DO COLLATERALS AFFECT QT DİSPERSİON IN PATIENTS WITH ACUTE MYOCARDIAL INFARCTION

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Summary

*QT interval dispersion is an attempt to measure noninvasively the propensity of the heart to support reentrant circuits. QT dispersion increases in patients with acute myocardial infarction (MI) and a quicker restoration of blood flow in the infarct related artery decreases QT dispersion. Effects of collateral blood flow on QT dispersion and the occurence of ventricular arrhythmias is controversial. This study addresses the relationship between collateral blood flow, QT dispersion and ventricular arrhythmias. Eighty- two patients admitted within 6 hours and underwent thrombolytic treatment due to acute anterior MI were enrolled in this study. Twenty-five patients with collaterals were compared with age and genderly matched fifty-seven patients without coronary collaterals. Maximum corrected QT interval (QTc max) and corrected QT (QTc) dispersion values were higher in patients without collaterals both on admission and on the 5th day post- MI than those with collaterals. Ventricular arrhythmias were also more common in the patients without collaterals during hospitalization. QTc max on the fifth day post-MI was positively correlated with age, QTc dispersion was positively correlated with age and degree of LAD stenosis. Logistic regression analysis showed that only the collaterals and QT dispersion values affect the development of ventricular arrhythmias. In the patients with acute MI, collateral formation to the infarct related artery leads to decrease in QTc max, QTc disp values. Furthermore, these patients with collaterals had much lower arrhythmic events. All these findings support that the collateralisation at the time of infarct will reduce QTc dispersion and risk of re-entrant arrhythmia. Finally, we suggest that the collateral formation has a protective role on myocardial electrophysiology. (**Arch Turk Soc Cardiol 2003;31:663-70**)*

Key Words: *Acute myocardial infarction, collateral, QT dispersion*

Özet

Akut Miyokard Enfarktüslü Hastalarda Kollateral Gelişiminin QT Dispersiyonu Üzerine Etkisi

QT dispersiyonu kalpteki reentran dispersiyonu öngüleri non-invazif olarak belirleme yöntemidir. Akut miyokard enfarktüslü hastalarda QT dispersiyonu artar ve enfarkt ile ilişkili arterdeki akımın hızlı bir biçimde düzeltilmesi QT dispersiyonunu azaltır. Ancak, kollateral kan akımının QT dispersiyonu ve ventriküler aritmi oluşumuna etkisi tartışmalıdır. Bu çalışmada kollateral kan akımı, QT dispersiyonu ve ventriküler aritmiler arasındaki ilişki

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Çalışmaya akut miyokard enfarktüsü ilk 6 saati içinde kliniğimize kabul edilen ve trombolitik tedavi uygulanan hastalar alınmıştır. Kollaterali olan 25 hasta, yaş ve cinsiyet açısından benzer kollaterali olmayan 57 hasta ile karşılaştırılmıştır. Hem başvuruda, hem de enfarktüs sonrası 5. günde düzeltilmiş maksimum QT aralığı (QTc max) ve düzeltilmiş QT dispersiyonu (QTc disp) kollaterali olmayan hastalarda kollaterali olanlardan daha yüksek bulunmuştur. Kollaterali olmayan hastalarda hastanede kalış süresince ventriküler aritmiler daha sık bulunmuştur. Enfarktüs sonrası 5. gündeki QTc max yaşla, QTc dispersyonu ise yaş ve sol ön inen damardaki darlığın derecesi ile ilişkili bulunmuştur. Yine anjina öyküsü olan hastalarda QTc dispersiyonu ve ventriküler aritmiler daha düşük olarak bulunmuştur. Akut miyokard enfraktüslü hastalarda enfarkt ile ilişkili artere kollateral gelişimi QTc max ve QTc dispersiyonuda belirgin azalmaya neden olmaktadır. Ayrıca bu hastalarda çok daha az aritmik olay görülmüştür. Tüm bu bulgular kollateralizasyonun QTc dispersiyonunu ve aritmi riskini azalttığını desteklemektedir. Sonuç olarak, kollateral oluşumunun miyokardiyal elektrofizyolojide koruyucu etkisinin olduğu düşünülmektedir.

