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ALTERNATIONS IN INTRAVENTRICULAR FILLING PATTERN BY COLOR DOPPLER M-MODE DURING INDUCED MYOCARDIAL ISCHEMIA

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Summary. *It has been shown that regional myocardial ischemia during angioplasty is associated with retarded apical filling. To test the importance of retarded apical filling by color Doppler M-mode to detect ischemia during dipyridamole (DIP)stress echo we evaluated 29 patients (pts) (12 females, age 57±87 years).The high dose DIP (0.84 mg/kg over 10 min) was used. The color M - mode record was used to calculate the duration of abnormal apical flow as measured from the onset of the QRS complex to the disappearance of color signals directed toward the apex. Echocardiographic images were compared at rest and during stress to identify the presence of new or worsening wall motion abnormalities (WMA). Fourtheen pts (group A) were designated as having coronary artery disease on the basis on WMA during the stress test and abnormal coronary anatomy. Fifteen pts (group B) without WMA in the presence of normal coronary anatomy were designated as having no coronary artery disease.*
All but two pts in group A developed an abnormal apical filling response to DIP stress (sensitivity 86%). In these pts the marked retardation of apical filling was detected during the ischemia (55±18 ms v 120±34 ms) ($p<0.01$).In Group B there were no dynamics in apical filling (specificity 100%).
Color M - mode Doppler imaging revealed retarded apical filling during DIP induced myocardial ischemia. This abnormal filling pattern may be a useful adjunct to WMA during DIP stress echo.

Key words: *Color doppler echocardiography, myocardial ischemia, dipyridamole*

Introduction

Color M - mode Doppler (CMD) has recently been introduced to the assessment of left ventricular diastolic dysfunction (1,2,3,4). An abnormal diastolic pattern with retarded apical filling of the left ventricle has been found in patients with left ventricular dyssynergy (1). Stugaard et al (2) showed that regional myocardial ischemia induced by percutaneous transluminal coronary angioplasty was associated with apparent impairment of left ventricular apical filling. This observation has been reproduced in an animal model of regional and global depression of myocardial function induced by ischemia or beta blockade (3). It is assumed that abnormal intracavitary filling pattern may be a sign of impaired left ventricular relaxation (2,3,4).

The aim of our study was to test the ability of late apical filling by color M-mode Doppler to detect ischemia during dipyridamole stress echocardiography.

Patients and Methods

Study group

The population of this study consisted of 29 pts (17 men and 12 females), aged 57±8 years. Fourtheen pts (group A) were designated as having coronary artery disease on the basis of wall motion abnormalities during the DIP stress echo and angiographic evidence of obstructive coronary artery disease. Fifteen pts (Group B) without wall motion abnormalities and normal coronary anatomy were designated as having no coronary artery disease. They were admitted for evaluation of chest pain of suspected myocardial ischemic origin.None of the Group A pts had LV aneurysm. All pts were in regular sinus rhythm. Standard left sided heart catheterization and echocardiographic examination were performed within 72 hours.

Study protocol

After a baseline ECG, blood pressure measurement and two dimensional and Doppler echocardiograms examinations, a Dipyridamole was administrated (0.56 mg/kg/tt plus 0.28 mg/kg/tt over 10 min) by the protocol of Picano (5).

Echocardiographic examinations

An Acuson 128 X/10 machine was used for the echocardiographic examinations. In ischemic group, a wall motion score index was generated using 16 left

ventricular wall segments as previously described (6). A test result was considered positive if either a new wall motion abnormality developed, or if there was a deterioration of resting abnormality, i.e. hypokinesioa becoming akinesia or diskinesia. Left ventricular end-diastolic volume, end-systolic volume and ejection fraction were measured from the apical four and two chamber views using Simpsons rule.

