Bazett's formula:

$$QTc = \frac{QT}{\sqrt{RR}}$$

No correction was used if heart rate (HR) was <60.

ECG LVH criteria:[8]

We used the Cornell Voltage Criteria to define LVH which is as follows:

1. S in lead V3 + R in lead aVL >28 mm (male)
2. S in lead V3 + R in lead aVL >20 mm (female).

Defining norms

Glycemic control was defined as per criteria given by the American Diabetes Association 2014.[9] We defined good glycemic control as (1) fasting plasma glucose ≤126 mg% or (2) PP2BG ≤180 mg%.

QTc interval – values >0.43 s in male and >0.45 s in female were considered as abnormal.[10]

BP – systolic BP (SBP) <130 mmHg and diastolic BP (DBP) <80 mmHg was taken as controlled BP.[11]

Statistical analysis

We presented the numerical data as mean ± standard deviation and categorical data as number (percentage). Statistical analysis was done by software GraphPad InStat 3 (a free demo version statistical software of GraphPad Software Ltd, Inc. California, USA). Student's t-test was used to compare observed difference in distribution of QT values. For association between QT parameters and various confounding parameters odds ratio was calculated, keeping confidence interval 95%, taking QTc >0.43 s in males and QTc >0.45 s in females as positive outcomes and QTc ≤0.43 s in males and QTc ≤0.45 s in females as negative outcome. Categorical data were analyzed by Fisher's exact test. Any observed difference was considered significant statistically with $P < 0.05$.

Results

Hypertensive T2D had higher age, but comparable gender distribution and duration as compared to normotensive T2D. Two groups did not differ significantly in BP control, HR, or rate pressure product (RPP), though normotensives had higher BP than hypertensives. Hypertensives were taking more adjuvant to biguanide for diabetes as compared to normotensives with statistical significance. QT parameters such as average QTc, maximum QTc, minimum QTc, and QTd were comparable between groups. However, normotensives had lower prevalence of prolonged QTd (16% vs. 22%, $P = 0.447$) as compared to hypertensives. Only 6 patients had ECG LVH but all were normotensives [Table 1].

QT parameters correlated positively with age, duration, SBP, DBP, HR, and RPP, but all correlations were statistically insignificant except correlation between QTd and RPP. QTd correlated more with these confounders than QTc [Table 2].

Subgroup with controlled BP was statistically not different from the one with BP uncontrolled with reference to age, gender distribution, duration, antihypertensive therapy (AHT), and ECG LVH prevalence. Quantitative QT parameters had small and insignificant difference between two subgroups based on BP control. However, qualitatively T2D with uncontrolled BP had prolonged QTc (16% vs. 13%, $P = 0.55$) and QTd (27% vs. 14%, $P = 0.033$) as compared to the one with BP controlled [Table 3].

Table 1: Baseline and clinical data of type 2 diabetics-normotensive versus hypertensive, and in all patients

Parameter (unit)	Statistic	Whole group (*n*=199)	HT T2D (*n*=138)	NT T2D (*n*=61)
Age (years)	Mean±SD	55.60±9.73	56.47±9.58	53.66±9.87
Male/female	*n* (%)	67/132 (34)	48/90 (35)	19/42 (31)
Duration (years)	Mean±SD	5.79±6.18	5.80±5.91	5.75±6.81
FPG (mg/dL)	Mean±SD	168.72±68.84	167.02±71.44	174.83±59.53
PP2BG (mg/dL)	Mean±SD	256.43±105.20	248.30±104.79	287.17±103.22
GC (+,-)	*n* (%)	64/135 (32)	39/99 (28)	25/36 (41)
SBP (mmHg)	Mean±SD	130.15±15.96	131.09±15.74	128.03±16.39
DBP (mmHg)	Mean±SD	82.70±7.31	82.49±6.68	83.18±8.61
HR (bpm)	Mean±SD	80.21±13.66	79.29±13.46	82.28±13.72
RPP (mm of Hg.bpm)	Mean±SD	104.51±22.43	104.21±22.76	105.20±21.80
Pharmacotherapy				
Biguanide	*n* (%)	196 (98)	136/2 (99)	60/1 (98)
Sulfonylurea	*n* (%)	128 (64)	97/41 (70)	31/30 (51)*
Statins	*n* (%)	96 (48)	82/56 (59)	14/47 (23)**
Aspirin	*n* (%)	63 (32)	54/84 (39)	9/52 (15)*
BB	*n* (%)	112 (56)	112/26 (61)	-
ACEI	*n* (%)	57 (29)	57/81 (30)	-
CCB	*n* (%)	20 (10)	20/118 (10)	-
QTc avg (s)	Mean±SD	0.42±0.02	0.42±0.02	0.42±0.02
QTc max (s)	Mean±SD	0.45±0.03	0.44±0.05	0.45±0.03
QTc min (s)	Mean±SD	0.38±0.04	0.39±0.05	0.40±0.03
QTd (ms)	Mean±SD	47.80±23.13	47.29±24.02	48.97±21.12
QTc-AbN/N	*n* (%)	29/170 (15)	19/119 (14)	10/51 (16)
QTd-AbN/N	*n* (%)	40/159 (20)	30/108 (22)	10/51 (16)
$SV_1+RV_{5/6}$ (mm)	Mean±SD	16.07±5.48	16.59±5.69	16.67±6.13
RaV_L+SV_3 (mm)	Mean±SD	8.83±5.19	9.17±4.12	10.61±5.48
ECG LVH (+,-)	*n* (%)	6/193 (3)	0/130 (0)	6/55 (10)*

