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The role of surface ECG and transthoracic echocardiography for predicting postoperative atrial fibrillation after coronary artery bypass surgery

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ABSTRACT

الأهداف: يعد حدوث الارتجاف الأذيني أمرا شائعاً بعد إجراء عملية تركيب مجازة للشريان التاجي. تعتبر القياسات غير الموسعة التي من الممكن من خلالها التوقع بخطورة الارتجاف الأذيني غير كافية. كان الهدف من هذه الدراسة من أجل تقييم أدوار تخطيط الدماغ السطحي وتخطيط أصداء القلب عبر الصدر لتوقع الارتجاف الأذيني بعد عملية تركيب مجازة للشريان التاجي.

الطريقة: أجريت هذه الدراسة في الفترة ما بين عام 2002م الى 2004م بقسم الجهاز القلبي الوعائي بجامعة هيسيتيب. شملت الدراسة 70 مريضاً خضعوا العملية تركيب مجازة للشريان التاجي. تم تسجيل تخطيط الدماغ السطحي قبل العملية الجراحية بيوم واحد وتمت إعادتها خلال خمسة أيام بعد تركيب المجازة للشريان التاجي. تم تعريف موجات بي المشتتة (بي دبليو دي) كفرق بين فترة الموجات بي القصوى والصغرى. تمت مقارنة الفروقات لفترة موجات بي بين قياسات تخطيط الدماغ السطحي قبل وبعد العملية الجراحية.

النتائج: حدث الارتجاف الأذيني بعد العملية الجراحية في 17 (24%) حالة من إجمالي الحالات البالغ عددها 70 حالة. تبين أن (PWD) أعلى بشكل ملحوظ في المرضى الذين تعرضوا للارتجاف الأذيني بعد العملية الجراحية. (60±19versus 47±13, p=0.003) / اليوم الأول بعد العملية الجراحية (56±12versus 44±11, p<0.002) وفي اليوم الخامس (51±29versus 41±11, p<0.001). كان المرضى المصابين بالارتجاف الأذيني أكبر في العمر بشكل ملحوظ. كان متوسط العمر للمجموعة المصابة بالارتجاف الأذيني (68±7 عاما) وكان في مجموعة نظم الجيب (اس آر) (59+10 عاما) (p<0.001). أصيبت مجموعة الارتجاف الأذيني بتوقف عمل الوظيفة الانقباضية للبطين الأيسر (56±13%versus 56±8%, p=0.042)، قبل العملية الجراحية، (49±8%versus 60±10%, p=0.001)، بعد العملية الجراحية) وأذين القلب الأيسر لديها أكبر (46±5versus 39±5 mm, p<0.001)، قبل العملية الجراحية و (44±7versus 39±5 mm, p=0.046) بعد العملية الجراحية) من مجموعة (SR).

خاتمة: تؤكد الدراسة الوصفية أن (PWD) على تخطيط الدماغ السطحي وقياسات تخطيط أصداء القلب عبر الصدر بسيطة وذات مدخلات يعتمد عليها في توقع الإصابة بالارتجاف الأذيني بعد إجراء عملية تركيب مجازة للشريان التاجي.

Objective: To evaluate the roles of surface electrocardiogram (ECG) and transthoracic echocardiography (ECHO) for prediction of atrial fibrillation (AF) after coronary artery bypass grafting (CABG).

Methods: This study was conducted from 2002-2004 at the Cardiovascular Department of Hacettepe University, Ankara, Turkey. Seventy consecutive patients were enrolled in this study that underwent elective CABG. A 12-lead ECG was recorded one day before cardiac surgery and was repeated during the 5 days after CABG. P-wave dispersion (PWD) was defined as the difference between maximum and minimum P-wave duration. Differences in P-wave duration were compared between the pre- and postoperative 12-lead ECG measurements.

Results: Postoperative AF developed in 17 (24%) cases of 70 patients. The PWD was found to be significantly higher in patients with AF preoperatively (60±19 versus 47±13, p=0.003), postoperative first day (56±12 versus 44±11, p<0.002) and fifth day (51±29 versus 41±11, p<0.001). Patients with AF were significantly older, the mean age of the AF group was (68±7 years) and of the sinus rhythm (SR) group was (59±10 years) (p<0.001). The AF group had left ventricular systolic dysfunction (56±13% versus 56±8%, p=0.042, preoperatively; 49±8% versus 60±10%, p=0.001, postoperatively) and a larger left atrium (46±5 versus 39±5 mm, p<0.001, preoperatively and 44±7 versus 39±5 mm, p=0.046, postoperatively) than the SR group.

Conclusion: This prospective study demonstrated that PWD on surface ECG and additional echocardiographic parameters are simple and reliable indexes to predict the development of AF after CABG.