Color M-mode Doppler echocardiography

In this study the echocardiographic color flow images analized were obtained from the apical cardiac window in four chamber view.The M-mode cursor line was placed centrally in diastolic inflow, interrogating flow at the mitral tip and in the apical region simultaneously. Care was taken that all recordings before and during the stress test were performed in the same apical window and at the same site in the inflow part of the left ventricle.The color M-mode record was used to calculate the duration of abnormal apical flow as measured from the onset of the QRS complex to the disappearance of color signals directed toward the apex.In each subject color M-mode measurements were performed at rest and during peak stress by averaging the values of 6 to 10 cardiac cycles, recorded at end expiration.

Statistical analysis

Data are presented as mean values ±SD. Students t test was performed for comparisons of variables between groups (p values less than 0.01 were considered significant).

Results

The dipirydamole echocardiographic stress test was positive in 14 pts (Group A), 11 pts had angina and 12 had ST changes (ST depression >1 mm). Thirteen of these pts had LAD stenosis; 6 pts had 3 vessel and 8 pts two vessel coronary artery disease; 4 pts had anterior, 3 pts inferior infarction and 7 pts had angina pectoris. In the Group A, wall motion score index increased from 1.15±0.09 at rest to 1,45±0.18 during the stress. All patients had apical wall motion abnormalities during peak stress. Changes in left ventricular ejection fraction (55±8 at rest to 52±7% after stress test) were not significant (NS). All pts except two pts in Group A developed an abnormal apical filling response to DIP stress (sensitivity 86%).In these patiens the marked retardation of apical filling was detected during the ischemia (Fig 1) (55±18 ms v 120±34ms) ($p<0.01$). In Group B pts with negative stress test EF increased from 66±6 at rest to 70±5 (NS) after the stress test. In these pts there were no dynamics in apical filling (20±10 v 29±12 ms) (specificity 100%).The results are shown in Tab 1. In ischemic group heart rate increased from 71±11 at rest to 90±15 beats/min ($p<0.01$) after dipyridamole infusion, and in control group, heart rate increased from 70±12 to 88±16 beats/min ($p<0.01$).

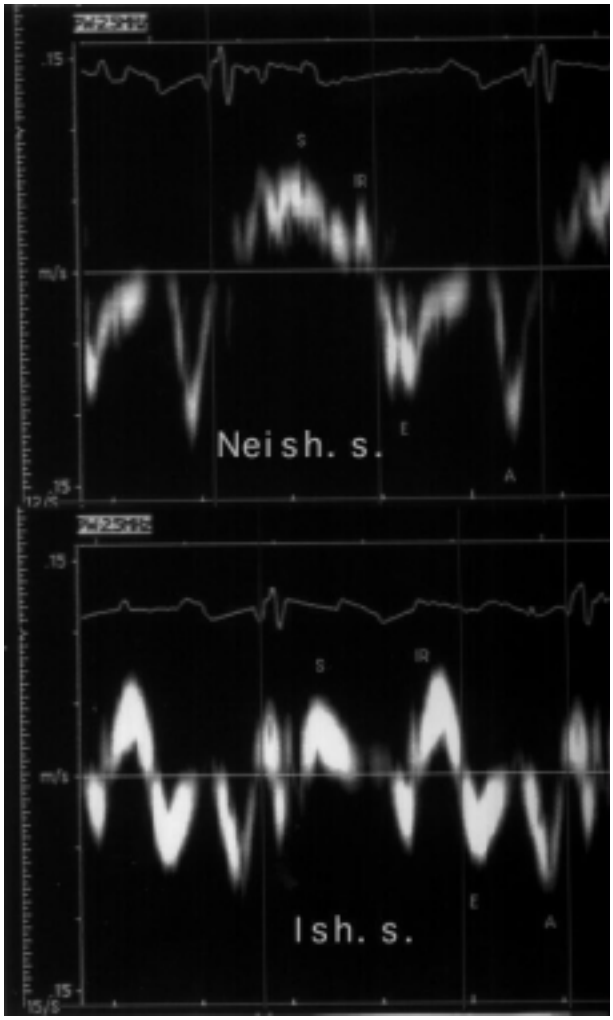

Fig. 1. Color-coded M-mode Doppler recordings of intraventricular fillng patterns before (upper panel) and during ischemia (lower panel). Apical velocities are recorded in upper part of the pictures. Vertical axis represents distance from the tip of mitral valve toward apex and horizontal axis represents time. Note that apically directed (red) color flow ceases soon after onset of the QRS complex (upper panel), and during ischemia (lower panel) there is a persistence of apically directed (red) paradoxal flow during systole.