Values are expressed as mean±SD or n, statistical significance - *P<0.05; **P<0.001 compared to control (NT T2D). Unpaired t-test for means/normality test for numbers. FPG=Fasting plasma glucose, PP2BG=Postprandial blood glucose, GC=Glycemic control, SBP=Systolic BP, DBP=Diastolic BP, HR=Heart rate, bpm=Beats per minute, RPP=Rate pressure product, BB=Beta-blocker, ACEI=Angiotensin-converting enzyme inhibitor, CCB=Calcium channel blocker, QTc=QT corrected for heart rate, QTc avg=Average QTc, QTc max=Maximum QTc, QTc min=Minimum QTc, QTd=QT dispersion, AbN=Abnormal, N=Normal, LVH=Left ventricular hypertrophy, SD=Standard deviation, , T2D=Type 2 diabetics, NT=Normotensive, ECG=Electrocardiographic, BP=Blood pressure, +=Positive, -=Negative, HT=Hypertension, SV1=Amplitude of S wave in lead V1 , RV6=Amplitude of R wave in lead V6, NT T2D =Normotensive type 2 diabetic

Table 2: Correlation of QT parameters with other test parameters

Variable	QTc	QTd
	R	*R*
Age	0.03	0.03
Duration	0.12	0.11
SBP	−0.01	0.08
DBP	0.01	0.12
HR	0.10	0.13
RPP	0.07	0.16*

Values are expressed as correlation coefficient. Statistical significance - *P<0.05. Spearman's correlation test. SBP=Systolic BP, DBP=Diastolic BP, HR=Heart rate, RPP=Rate pressure product, QTc=QT corrected for heart rate, QTd=QT dispersion

We compared effect of individual pharmacotherapeutic agent on QT parameters. Presence or absence of individual pharmacotherapeutic agent seemed to have no clear-cut difference with respect to QT results. However, trends of qualitative prolongation of QTc were reversed than that of QTd. Most of the results were insignificant statistically except use of aspirin and qualitative QTd [Table 4].

Discussion

Type 2 diabetes is the epidemic of modern era affecting India adversely[12] and HTN is making a deadly duo with it. Both individually are known to have adverse cardiovascular outcome, ventricular arrhythmias being one of them. Ventricular arrhythmias can be diagnosed by ECG-based QT parameters of prolongation and dispersion.[13] We published recently a study showing low-to-moderate prevalence of prolonged QTc and QTd, qualitatively more than quantitatively, in T2D with very low ECG LVH and high prevalence of preventive pharmacotherapy, associated with male gender and glycemic control.[14] We further evaluated these patients to test the significance of presence of HTN, disease control, and drug therapy in the same T2Ds.