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Anahtar kelimeler: *Akut miyokard infarktüsü, kollateral, QT dispersiyonu*

Many lethal ventricular arrhythmias are sustained by reentrant mechanisms and if areas of the heart have a shortened refractory period relative to adjacent areas, this could provide a potential reentry point for ventricular arrhtyhmias. QT interval dispersion is an attempt to measure noninvasively the propensity of the intact heart to support these reentrant circuits[1]. Although the QT interval shortens in the very early stages (< 12 hrs) of acute myocardial infarction (AMI) [2]. And after this early QT interval shortening, QT interval lengthening occurs[2] probably due to the profound changes in sympathetic and parasympathetic cardiac outflow. Whether the QT interval prolongation has an impact on acute phase arrhtyhmias is not clear from the data. QT dispersion is increased during AMI[1]. In a previous report, QT interval dispersion in those with AMI (56 ±24 ms) was increased when compared with an age matched healthy control group (30 ±10 ms)[3]. A quicker restoration of blood flow in the infarct related artery post MI decreases QT dispersion[4]. An excellent study from the TEAM-2 investigators examining the influence of thrombolysis on QT dispersion found a graded relation between TIMI flow 2.4 ±1 hr post thrombolysis and QT dispersion with TIMI 0, 1, 2 and 3 flow having 97 ± 32, 88 ±31, 63 ±23 and 58 ±21 ms, respectively[4]. But the effects of collateral blood flow to the occurence of ventricular arrhythmias and QT dispersion is controversial. Thus, in this study we aimed to show whether the collateralisation at the time of infarct will limit dispersion of ventricular recovery and hence reduce QT dispersion and risk of re-entrant arrhythmia.

MATERIAL AND METHODS

The patients admitted to our clinics, diagnosed to acute anterior myocardial infarction and underwent thrombolytic therapy between January 2000 and August 2002 were enrolled in this study. The patients with abnormal serum electrolytes, historical and/or electrocardiographic findings of a previous myocardial infarction, chronic treatment with antiarrhythmic drugs, digitalis or other drugs affecting QT interval, clinical signs of left ventricular failure and cardiogenic shock at admission, with significant stenosis (> 50 % lumen diameter stenoses) other than that in the culprit lesion, preexcitation syndromes, ventricular pacing, bundle branch block, intraventricular conduction disorders, previous bypass surgery, admitted after 6 hours from the onset of symptoms were excluded from the study. All patients were admitted within 6 hours after the onset of acute MI. Diagnoses of acute MI was established by ST segment elevation, defined subsequently, in more than two leads associated with

typical chest pain and confirmed by elevation of serum creatine kinase MB isoenzyme greater than two times the normal upper limit during the patients clinical course. All patients underwent thrombolytic therapy within 6 hours after symptoms and all patients received standart medical therapy in accordance with conventional guidelines. Cardiac catheterization and transthoracic echocardiography were performed after the patients clinical status was stabilized, on the sixth day of hospitalization.

A high quality 12- lead ECG recorded at 50 mm/s speed and 10 mm/mV gain. A minimum of eight leads, of at least four were precordial, was required for QT dispersion to be calculated. QT and RR intervals were measured in at least two consecutive cycles and the mean value for each lead was considered for further calculations. ECGs were analysed by two observers blind to outcome manually using caliper and magnifying lens. QT interval was measured from the onset of the QRS complex to the ned of the T wave, defined visually as the point of return of the T wave to baseline. The nadir of the T and U waves did not involve extrapolation of the T downslope to the isoelectric baseline. Results are given as QT dispersion (the difference between the maximum and minimum QT across the 12- lead ECG) and rate corrected QT dispersion (using Bazzet's formula). Measurements were performed at the admission and repeated on the 5th day post- MI. Intra and interobserver mean percent errors were 3.4 and 3.6 % for corrected QT maximum (QTc max), 3.7 and 3.6 % for QT minimum (QTc min) and 2.9 and 3.2 % for QT dispersion (QTc disp).