Table 1. Echocardiographic parameters in study group

	Group A		Group B	
	rest	stress	rest	stres
EF%	55±8	52±7	66±6	70±5
SI	1.15±0.09*	1.45±0.18	1	1
Q-Ems	55±18*	120±34	20±10	29±12

*p<0.05, EF%=ejection fraction; SI=score index; Q-E=time interval from Q wave ECG to the end of apical filling

Discussion

In the present study we have demonstrated a marked

change in the intraventricular filling pattern during dipyridamole induced myocardial ischemia. In these patients the apical filling was retarded, whereas patients without coronary artery disease and negative dipyridamole stress test had no dynamics in the temporal distribution of intraventricular flow velocities pattern.

A pattern of retarded apical filling has been observed in patients with dilated cardiomyopathy as well as in apical dyssynergy (1,7). De Maria showed that the timing of apical paradoxal systolic flow correlated with the magnitude of regional and global ventricular dysfunction by cineangiography (1). In this study a relative contribution of low velocity radial swirling and direct systolic expansion to the development of the abnormal intraventricular flow has been considered. This finding also seems to be concidered with the observations of Beppy et al (8), who reported that apical dyskinesis was associated with more extensive flow disruption than akinesis was. Brun (9) reported that this abnormal filling pattern might be attributed to delayed left ventricular relaxation with a subsequent reduction in the transmitral driving pressure.However, it is difficult to explain how a moderate prolongation of relaxation can account for the dramatic retardation of apical filling during ischemia. In another study (3) the pattern of retarded apical filling was observed during left ventricular ischemia as well as during myocardial depression with beta blockade. Thus, the altered filling pattern could not be ascribed to ischemia as such rather it is related to depression of myocardial function.It is also demonstrated that retardation of apical filling in depressed ventricle cannot be attributed to changes in loading conditions or heart rate (3). Furthermore, this paradoxal systolic flow toward the apical region invariably indicates that some of the energy imparted to red cells by myocardial contraction is being diverted from ejection of blood into the aorta. Fluid dynamics theory predicts that flow is generated by the presence of regions of different pressure. It might thus, be anticipated that such abnormal intraventricular flow pattern should be inducible by alternatons in the characteristic pressure gradient pattern between adjacent regions within the left ventricular chamber. A characteristic pattern of intraventricular systolic pressure gradients has been demonstrated within the left ventricular chamber (10). With extensive anterior-apical systolic dysfunction the physiological intraventricular systolic ejection gradient is likely to be attenuated or lost (10), similary to early diastolic pressure gradient (11). Thus, we can speculate that in some patients during ischemia, the absence or diminution of intraventricular systolic pressure gradients can contribute to the presence of paradoxal or systolic flow toward the apical region instead into aorta.

According to our results, segmental, rather than the global left ventricular dysfunction, has been the cause of the retarded apical filling, detected in our patients, dyring dipyridamole induced ischemia. It was based on the fact that wall motion score index significantly increased and the changes in left ventricular ejection fraction were insignificant during the ischemia. Delayed arrival of blood on the level of apex seems to be primarily dependent on degree of apical wall motion abnormalities, because all patients of the ischemic group had apical asynergy during the stress test. In an experimental study (3), as we have already mentioned, late apical filling was observed in severe, global depression of myocardial function (3), induced by beta blockade. However, in clinical practise, during the stress test, it is probably not possible to reduce global left ventricular function to the level, necessary to induce delay in apical filling. Therefore, we think that segmental, particularly apical dysfunction, is the most important cause of retarded filling during the stress test.

