以杜卜勒能量超音波心圖探討前壁心肌梗塞病患左心室內血流循跡與血栓形成的關係
(主 持 人：高憲立)

Power Doppler-derived speckle tracking image of intraventricular flow in patients with anterior myocardial infarction: correlation with left ventricular thrombosis.

中文摘要：

關鍵詞: **心肌梗塞，局部血流，血栓，粒子循跡，杜卜勒能量超音波。**

對於急性心肌梗塞的病患而言，左心室血栓為一常見的併發症。此併發症常可引起週邊甚至腦部的栓塞。過去學者的研究指出，利用杜卜勒超音波心圖或彩色血流譜，其描繪出不正常的心室血流途徑，比一般的臨床評估或超音波心圖檢查，更能預測病人產生左心室血栓的機率，可以作為抗凝血劑治療與否的參考依據。近年來，利用杜卜勒能量超音波心圖產生的超音波散射粒子的影像，已經可以用粒子循跡圖的方式追蹤血液流動的情形。此種超音波能量轉換的粒子循跡圖對於低速的血流，能以較高的掃瞄圖速，描繪出血液在心室內流動的軌跡，其敏感度也勝過以前使用的彩色血流譜。

本研究欲探測的假說，乃是在急性心肌梗塞後，欲預測左心室血栓形成，不正常的左心室內血流空間分佈較臨床資料及傳統的雙面超音波心圖變項更具準確度。我們選取 79 **位前壁心肌梗塞病患在** 72 **小時內及出院前施行二次超音波心圖檢查，若左心室心尖部出現旋轉的渦流被視為不正常。以杜卜勒能量超音波心圖**(Power Doppler Echocardiography)**檢查，移動的血流可以產生粒子循跡影像，判定心室內血流軌跡。在有些左心室運動失全的區域，會顯現區隔性的渦流，表示血液在此有遲留的現象。此篇研究顯示以此種粒子循跡影像來判定左心室內血栓形成，較傳統的雙面及彩色超音波心圖變項更具準確度。**

英文摘要：

Key Words: myocardial infarction, regional blood flow, thrombus, speckle-tracking, power motion image.

With regard to the predictive accuracy for left ventricular thrombosis after myocardial infarction, the abnormal spatial distribution of left ventricular flow is superior to conventional clinical and two-dimensional echocardiographic variables. Tracking the speckle patterns produced by moving blood has been recently validated with power Doppler ultrasonic imaging. To evaluate the ability of power Doppler-derived speckle tracking image in delineating abnormal left ventricular flow patterns and in predicting left ventricular thrombosis after anterior wall myocardial infarction, echocardiography was prospectively performed in 79 patients within 72 h after anterior wall myocardial infarction onset and repeated before discharge. The apical rotating flow pattern in color flow map was recognized as abnormal. By power Doppler echocardiography, the moving blood could generate speckle tracking images to delineate the intraventricular flow. A swirling flow pattern indicating the compartmentalization of left ventricular blood flow with some blood stagnant in the apical dyssynergic area was identified. The flow pattern shown by the speckle tracking image was superior to the color-flow map in correlating with left ventricular thrombosis. It implicated that the more the detail in which we can describe the blood flow pathway, the more information we can realize.

Background

Left ventricular thrombus formation following acute myocardial infarction (MI) is a common complication and associated with increased risk of peripheral embolism.[1,2,3] Regional wall motion abnormalities shown on 2-dimensional echocardiography, especially over the apical area, have been used to identify patients prone to develop a thrombus.[4,5] Recent investigations by Doppler echocardiography or color flow mapping (CFM), furthermore, have suggested that the abnormal left ventricular spatial flow pattern is superior to conventional clinical and two-dimensional echocardiographic assessment in estimating the risk of left ventricular thrombosis after MI and of importance in considering anticoagulation.[6, 7] There are several methods for assessing the dynamics of blood in the left ventricular cavity. Pulsed-Doppler echocardiography provides a precise temporal pattern of flow velocity at any site in the cavity. However, it is a pinpoint evaluation, limited in the sampling volume and spatial resolution, requiring a complicated mapping technique to elucidate the whole blood pathway.[8] Color fow mapping (CFM) has the problems of aliasing, unsatisfactory temporal resolution, and only encodes the mean Doppler frequency shift per study packet.[9] Schwarz et al. have verified that the "intensity" of Doppler signals could be used for quantitating ultrasonic backscatter in flow system.[10, 11] The direction of blood flow in the speckle images can be assessed visually in such a high frame rate with little impediment.

In this study, we designed a study to evaluate the ability of power Doppler-derived speckle tracking image, PMI,[12] in delineating abnormal left ventricular flow patterns and in predicting left ventricular thrombosis after anterior wall myocardial infarction.