Coronary angiograms after acute MI were obtained on the 6th day and evaluated by two experienced angiographers blinded to the characteristics of patients. The degree of coronary narrowing was determined by visual assessment from a review of at least 2 wiews of each coronary artery. Culprit lesion, correlated with the location of MI, was defined when the lesion was totally occluded or showed severe stenosis and the patients with signficant stenosis other than that in the culprit lesion were excluded. Collaterals were graded according to the criteria of Rentrop[5]. This classification is summarized as follows: grade 0= no visible filling of any collateral channels; grade 1= filling of side branches only, without epicardial opacification, by means of collaterals; grade 2= partial epicardial vessel filling by collaterals; and grade 3= complete epicardial vessel filling by collaterals. The patients were classified into two groups according to the presence of collaterals to the infarct related artery. Twenty-five patients with collaterals (15 male, 10 female with an avarage age of 53.9± 13.7 years) were compared with fifty-seven patients without coronary collaterals (38 male, 19 female with an avarage age of 58.6± 10.2 years) regarding some clinical, electrocardiographic (QTc intervals and QTc dispersion) and angiographic parameters. All the patients were applied transthoracic echocardiography on the 6th day and left ventricular ejection fractions were defined.

Ventricular arrhythmias, non-sustained (3 or more consecutive premature ventricular complexes at a rate greater than 100 beats/min and lasting less than 30 seconds) and sustained ventricular tahcycardia, ventricular fibrillation were detected during monitorization and by telemetry. Ventricular arrhythmias were classified according to modified Lown criterias and grade 4a and 4b arrhythmias were classified as serious ventricular arrhythmias[6].

STATISTICAL METHODS

Continous variables are expressed as mean SD, categorical variables as a percent. For continous variables student's t- test, and for categorical variables Chi- square, Fischer's exact and Mann- Whithney U tests were performed to compare study and control groups. Pearson's correlation analysis was used to find any correlation between the QT dispersion, age, LAD stenosis and peak CK-MB levels. Logistic regression analysis were performed to define the independent determinants for the development of ventricular arrhythmias. A p value < 0.05 was considered statisticallly significant.

RESULTS

In all of the patients in both groups, the infarct area was anterior wall and infarct related artery were the left anterior descending artery (LAD). Fifty-seven patients without coronary collaterals to the infarct related artery (38 male, 19 female with

an avarage age of 58.6 ±10.2 years) and twenty-five patients with collaterals (15 male, 10 female with an avarage age of 53.9 ±13.7 years) were enrolled in this study. All the patients were admitted within 6 hours and underwent thrombolytic treatment within 6 hours of symptoms. The time period between the onset of symptoms and thrombolytic treatment was similar in both groups (3.0 ±1.1 vs 3.2 ±1.1 hours, p= 0.3). There were no differences between both groups concerning age, sex, hypertension (HT), Diabetes mellitus (DM), and previous medications. But the prior angina history (72 % vs 19.3 %, p= 0.02), degree of stenosis in the LAD (94.2± 3.9 vs 87.9 ±8.2, p= 0.001) were higher in patients with collaterals compared to those without collaterals. Furthermore, QTc max and QTc dispersion values (428.8 ±26.2 vs 417.3 ±14.8, p= 0.04; 51.7 ±19.6 vs 39.2 ±20.2, p= 0.01 and 451.8 ±29.7 vs 432.1 ±43.1, p= 0.02; 69.3± 30.8 vs 46.1± 29.5, p= 0.002) were higher in patients without collaterals both on admission and on the 5th day post- MI than those with collaterals. QT max values on the fifth day were similar (419.9 ±18.8 vs 415.2 ±15.2, p=0.05) but QT dispersion values were higher in those without collaterals (46.2 ±14.1 vs 37.3 ±12.4, p=0.01). Ventricular arrhythmias were also more common in the patients without collaterals during hospitalization. Left ventricle ejection fractions were higher in the patients with collaterals than those without collaterals (47.3 ±11.2 vs 40.2 ±14.1, p= 0.001). Peak CK-MB levels were higher in those without collaterals (149.9 ±92.8 vs 119.8 ±72.6, p=0.001) (Table 1). The patients with diabetes mellitus (75.9± 33.9 vs 50.6 ± 21.7, p= 0.001), ventricular arrhythmias (89.5 ±14.3 vs 43.2 ±26, p= 0.001), no prior history of angina (73.6 ± 26.0 vs 44.6 ±25.2, p= 0.001) and the patients who were smokers were found to have higher QTc dispersion values when compared to those without previous angina history, DM, ventricular arrhythmias and smokers. Ventricular arrhythmias (Grade 4a and 4b) were more common in the patients without prior angina compared to those with angina (29.7 % vs 4.6 %, p= 0.002). Pearson's correlation analysis revealed that QTc max on the fifth day post- MI was positively correlated with age (r=0.3, p=0.02), QTc dispersion was positively correlated with age (r=0.2, p=0.003) and degree of stenosis in LAD (r=0.3, p=0.003). QTc max (r=-0.4, p=0.03) and QTc disp (r=-0.6, p=0.004) were negatively correlated with peak CK-MB levels. Logistic regression analysis showed that only the collaterals and QT dispersion values affect the development of ventricular arrhythmias (Table 2).