In our study we have used intraventricular not mitral flow velocity pattern to analize diastolic filling. The mitral flow velocity profile,which is loading dependent, is determinated mainly by the left atrial to left ventricular pressure gradient, and intraventricular filling pattern by the intraventricular pressure gradient which is mostly generated by the uniformity of regional left ventricular relaxation and elastic recoil. The normal mitral flow velocity pattern may be present even in the patients with marked impairement of diastolic function and hence retarded apical filling might serve as a clinically useful marker of diastolic disfunction (3).

The abnormalities of the Doppler transmitral flow velocity profile has been reported after transient ischemia produced by percutaneous coronary ballon angioplasty (12), rapid atrial pacing (13), dipyridamole (14) and Dobutamine (15) infusion and exercise (16). However, the hemodinamic accompaniments of ischemia are variable and depend on the technique used to provoke it. Hence, the alternations of mitral flow velocity pattern will not be the same during various forms of myocardial ischemia. The changes of Doppler transmitral flow velocity pattern during dipyridamole infusion have been found to be less useful in detectng transient myocardial ischemia (14).

It has been recently reported (17) that flow velocity propagation (FVP) of early left ventricular filing by color Doppler M-mode, during dobutamine induced myocardial ischemia has a high sensitivity (100%) and specificity (59%) in detection of coronary artery disease. The slope of FVP of early left ventricular filling was decreased during ischemia, indicating slower relaxation.

In our study we have investigated the timing of apical filling using color Doppler M-mode. We have shown that worsening of left ventricular regional contractility, during dipyridamole stress test, is followed by the delay of apical filling.We found a high sensitivity (86%) and specificity (100%) of this sign in detection of myocardial ischemia induced by Dipyridamole. Therefore, the late apical filling detected by color doppler M-mode may be a useful adjunct to wall motion abnormalities in detection of coronary artery disease.

References

1. Garrahy P, Kwan O, Booth D, De Maria A. Assessment of abnormal systolic intraventricular flow patterns by Doppler imaging in patients with left ventricular dyssynergy. Circulation 1990;82:95-104.
2. Stugaard M, Smiseth OA, Risoe C, Ihlen H. Intraventrcular early diastolic filling during acute myocardial ischemia: assessment by multigated color M-mode Doppler echocardiography. Circulation 1993;88:2705-2713.
3. Stugaard M, Risoe C, Ihlen H, Smiseth OA.Intracavitary Filling pattern in the failing left ventricle assessed by Color M-mode Doppler echocardiography.JACC 1994; 24,3:663-670.
4. Stugaard M, Smiseth OA, Risoe C, Ihlen H.Intraventricular early diastolic velocity profile during acute myocardial ischemia:A Color M-mode Doppler echocardiographic study. J Am Soc Echocardiogr l995;8:270-279.
5. Picano E, Lattanzi F, Masini M, Distante A, l' Abatte A. Hight dose dipyridamole echocardiography test in effort angina pectoris. J Am Coll Cardiol 1986; 8:848-854.
6. American Society of Echocardiography Committee on Standards, Subcomittee on Quantitation of Two-Dimensional Echocardiograms. Recommendations for quantitation of the left ventricle by two-dimensional echocardiography. J Am Soc Echocardiogr 1989;2:358-367.
7. D' Cruz IA and Sharaf IS. Patterns of flow within the dilated cardiomyopathic left ventricle: Color flow Doppler observations. Echocardiography 1991;8:227-231.
8. Beppu S, Izumi S, Miyatake K, Nagata S, Park YD, Sakakibara H, Nimura Y Abnormal blood pathways in left ventricular cavity in acute myocardial infarction. Circulation l988; 78:157-164.
9. Brun P, Tribouilloy C, Duval AM, et al. Left ventricular flow propagation during early filling is related to wall relaxation: A Color M-mode Doppler analysis. J Am Coll Cardiol l992; 20:420-432.
10. Pasipoularides A, Murgo JP, Miller JW, Craig WE: Nonobstructive left ventricular ejection pressure gradients in man. Circ Res 1987;61:220-227.
11. Courtois M, Kovacs S, Ludbrook A. Physiological early diastolic intraventricular pressure gradient is lost during acute myocardial ischemia. Circulation 1990;81:1688-1696.
12. Labovitz AJ, Lewen MK, Kern M, Vandormael M, Deligonal U, Kennedy HL. Evaluation of left ventricular systolic and diastolic dysfunction during transient myocardial ishemia produced by angioplasty. J Am Coll Cardiol 1987;10:748-755.
13. Iliceto S, Amico A, Marangelli V, D' Ambrosio G, Rizzon P. Doppler echocardiographic evaluation of the effect of atrial pacing-induced ischemia on left ventricular filling in patients with coronary artery disease. J Am Coll Cardiol l988;11:953-961.
14. Grayburn PA, Popma JJ, Pryor SL, Walker BS, Simon TR, Smitherman C. Comparison of dipyridamole-Doppler echocardiography to thallium-201 imaging and quantitative coronary arteriography in the assessment of coronary artery disease. Am J Cardiol 1989;63:1315-1320.
15. El-Said M, Roelandt J, Fioretti P, McNeili A, Forster T, Boersma H, Linker D. Abnormal left ventricular early diastolic filling during dobutamine stress Doppler echocardiography is a sensitive indicator of significant coronary artery disease. J Am Coll Cardiol 1994;24:1618-1624.
16. Presti C, Walling A, Montemayor I, Campbell J, Crawfort M. Influence of exercise-induced myocardial ischemia on the pattern of left ventricular diastolic filling: A Doppler echocardiographic study. J Am Coll Cardiol 1991;18:75-82.
17. Aros M, Rodriguez L, Leung D, Garcia M,vandervoort P, Marwick T. Color Doppler M-mode assessment of flow velocity propagation during early filling: A useful adjunct to wall motion analysis during dobutamine stress echocardiography J Am Coll Cardiol 1995; Abstracts 159A.