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Coronary artery bypass grafting (CABG) is an effective treatment for myocardial ischemia and is particularly important in patients with multi vessel coronary disease. Atrial fibrillation (AF) is common after CABG, and generally occurs within the first week after surgery.[1,2] Atrial fibrillation can cause hemodynamic and thromboembolic complications and delay hospital discharge. Older age, male gender, P-wave signal-averaged ECG, and withdrawal of beta-blocking agents before CABG are the perioperative clinical variables for AF.[3,4] There were no definite clinical predictors. The incidence of AF after CABG varies between 5-40%.[5-8] Although recent studies have identified clinical predictors of postoperative AF, the pathophysiologic basis of AF after CABG surgery is not known entirely.[8-10] P-wave abnormalities have been thought to reflect multiple factors such as left atrial (LA) enlargement, altered conduction, and underlying heart disease. The P-wave dispersion (PWD) is a non-invasive ECG parameter for predicting AF and first described by Dilaveris[11] et al in 1998 as the difference between maximum and minimum P-wave duration measured on the standard 12-lead surface electrocardiogram. An association between AF and homogeneous and discontinuous propagation of sinus impulses has been reported previously.[11,12] Prolonged P-wave duration and increased PWD have an increased risk for AF.[11,13] The aim of this study was to evaluate the predictive value of surface ECG and echocardiography (ECHO) for AF after CAGB.

Methods. This study was conducted from 2002-2004 at the Cardiovascular Department of Hacettepe University, Ankara, Turkey. After approval from the Ethics Committee, the study group consisted of 70 consecutive patients with coronary artery disease who underwent elective CABG. All patients had normal sinus rhythm before the surgery. None of the patients had any previous history of ECG documented paroxysmal AF. Patients who had chronic obstructive pulmonary disease, a history of previous CABG and arrhythmia, valvular heart disease, uncontrolled hypertension, congenital heart disease, hyperthyroidism, ventricular pre-excitation, atrioventricular conduction abnormalities, abnormal serum electrolytes, or who had been using anti-arrhythmic medication other than beta-blocking agents were excluded from the study. Subjects were also excluded from the study if the end of the P-wave of their ECG could not be determined reliably. Transthoracic ECHO examinations were performed on all subjects. A 12-lead ECG was recorded one day before cardiac surgery and was repeated during the 5 days after CABG. All the patients had beta-blocking agent medication pre- and postoperatively. The Local Ethics Committee approved the protocol of this study, and informed consent was obtained from all participants. All ECHO examinations were undertaken to evaluate the presence of any structural and functional cardiac abnormalities with the use of a System 5 (GE Vingmed Ultrasound, Horten, Norway) cardiac ultrasound scanner and 2.5-3.5 MHz transducers. All patients were examined in the left lateral and supine position by precordial M-mode, 2-dimensional, Doppler ECHO. One lead ECG was recorded continuously. Left ventricle end-diastolic, end-systolic diameters, and end-systolic LA diameters were measured from M-mode in the parasternal long axis views.

Twelve-lead ECG analysis. A 12-lead ECG was recorded for each patient and a normal subject at a rate of 25 mm/s in a supine position. At the time of the ECG recording, all the patients were in sinus rhythm. P-wave durations were measured manually by 2 of the investigators without knowledge of the clinical status of the patients. The onset of the P-wave was defined as the junction between the isoelectric line and the beginning of the P-wave deflection, and the offset of the P-wave at the junction between the end of the P-wave deflection and the isoelectric line. Maximum and minimum P-wave durations were measured from the 12-lead surface ECG and P-wave measurements were carried out from all 12 leads. The PWD was defined as the difference between maximum (Pmax) and minimum P wave (Pmin) duration and it is calculated as (PWD = Pmax–Pmin). Heart rate and rhythm were continuously monitored for the first 48 hours in the intensive care unit using individual bedside monitors and daily 12-lead ECGs were performed from the first postoperative day until discharge (fifth day), and in case of clinical suspicion of arrhythmia were continued in the postoperative period. An experienced cardiologist confirmed the occurrence of AF. In this study, AF was defined as an irregular random ventricular rate without visible P waves on a 12-lead ECG. Only the episodes of AF that were longer than 30 minutes were included. Atrial fibrillation was the only documented rhythm abnormality in our study. Amiodarone and digoxin were used to convert AF to sinus rhythm in all cases. All patients recovered normally. There were no in hospital deaths or perioperative myocardial infarctions.

Operative technique and post-operative follow up. They were premedicated with peroral diazepam. Induction of anesthesia was performed with etomidate and fentanyl. Vecuronium bromide was administered. A standard median sternotomy incision was used for the exposure of the heart. The internal mammary artery and saphenous vein grafts were used for coronary anastomosis. Following cross clamping of the aorta, myocardial protection was accomplished by 10-15 cc/kg antegrade or a combination of antegrade and retrograde cold cardioplegia and topical ice slush. Patients were

continuously monitored in the intensive care unit using individual bedside monitors. After the patients had been transferred to an ordinary ward, they were monitored for AF. An experienced cardiologist confirmed the occurrence of AF.