Table 1: *Baseline characteristics of the study population*

Variables	Patients with collaterals n=25	Patients without collaterals n=57	p
Male %	60	66.6	NS
HT %	56	52.6	NS
DM %	20	28.1	NS
Previous Medications			
% B- blockers	12	17.5	NS
Nitrates	12	17.5	NS
Aspirin	16	15.8	NS
Age (years)	53.9± 13.7	58.6± 10.2	NS
Previous angina %	72	19.3	0.02
Degree of stenosis in LAD %	94.2± 3.9	87.9± 8.2	0.001
Peak CK-MB levels	119.8± 72.6	149.9± 92.8	0.001
At Admission			
QTc max	417.3± 14.8	428.8± 26.2	0.04
QTc min	368.1± 31.2	372± 26.4	NS
QTc disp	39.2± 20.2	51.7± 19.6	0.01
On the 5th day			
QTc max	432.1± 43.1	451.8± 29.7	0.02
QTc min	380.4± 15.2	378.2± 16.7	NS
QTc disp	46.1± 29.5	69.3± 30.8	0.002
Ventricular arrhythmia %	8	19.3	0.02

HT: Hypertension, DM: Diabetes Mellitus, LAD: Left anterior descending artery, QTc max: Maximum corrected QT interval, QTc min: Minimum corrected QT interval, QTc disp: Corrected QT dispersion

Table 2: *Logistic regression analysis revealed that only collaterals and QT dispersion affect the development of ventricular arrhythmias*

Variables	ß	S.E.	RR	95 % Confidence Interval	p
Smoking	1.33	0.68	1.81	0.99-14.64	0.2
Collaterals	-1.89	0.79	-6.67	0.03-0.71	0.01
DM	1.41	0.69	4.1	1.06-16.1	0.06
Previous angina	8.8	28.3	0.9	0.0-8.3	0.9
QT dispersion	-1.1	0.6	1.1	0.03-1.9	0.03

RR: Relative Risk ratio

DISCUSSION

Abnormalities in the QT interval are divided into three types, prolongation of the QT interval, increases in the QT dispersion of the QT interval and abnormalities in the heart rate dependent behaviour of the QT interval. Whether the QT interval prolongation has an impact on acute phase arrhythmias is not clear from the data. One study claimed an astonishing 100% specificity and sensitivity for QTc interval prolongation more than 440 ms predicting any acute phase ventricular arrhythmia[7]. The study by Ahnve et al reported that those with acute phase ventricular tachycardia had a longer QTc at 434 ms than those without acute phase VT, at 421 ms[8]. QT dispersion is clearly increased during AMI[1,3]. Some studies show that QT dispersion is largest at day 3 post MI, others that QT dispersion is most abnormal within the first day and falls within 24 hours[9,10]. Whether increased QT dispersion in AMI predicts acute phase ventricular arrhythmias (rhythm disorders of the initial 12 hours after the onset of symptoms) is also controversial. In one study, those with acute phase ventricular arrhythmias had significantly higher QT dispersion than those without acute phase arrhythmias, however, a larger and better designed case contral study found no difference in QTc dispersion between those who did and did not have acute phase ventricular arrhythmias[9,11]. In another study, the patients with VF compared without VF, and QTc dispersion durations were higher in patients with VF attacks[3]. The sensitivity, spesificity and positive predictive accuracy of a QTc dispersion of 80 ms for acute phase VF was 72, 94, 67 %, respectively. But in the largest study to date (TAMI-9 and GUSTO- I), no significant differences in QT dispersion were observed at any time between those with and without VF[12]. Aitchison et al[13] reported that the significant changes in QTc and QTc dispersion with time may account for the lack of correlation between admission QTc and ventricular fibrillation after acute MI In our study, the patients experienced ventricular arrhythmias during hospitalization were found to have higher QTc dispersion compared to those without ventricular arrhythmias (89.5± 14.1 vs 43.2± 26, p= 0.001).