HTN is known to prevail highly than T2DM[15] and known to lead to LVH.[16] This can be seen as high prevalence of

QT abnormality that can lead to ventricular arrhythmia with possibility of sudden cardiac death as terminal event. Presence of HTN, though an additional risk factor, also offers advantage of use of antihypertensive drug[17] that can correct cardiovascular abnormality underlying this prediction. We found no difference in QT interval variable in normotensive and hypertensive known T2D, contradictory to few others.[6,16,18] This indicates that the risk offered by this coexisting disease is overcome by therapy with reference to HTN. BP reduction can normalize QTc and QTd as previously documented[19] and we found the same. Newly diagnosed hypertensive[20] and nonhypertensives[21] T2Ds have more QT abnormality prevalence, but in our study, mean treatment duration in hypertensives was 4 years that was sufficient to offer the protective impact. We did not find significant effect of controlled BP on QTc and QTd in contradiction to other who found direct correlation between BP and QT interval.[19,22,23] This can be because BP on average was not too high, mean SBP being 130 mmHg and mean DBP being 83 mmHg. T2Ds are strictly monitored for BP control at each visit and this may hide the effect on uncontrolled BP that otherwise make QT profile worse. As such individual drug had small significant advantage including aspirin, statins, and antihypertensives. Here, notable is beta-blocker that was used by more than half patients that is known to offer protection against repolarization abnormality in T2D[17] additive to benefits offered by intensive therapy for glycemic control.

Table 3: Comparison of the study parameters between type 2 diabetics with and without blood pressure control

Parameter (unit)	Descriptive statistic	BP controlled (*n*=101)	BP uncontrolled (*n*=98)
Age (years)	Mean±SD	54.70±10.00	55.70±10.06
Male/female	*n* (%)	34/67 (34)	33/65 (33)
Duration (years)	Mean±SD	5.71±6.37	5.87±6.02
GC (+,-)	*n* (%)	37/64 (37)	27/71 (28)
RPP (mmHg.bpm)	Mean±SD	94.17±17.54	115.17±21.96**
BB (+,-)	*n* (%)	51/50 (50)	61/37 (61)
Statins (+,-)	*n* (%)	54/47 (54)	42/56 (43)
Aspirin (+,-)	*n* (%)	36/65 (36)	27/71 (28)
ACEI (+,-)	*n* (%)	25/76 (25)	32/66 (33)
QTc avg (s)	Mean±SD	0.42±0.02	0.42±0.02
QTc max (s)	Mean±SD	0.44±0.05	0.45±0.03
QTc min (s)	Mean±SD	0.39±0.05	0.39±0.05
QTd (ms)	Mean±SD	46.46±23.84	49.19±22.41
QTc-AbN/N	*n* (%)	13/88 (13)	16/82 (16)
QTd-AbN/N	*n* (%)	14/87 (14)	26/72 (27)*
$SV_1+RV_{5/6}$ (mm)	Mean±SD	16.84±5.62	16.39±6.03
RaV_L+SV_3 (mm)	Mean±SD	9.27±4.49	9.96±5.10
ECG LVH (+,-)	*n* (%)	1/100 (1)	5/93 (5)

Values are expressed as mean±SD or n. Statistical significance - *P<0.05; **P<0.001 compared to BP controlled. Unpaired *t*-test for means/normality test for numbers. GC=Glycemic control, RPP=Rate pressure product, BB=Beta-blocker, QTc=QT corrected for heart rate, QTc avg=Average QTc, QTc max=Maximum QTc, QTc min=Minimum QTc, QTd=QT dispersion, AbN=Abnormal, N=Normal, LVH=Left ventricular hypertrophy, ECG=Electrocardiographic, BP=Blood pressure, SD=Standard deviation, ACEI=Angiotensin-converting enzyme inhibitor, +=Positive, -=Negative, SV1=Amplitude of S wave in lead V1 , RV6=Amplitude of R wave in lead V6

One HR variability (HRV)-based study done by us showed[24] that T2Ds having poor glycemic control have a nonsignificant difference of cardiac dysautonomia by control of BP or blood glucose. It suggests diabetes to be a major factor for cardiac autonomic imbalance, residual risk even after treatment and need for screening using HRV, optimum glycemic control, and further studies. In same T2Ds, we found that as a coexisting factor HTN did not make significant difference in cardiac autonomic status.[25] These two emphasize the risk that is residual despite undergoing antihypertensive treatment and early screening of the same by HRV or QTc, optimum glycemic control, and other interventions. However, HRV in our patients with diabetes showed more adverse result than QTc or QTd, in line with the finding. It suggests that cardiac dysautonomia in hypertensives is not related to repolarization abnormalities in LVH.[26] On the other hand, HRV analysis may not reveal the abnormalities in cardiac autonomic control of the ventricle.[26] These clues to the fact that though both QT and HRV are cardiac autonomic function tests, they do not assess the same domain.