Patients and Methods

One hundred and nine patients with acute anterior wall MI were admitted to our hospital. Twenty-one patients whose speckle tracking images of intraventricular flow were unsatisfactory for blood flow pathway descriptions were excluded. The remaining 79 patients (69 men and 10 women aged 34 to 79 yeas, mean 56 ± 12) were enrolled in the study. The echocardiographic assessments were performed within 72 h after MI to determine the flow pattern and were repeated before discharge to identify the evolutional changes of flow pattern and the left ventricular thrombus formation during the hospital stay.

Two-dimensional echocardiography

Patients underwent echocardiographic examinations with a commercially available ultrasound system (ATL 3000CV, Advanced Technologies Laboratory, Bothell, Washington) using a 2.0 MHz transducer. To determine the severity of apical dyssynergy, the score of the 4 apical segments was summed and represented the geometric abnormalities in the apical area resulting from anterior wall MI. The echocardiographic definition of a thrombus was a mass distinct from the endocardium and with different echogenicity from that of the adjacent dyssynergic myocardium. In all instances, the diagnosis of ventricular thrombus was agreed by two independent investigators in a blinded manner.

Pulsed Doppler and color flow map echocardiography

Left ventricular flow pattern was investigated by pulsed wave Doppler, CFM, and color M-mode echocardiography by two independent observers. Normal flow was defined as simultaneous onset of inflow throughout the left ventricle with discontinuous apical flow. On CFM, inflow was encoded in red in early diastole. The color M-mode echocardiography would show a nearly vertical flank in red of early diastolic inflow. Discontinuity of left ventricular apical flow was present on two-dimensional color flow recording when the apex was completely encoded in blue during systole without the persistence of apical red. To

elucidate the whole ventricular blood pathway, the sample volume or cursor beam was located near the ventricular septum and lateral free wall in the apical 4 chamber view respectively. There were two distinct abnormal flow patterns: apical rotating flow and vortex ring formation.

Power motion imaging echocardiography

When the ultrasound system was set in PMI, the power within Doppler shift spectrum for ultrasound beam from different depth was processed. By PMI echocardiography, we defined the abnormal intraventricular blood flow pattern by forming a closed loop of swirling flow in the apex (looping sign). The left ventricular cavity could be considered as composed of two parts. The apical dyssynergic segments molded a closed loop of blood flow that hampered the apical blood running to the outflow tract and restricted the mitral inflow advancing into this area. Therefore, the apical area was separated from blood turnover and the basal portion of left ventricle became the only part for blood turnover.

Cardiac catheterization

After obtaining the informed consents, cardiac catheterization was performed with a computer-aided quantitative angiographic analysis system (DCI-S Automated Coronary Analysis System, Philips Medical Systems, Eindhoven, The Netherlands).

Statistic analysis

All continuous variables were expressed as mean values ± standard deviation and were tested for significance by a two-tailed Student t test. Dichotomous variables were analyzed with two-by-two tables and tested for statistical significance by the Fisher exact test. A p value <0.05 was considered statistically significant.

Results

Within 3 days after admission, 33 patients had apical rotating flow pattern by CFM and pulse wave Doppler echocardiography. Among these patients, PMI echocardiography showed looping signs in 15. Seven patients were found to have ventricular thrombus during the initial examination. No patient was found to have abnormal flow pattern of vortex ring formation. All but 2 patients with normal flow pattern received heparinization in the initial 72 h after MI. The second echocardiographic examination (13 ± 3 d after admission) showed no changes in the flow pattern and disappearance of the thrombus noted at the initial examination. However, another 2 patients had new thrombus formation after discontinuing heparinization with one in them experiencing a possible cerebral embolic event. One patient with apical thrombus was free from abnormal flow pattern, neither by CFM nor by PMI. Patients with abnormal flow pattern, especially with looping sign on PMI were prone to develop ventricular thrombus. The compartmentalization of left ventricular blood flow pathway seen by PMI had a positive predictive value of 60% and a negative predictive value of 99% for left ventricular thrombus formation. The abnormal flow patterns shown by CFM, on the other hand, had the similar negative predictive value of 98% but the lower positive predictive value of 27%. The IVRT was longer in patient with thrombus, but the statistical significance was only marginal.After the stepwise logistic regression analysis, the looping sign in PMI was the only independent predictor for thrombus formation, with an odd ratio of 94.5 (95% confidence interval 21.9 to 408.7).

Discussion

Speckle tracking images, circumstantially delineating the abnormal left ventricular flow

patterns, was superior to conventional velocity mode CFM in revealing the relationship between flow and thrombus formation for patients with anterior MI. It implicated that in more detail we can describe the blood flow, the more information we can get. The generation of speckle images is certainly dependent on the interaction between the transducer frequency and the moving target velocity. Under common transthoracic echocardiography, it is rare to see speckles in the left ventricular cavity except with extremely low blood flow velocity. With angle independence and high sensitivity for low-velocity flow, power Doppler echocardiography can generate satisfactory speckle tracking images in this study. The newly developed technique, such as high frequency probes or harmonic algorithms may make progress in the evolvement of speckle tracking. Further investigation is needed.

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