PROMENE U INTRAVENTRIKULARNOM PUNJENJU LEVE KOMORE POMOĆU KOLOR M-MOD DOPPLER TEHNIKE U TOKU IZAZVANE ISHEMIJE MIOKARDA

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Kratak sadržaj: *Opisano je da u toku ishemije izazvane koronarnom angioplastikom dolazi do kasnijeg punjenja vrha leve komore. U radu smo ispitivali značaj kasnijeg punjenja vrha leve komore pomoću kolor Doppler M-mod tehnike u otkrivanju ishemije miokarda izazvane dipiridamolom (Dip). Ispitivano je 29 bolesnika (12 žena i 17 muškaraca, prosečne starosti 57±8 godina). Date su visoke doze Dip (0.84mg/kgtt u toku 10 minuta). Kolor M-mod Doppler tehnika je korišćena da bi se izračunalo trajanje apikalnog punjenja koje se izračunavalo od početka QRS kompleska do završetka apikalnog protoka. Dvodimenzionalnom ehokardiografijom je analizirana globalna i regionalna kontraktilnost leve komore u mirovanju i u toku stres testa. Grupa A se sastojala od 14 bolesnika koji su imali pozitivan stres test i koronarnu arterijsku bolest. Ispitanici druge grupe B (15 ispitanika) nisu imali koronarnu arterijsku bolest i stres test je bio negativan.*

Svi, osim dva bolesnika grupe A, su imali kasnije punjenje vrha leve komore za vreme Dip stres testa (senzitivnost 86%). U ovih bolesnika značajno je kasnilo punjenje vrha srca u toku ishemije u odnosu na bazalne vrednosti (55±18 ms vs 120±34 ms) ($p<0.01$). U grupi B nije bilo dinamike u apikalnom punjenju (specifičnost 100%).

Kolor M-Mod Doppler tehnikom je dokazano kasnije apikalno punjenje za vreme ishemije miokarda izazvane Dip. Ovaj poremećaj u intraventrikularnom punjenju leve komore je korisna dopuna u analizi regionalne pokretljivosti zidova leve komore u toku Dip izazvane ishemije miokarda.

Ključne reči: *Kolor dopler ehokardiografija, ishemija miokarda, dipiridamol*

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