Table 4: Effect of pharmacotherapy on QT parameters in the study group

Drug	Data	Duration (mean±SD)	GC, *n* (%)	PC, *n* (%)	QTc-value, mean±SD	QTd-value, mean±SD	QTc-AbN, *n* (%)	QTd-AbN, *n* (%)
BB	Positive (*n*=112)	5.90±6.06	34 (30)	48 (43)*	0.42±0.02	46.49±24.33	12 (11)	25 (22)
	Negative (*n*=87)	5.64±6.38	30 (34)	50 (57)	0.42±0.02	49.49±21.36	17 (20)	15 (17)
Statin	Positive (*n*=96)	6.47±6.55	32 (33)	47 (49)	0.42±0.02	46.81±23.86	15 (16)	10 (20)
	Negative (*n*=103)	5.15±5.78	32 (31)	51 (50)	0.42±0.02	48.73±22.50	14 (14)	21 (20)
Aspirin	Positive (*n*=63)	6.38±6.49	25 (40)	36 (57)	0.42±0.02	44.20±23.54	9 (14)	7 (11)*
	Negative (*n*=136)	5.51±6.04	39 (29)	62 (46)	0.42±0.02	49.47±22.83	20 (15)	33 (24)
ACEI	Positive (*n*=57)	6.33±6.58	16 (28)	25 (44)	0.42±0.02	46.75±26.14	11 (20)	7 (12)
	Negative (*n*=142)	5.57±6.03	48 (34)	73 (51)	0.42±0.02	48.23±21.89	18 (13)	33 (23)
Multiple	Positive (*n*=49)	6.33±6.72	13 (27)*	22 (45)**	0.42±0.02	47.00±27.15	10 (20)	6 (12)
AHT	Negative (*n*=89)	5.52±5.43	51 (57)	76 (85)	0.42±0.02	47.44±22.27	9 (10)	24 (27)

Values are expressed as mean±SD or n. Statistical significance - *P<0.05; **P<0.001 compared to drug nonuser. Unpaired *t*-test for means/normality test for numbers. GC=Glycemic control, PC=Pressure control, AHT=Antihypertensive therapy, QTc=QT corrected for heart rate, QTd=QT dispersion, AbN=Abnormal, BB=Beta-blocker, ACEI=Angiotensin-converting enzyme inhibitor, SD=Standard deviation

In another study published by us, we found that in known hypertensive on monotherapy with poor pressure control, there was high prevalence of prolonged QTc, both qualitatively and quantitatively, associated with female gender and age but not duration or BP.[5] In same patients, we found prolonged QTc to be more adverse, more so in newly diagnosed hypertensives, unaffected by duration or use of ACEI, or CCB but associated with modifiable risk factors.[27] This study done in hypertensives with incident coexisting T2DM showed higher prevalence of QTc abnormality than the present study done in known T2DM with incident HTN. It suggests that HTN, that is not aftermath of hyperglycemia, is more dangerous as it is asymptomatic in majority and screening will be late so as onset of AHT. Hence, in such case, LVH prevalence will be high, and despite therapy and BP control, repolarization abnormality would be prevailing higher. But in T2Ds, screening for HTN by routine BP measurement is a norm. So here HTN is diagnosed early, at perhaps lower than normal SBP cutoff, treated early and with better compliance to pharmacotherapy owing to coexisting diabetes which is thought to apprehend subject more than HTN alone. When we compare these two studies again, BP was significantly affecting QTc in the previous study[5] than the present. This indicates that in patients with T2DM developing HTN due to T2DM (like the ones of the present study), hyperglycemia could be more significant factor affecting QTc and QTd than BP which might have remained untreated due to asymptomatic nature of disease. Antihypertensive class difference was not affecting QTc extensively in both these studies, and it underscores importance of BP controlled and use of beta blocker that prevailed in fair numbers in either study.