The protective effects of collaterals during and after acute MI is also under debate. Julliere et al demonstrated in 14 patients with occlusion of LAD without myocardial infarction and with good collaterals, that after 48 months of follow- up there was no deterioration in left ventricular systolic function[14]. Kodama et al demonstrated among 21 post- myocardial infarction patients that the presence of coronary collateral flow 1 month after the acute event was associated with less dilation of the left ventricle after 2 years[15]. On the other hand, Boherer et al showed absence of significant differences in morbidity and mortality between patients with and without collaterals in the follow- up of 146 patients with AMI for 3.5 years[16]. In another report studying 102 patients with anterior wall infarction, the patients with well- developed collaterals were shown to have a significantly higher long- term mortality in relation to those with poor or absent collateral circulation[17]. Nicolau et al reported that the patients treated with thrombolytic therapy and adequate coronary collateral circulation have a worse prognosis than those who developed adequate anterograde flow, probably due to residual myocardial ischemia[18]. Furthermore, the prognostic importance of collateral circulation in patients with chronic ischemic heart disease could not be defined so far. This may be explained by two points: First the presence of collaterals may be counterbalanced by the severity of coronary artery lesions; secondly, the collateral dependent viable myocardium may predispose to fatal arrhythmias[19]. Infact, the anatomic substrate for reentrant ventricular tachycardia after MI is usually located in the endocardial and subendocardial portions of the infarct zone[20] and early experimental studies showed that purkinje fibers suviving in the infarction zone could be responsible for these arrhythmias[21]. Radionuclide perfusion scanning[22], contrast echocardiography

[23] demonstrate a vascular supply to these areas. Inoue et al reported the suppression of aconitine-induced ventricular tachycardia by intracoronary injection of saline solution into the coronary supplying the arrhythmia focus in dogs[24]. Okishige et al reported abolition of incessant polymorphic ventricular tachycardia after infusion of 50 % ethanol into an infarct- related left anterior descending artery in a patient 2 weeks after MI [25]. Brugada et al demonstrated the importance of collateral blood to the infarct zone to maintain the viability of cells responsible for ventricular tachycardia after MI and superselective administration of iced saline terminated the VT in five of six patients[26]. Friedman et al also reported that selective cannulation of a collateral vessel to an infarct- related artery followed by infusion of an antiarrhythmic drug resulted in a noninducible state in three patients with inducible VT[27]. On the contrary, Schley G et al demonstrated that the influence of well- developed collaterals on the decrease of the fibrillation threshold after coronary occlusion exceeds the dependence on the size of the ischemic area[28]. Hirata M et al also showed the disappearence of ventricular arrhythmia caused by coronary occlusion during retrograde blood flow through collaterals[29]. The decreased frequency of ventricular arrhythmias and lower QTc disp in patients with collaterals in our study suggest the protective effects of collaterals. Peak CK-MB levels were greater in the patients without collaterals suggesting less myocardial necrosis in these patients. This might also affect the QT max and dispersion.

Just in the previous reports about the protective effects of the preinfarction angina protects against out- of- hospital ventricular fibrillation[30,31], QTc dispersion and the frequency of ventricular arrhythmias were lower in patients with preinfarction angina compared to those without preinfarction angina in our study.

Rentrop et al demonstrated that 33 % of the patients with occluded culprit coronary arteries have some degree of angiographic collateral circulation in the first 12 hours of AMI and this percentage increases to 90% when patients were studied between 10 and 14 days of evolution[32]. In another study, well- developed collaterals are shown to be present in 16 % of the patients in the 6 hours of myocardial infarction, 62 % when studied between 14 and 45 days and 84 % after 45 days [33]. Thus, it is suggested that the development of collateral circulation is a lengthy process. This may explain the increase in the QTc dispersion values in both the study and control groups in the 5th day compared to those at admission. In accordance with previous reports[34-36], QTc QTc disp was higher in patients with DM and smoking in our study.