Cardiovascular diseases have been evolving as a major health burden for which heaviest toll is to be paid for type 2 diabetes, complicated by associated or aftermath, HTN.[28] Sudden cardiac death is a risk in T2D in the light of cardiac autonomic neuropathy and asymptomatic progression of CVD morbidity and mortality that need screening in the preclinical stage.[29] Early screening for both diabetes and HTN can reduce the cardiovascular aftermaths as evidenced by low prevalence of LVH and QT abnormality in our study patients. Good glycemic control is needed to offer the preventive benefit for morbidities such as vasculopathy,[30] cardiac dysautonomia,[24] ectopic fat distribution,[31] and many more. Such optimum disease control can be achieved by good self-care, attitudes, and practices in patients with diabetes.[32] ECG-based QT interval provides additive prognostic information beyond conventional risk markers like Echo LVH in hypertensive diabetics.[6] This simple screening tool is fairly accurate, reproducible, nor requiring patient compliance and easy to practice even at primary care level.[33] Secondary prevention by drugs like beta-blocker is also beneficial as suggested by this study.

Our study had limitations like small sample size, lack of biochemical investigations like serum electrolytes, lack of HbA1c report, and manual measurement of QT parameters and preponderance of females than males. The pretreatment or baseline data were not available and with single cross-sectional measurement we need further evidence in from longitudinal studies to establish causality.

Conclusion

In T2Ds, we found insignificant impact of HTN and AHT on moderately prevalent QT parameters of ECG. It suggests positive impact of associated preventive pharmacotherapy for hypertension without class difference to reduce risk of cardiac repolarization abnormality.

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Conflicts of interest

There are no conflicts of interest.

References

1. Yadav S, Arokiasamy P. Understanding epidemiological transition in India. Glob Health Action 2014;15:7.
2. Solanki JD, Makwana AH, Mehta HB, Gokhale PA, Shah CJ. A study of prevalence and association of risk factors for diabetic vasculopathy in an urban area of Gujarat. J Family Med Prim Care 2013;2:360-4.
3. Stevens SM, Reinier K, Chugh SS. Increased left ventricular mass as a predictor of sudden cardiac death: Is it time to put it to the test? Circ Arrhythm Electrophysiol 2013;6:212-7.
4. Pillai JN, Madhavan S. Cardiac autonomic neuropathy and QTc interval in type 2 diabetes. Heart India 2015;3:8-11.
5. Solanki JD, Gadhavi BP, Makwana AH, Mehta HB, Shah CJ, Gokhale PA. Early screening of hypertension and cardiac dysautonomia in each hypertensive is needed- inference from a study of QTc interval in Gujarati hypertensives. Int J Prev Med 2017;8:86-91.
6. Salles GF, Deccache W, Cardoso CR. Usefulness of QT-interval parameters for cardiovascular risk stratification in type 2 diabetic patients with arterial hypertension. J Hum Hypertens 2005;19:241-9.
7. Casale PN, Devereux RB, Alonso DR, Campo E, Kligfield P. Improved sex-specific criteria of left ventricular hypertrophy for clinical and computer interpretation of electrocardiograms: Validation with autopsy findings. Circulation 1987;75:565-72.
8. Lanjewar P, Pathak V, Lokhandwala Y. Issues in QT interval measurement. Indian Pacing Electrophysiol J 2004;4:156-61.
9. Moss AJ. The QT interval and torsade de pointes. Drug Saf 1999;21 Suppl 1:5-10.
10. Verrotti A, Prezioso G, Scattoni R, Chiarelli F. Autonomic neuropathy in diabetes mellitus. Front Endocrinol (Lausanne) 2014;5:205.
11. American Diabetes Association. Standards of medical care in diabetes–2014. Diabetes Care 2014;37 Suppl 1:S14-80.
12. Mohan V, Venkatraman JV, Pradeepa R. Epidemiology of cardiovascular disease in type 2 diabetes: The Indian scenario. J Diabetes Sci Technol 2010;4:158-70.
13. Zhang Y, Post WS, Blasco-Colmenares E, Dalal D, Tomaselli GF, Guallar E, *et al.* Electrocardiographic QT interval and mortality: A meta-analysis. Epidemiology 2011;22:660-70.
14. Solanki JD, Patel KJ, Lalwani N, Mehta HB, Shah CJ, Lakhtaria M. QTc and QTd in Gujarati type 2 diabetics predominantly using preventive pharmacotherapy and with very low ECG LVH. J Diabetol 2017;8:86-91.
15. Anchala R, Kannuri NK, Pant H, Khan H, Franco OH, Di Angelantonio E, *et al.* Hypertension in India: A systematic review and meta-analysis

of prevalence, awareness, and control of hypertension. J Hypertens 2014;32:1170-7.
16. Okin PM, Devereux RB, Gerdts E, Snapinn SM, Harris KE, Jern S, *et al.* Impact of diabetes mellitus on regression of electrocardiographic left ventricular hypertrophy and the prediction of outcome during antihypertensive therapy: The losartan intervention for endpoint (LIFE) reduction in hypertension study. Circulation 2006;113:1588-96.
17. Tsujimoto T, Sugiyama T, Noda M, Kajio H. Intensive glycemic therapy in patients with type 2 diabetes on β-blockers. Diabetes Care 2016;39:1818-26.
18. Subbalakshmi NK, Adhikari PM, Sathyanarayana Rao KN, Jeganathan PS. Influencing factors of QTc among the clinical characteristics in type 2 diabetes mellitus. Diabetes Res Clin Pract 2010;88:265-72.
19. Antonakis V, Tsioufis C, Tsiachris D, Andrikou I, Fantaki M, Dagres N, *et al.* Associations of hemodynamic load and ventricular repolarization in patients with newly diagnosed essential hypertension: A long-term follow-up study. J Clin Hypertens (Greenwich) 2014;16:219-24.
20. Saadeh A, Evans S, James M, Jones J. QTc dispersion and complex ventricular arrhythmias in untreated newly presenting hypertensive patients. J Hum Hypertens 1999;13:665-9.
21. Sato A, Tarnow L, Nielsen FS, Knudsen E, Parving HH. Left ventricular hypertrophy in normoalbuminuric type 2 diabetic patients not taking antihypertensive treatment. QJM 2005;98:879-84.
22. Peng S, Yu Y, Hao K, Xing H, Li D, Chen C, *et al.* Heart rate-corrected QT interval duration is significantly associated with blood pressure in Chinese hypertensives. J Electrocardiol 2006;39:206-10.
23. Mozos I, Serban C, Mihaescu R. The relation between arterial blood pressure variables and ventricular repolarization parameters. Int J Collab Res Intern Med Public Health 2012;4:860.
24. Solanki JD, Basida SD, Mehta HB, Panjwani SJ, Gadhavi BP, Patel P, *et al.* Impact of disease control and co-existing risk factors on heart rate variability in Gujarati type 2 diabetics: An observational study. J Family Med Prim Care 2016;5:393-8.
25. Solanki JD, Basida SD, Mehta HB, Panjwani SJ, Gadhavi BP. Comparative study of cardiac autonomic status by heart rate variability between under-treatment normotensive and hypertensive known type 2 diabetics. Indian Heart J 2017;69:52-6.
26. Perkiömäki JS, Ikäheimo MJ, Pikkujämsä SM, Rantala A, Lilja M, Kesäniemi YA, *et al.* Dispersion of the QT interval and autonomic modulation of heart rate in hypertensive men with and without left ventricular hypertrophy. Hypertension 1996;28:16-21.
27. Solanki JD, Gadhavi BP, Makwana AH, Mehta HB, Shah CJ, Gokhale PA, *et al.* QTc interval in young Gujarati hypertensives: Effect of disease, antihypertensive monotherapy, and coexisting risk factors. J Pharmacol Pharmacother 2016;7:165-70.
28. Sowers JR, Epstein M, Frohlich ED. Diabetes, hypertension, and cardiovascular disease: An update. Hypertension 2001;37:1053-9.
29. Hashimoto Y, Tanaka M, Senmaru T, Okada H, Asano M, Yamazaki M, *et al*. The QT Interval could be a marker of subclinical atherosclerosis in patients with type 2 diabetes. J Diabetes Metab 2013;4:302.
30. Solanki JD, Makwana AH, Mehta HB, Gokhale PA, Shah CJ. Evaluating glycemic control and its correlation with peripheral artery disease in ambulatory type 2 diabetic patients of an urban area of Gujarat, India. Int J Clin Exp Physiol 2014;1:221-5.
31. Solanki JD, Makwana AH, Mehta HB, Kamdar P, Gokhale PA, Shah CJ, *et al.* Effect of current glycemic control on qualitative body composition in sedentary ambulatory type 2 diabetics. Niger Med J 2016;57:5-9.
32. Solanki JD, Sheth NS, Shah CJ, Mehta HB. Knowledge, attitude, and practice of urban Gujarati type 2 diabetics: Prevalence and impact on disease control. J Educ Health Promot 2017;6:35.
33. Kumar R, Fisher M, Macfarlane PW. Review: Diabetes and the QT interval: Time for debate. Br J Diabetes Vasc Dis 2004;4:146-50.