As a result, in our study the patients with acute MI and collateral formation to the infarct related artery were found to have lower QTc max, QTc disp values compared to those without collaterals. In addition, the grades of the collaterals were inversely correlated with QTc disp. Furthermore, these patients with collaterals had much lower arrhythmic events. The only two parameters that affect the development of ventricular arrhythmias were collaterals and QTC dispersion. All these findings support that the collateralisation at the time of infarct will limit dispersion of ventricular recovery and hence reduce QTc dispersion and risk of re-entrant arrhythmia.

The most important limitation of the studies on QTc dispersion is the lack of standardization of QT measurement and the need for a more strict definition of QT interval dispersion. The lack of urgent coronary angiography in the first hours of acute MI to evaluate the early collateralization and TIMI flow in the infarct- related artery is another limitation of the study.

REFERENCES

1. Davey P: QT interval and mortality from coronary artery disease. Prog Cardiovasc Dis 2000;42:359- 84
2. Cinca J, Figueras J, Tenorio L, et al: J Time course and rate dependence of QT interval changes during non-complicated acute transmural infarction in human

beings. Am J Cardiol 1981;48:1023- 8

3. Van de Loo A, Arendts W, Hohnloser SH: Variability of QT dispersion measurements in the surface electrocardiogram in patients with acute myocardial infarction and in normal subjects. Am J Cardiol 1994;74:1113- 8
4. Moreno FL, Villanueva T, Karagounis LA, Anderson JL: Reduction in QT interval dispersion by successful thrombolytic therapy in acute myocardial infarction. TEAM- 2 Study Investigators. Circulation 1994;90:94- 100
5. Rentrop KP, Cohen M, Blanke H, Philips RA: Changes in collateral channel filling immediately after controlled coronary artery occlusion by an balloon angioplasty in humanbeings. J Am Coll Cardiol 1982;5:587-92
6. Kautzner J, Malik M. QT interval dispersion and its clinical utility. Pacing Clin Electrophysiol 1997,20: 2625-40
7. Goswami KC, Nayak KC, Chadda VS: Role of QT interval at the onset or acute myocardial infarction in predicting early phase ventricular arrhythmia. J Assoc Physicians India 1992;40:306-7
8. Ahnve S: QT interval prolongation in acute myocardial infarction. Eur Heart J 1985;6(Suppl D):85-95
9. Higham PD, Furniss SS, Campbell RW: QT dispersion and components of the QT interval in ischemia and infarction. Br Heart J 1995;73:32- 6
10. Glancy JM, Garrat CJ, de Bono DP: Dynamics of QT dispersion during myocardial infarction and ischemia. Int J Cardiol 1996;57:555-60
11. Leitch J, Basta M, Dobson A: QT dispersion does not predict early ventricular fibrillation after acute myocardial infarction. Pacing Clin Electrophysiol 1995;18:45-8
12. Tomassoni G, Pisano E, Gardner L, Krucoff MW, Natale A: QT prolongation and dispersion in myocardial ischemia and infarction. J Electrocardiol 1998;30 (Supll):187-90
13. Aitchison JD, Campbell RW, Higham PD: Time dependent variability of QT dispersion after acute myocardial infarction and its relation to ventricular fibrillation: a prospective study. Heart 2000;84:504-8
14. Julliere Y, Marie PY, Danchin N, Karcher G, Bertrand A, Cherrier F: Evolution of myocardial ischemia and left ventricular function in patients with angina pectoris without myocardial infarction and total occlusion of the left anterior descending coronary artery and collaterals from other coronary arteries. Am J Cardiol 1991;68:7-12
15. Kodama K, Kusuoka H, Sakai A, et al: Collateral channels that develope after an acute myocardial infarction prevent subsequent left ventricular dilation. J Am Coll Cardiol 1996;27:1133-9
16. Boherer JD, Lange RA, Willard JE, Hillis LD: Influence of collateral filling of the occluded infarct- related artery on prognosis after acute myocardial infarction. Am J Cardiol 1992;69:10-2
17. Gohlke H, Heim E, Roskamm H: Prognostic importance of collateral flow and residual coronary stenosis of the myocardial infarct artery after anterior wall Q- wave acute myocardial infarction. Am J Cardiol 1991; 67:1165-9
18. Nicolau JS, Nogueira PR, Pinto MAFV, Serrano CV, Garzon SAC: Early infarct artery collateral flow does not improve long- term survival following thrombolytic therapy for myocardial infarction. Am J Cardiol 1999; 83:21-6
19. Miyamoto S, Fujita M, Sasayama S: Bidirectional function of coronary collateral channels in humans. Int J Cardiol 2000;75:249-52
20. Michelson EL, Spear JF, Moore EN: Electrophysiologic and anatomic correlation of sustained ventricular tachyarrhythmias in a model of chronic myocardial infarction. Am J Cardiol 1980;45:583-90
21. Lazzara R, El- Sherif N, Scherlag BJ: Electrophysiological properties of canine Purkinje cells in 1-day-old myocardial infarction. Circ Res 1973;33:722-34
22. McFarland TM, McCarthy DM, Makler PT, Josephson ME: Relation between site of origin of ventricular tachycardia and relative left ventricular myocardial perfusion and wall motion. Am J Cardiol 1983;51:1329-33
23. Grill HP, Brinker JA, Cadden Taube J, et al: Contrast echocardiographic mapping of collateralized myocardium in humans before and after angioplasty. J Am Coll Cardiol 1990;16:1594-600
24. Inoue H, Waller BF, Zipes DP: Intracoronary ethyl alcohol or phenol injection ablates aconitine- induced ventricular tachycardia in dogs. J Am Coll Cardiol 1987;10:1342-9
25. Okishige K, Andrews TC, Friedman PL: Supression of incessant polymorphic ventricular tachycardia by selective intracoronary ethanol infusion. PACE 1991; 14:188-95
26. Brugada P, De Swart H, Smeets JLRM, Wellens HJ J:

The role of collateral blood supply in ventricular tachy cardia after myocardial infarction. Eur Heart J 1988;9:1104-11

27. Friedman PL, Selwyn SP, Edelmen E, Wang PJ: Effect of selective intracoronary antiarrhythmic drug administration in sustained ventricular tachycardia. Am J Cardiol 1989;64:475-80
28. Schley G, Meesman W, Mescher H, Wilde A, Wild U: Influence of spontaneous collaterals on the fibrillation threshold of the heart following acute coronary occlusion. Z Kardiol 1970;64: 202-11
29. Hirata M, Kikuchi K, Hashimoto K: Disappearance of ventricular arrhythmia caused by coronary occlusion during retrograde bleeding through collaterals. Jpn Circ J 1970; 34: 531- 8.
30. Gheeraert PJ, Henriques JP, De Buyzere ML, De Pauw M, Taeymans Y, Zijlstra F: Preinfarction angina protects against out- of- hospital ventricular fibrillation in patients with acute occlusion of the left coronary artery. J Am Coll Cardiol 2001; 38: 1369-74
31. Lu HR, Yu F, Dai DZ, Remeysen P, De Clerck F: Fundam Clin Pharmacol 1999;13:445 –54
32. Rentrop KP, Feit F, Sherman W, Thornton JC: Serial angiographic assessment of coronary artery obstruction and collateral flow in acute myocardial infarction. Circulation 1989;80:1166-75
33. Schwartz H, Leiboff RH, Bren GB, et al: Temporal evolution of the human coronary collateral circulation after myocardial infarction. J Am Coll Cardiol 1984; 4:1088-93
34. Cardoso C, Salles G, Bloch K, Deccache W, Siqueira-Filho AG: Clinical determinants of increased QT dispersion in patients with diabetes mellitus. Int J Cardiol 2001; 79:253- 62
35. Ileri M, Yetkin E, Tandoğan I, et al: Effect of habitual smoking on QT interval duration and dispersion. Am J Cardiol 2001 88:322-5
36. Fauchier L, Maison- Blanche P, Forhan A, et al: Association between heart rate- corrected QT interval and coronary risk factors in 2,894 healthy subjects (The DESIR Study). Am J Cardiol 2000;86:557-9