Statistics. Data were expressed as means ± standard deviation. The significance of correlations was assessed by Pearson correlation analysis. Correlations between the measured laboratory indices, and clinical, and demographic data were performed using the t-test. Numeric variables distribution between groups was tested by using the one-way analyses of variance method. Means were compared by ANOVA. A 2-tailed *p*-value of less than 0.05 was considered to be statistically significant. All statistical analyses were performed with the Statistical Package for Social Sciences (SPSS 11.5 for Windows, SPSS, Inc., Chicago, IL).

Results. The average age was 61±10 years. The majority of the patients were male (56 versus 14; 80% versus 20%). A total of 17 (24%) patients developed AF postoperatively. Demographic data, clinical characteristics, and medications are shown in **Table 1**. The PWD was found to be significantly high in patients with AF both preoperatively (60±19 versus 47±13, p=0.003), postoperative day one (56±12 versus 44±11, p=0.002), postoperative day 4 (54±18 versus 40±12, p=0.026), and postoperative day 5 (51±29 versus 41±11, p<0.001). Patients with AF were significantly older, the mean age of the AF group (68±7 years) was significantly higher than the sinus rhythm group (59±10 years, p<0.001). The AF group had left ventricular systolic dysfunction (56±13% versus 56±8%, p=0.042, preoperatively and 49±8% versus 60±10%, p=0.001, postoperatively) and a larger left atrium (46±5 mm versus 39±5, p<0.001, preoperatively and 44±7 mm versus 39±5 mm, p=0.046, postoperatively) than the subjects remaining in sinus rhythm. There was no significant relationship between pre/post-operative PWD and left atrium diameter, left ventricular ejection fraction, and age. Nineteen patients were diabetic, 36 had systemic hypertension, and 65 had myocardial infarcts before the investigation. There were no significant differences with respect to gender distribution (p=0.784), diabetes mellitus (p=0.705), hypertension (p=0.684), prior MI ratio (p=0.820), smoking (p=0.416), statins (p=0.733), cross-clamp time (p=0.526), or cardiopulmonary bypass time (p=0.811).

Discussion. Recent developments in coronary surgery have not resulted in a decrease in AF occurrence in the postoperative period.[14] The correlation between inter-atrial and intra-atrial conduction abnormalities and the induction of AF has been well documented.[13,15] In the present study, an increased PWD was found to be significantly correlated with postoperative AF, and PWD analysis could provide a non-invasive way of predicting the occurrence of AF after CABG. The PWD is an electrocardiographic marker that reflects discontinuous and inhomogeneous propagation of sinus impulses.[16] Many pre- and postoperative factors have been suggested to increase the incidence of postoperative AF such as age, gender, hypertension, withdrawal of beta-blocker drugs therapy, need for intra-aortic balloon support, and excessive bleeding. These have all been associated with AF in published reports.[12,16-20] In the present

Table 1 - Clinical characteristics of the patients.

Characteristics	Patients with POAF (n=17)	Patients without POAF (n=53)	*P*-value
Age			
Mean±SD	68.3±7	59.0±10.3	0.001
Male/female, n (%)	14/3 (82/18%)	42/11 (79/21%)	NS
Hypertension, n (%)	8 (47)	28 (53)	NS
Diabetes mellitus, n (%)	4 (24)	15 (28)	NS
Prior MI, n (%)	16 (94)	49 (93)	NS
LVEF <40%, n (%)	6 (35)	2 (4)	<0.001
Ejection fraction (mean ± SD)	48±11	59±9	<0.001
Left atrium diameter (cm)	4.6±0.5	3.8±0.6	<0.001
Medications			
Blocker, n (%)	70 (100)	70 (100)	NS
ACE inhibitor, n (%)	8 (47)	27 (51)	NS
Statin, n (%)	5 (29)	19 (36)	NS
Operative		40.7±20.0	
Cross-clamp time (minutes)	40.2±19.2	75.8±37.1	NS
CPB time (minutes)	78.1±22.3	4382.4±255.3	NS
Flow (cc)	4368.2±325.6		NS

POAF - Postoperative atrial fibrillation, LVEF - Left ventricle ejection fraction, CPB - Cardiopulmonary bypass, ms - milisecond, MI - myocardial infarction, ACE - angiotensin converting enzyme, CPB - cardiopulmonary bypass

study, there was no excessive bleeding and no patient for intra-aortic balloon support. The large number and the heterogeneity of these factors are probably the best testimonial of the poor understanding of the mechanisms and pathophysiology of this arrhythmia.[17] In this prospective study, we demonstrated that increased PWD is a reliable predictor of postoperative AF, with the other predictors of AF after CABG being increased age, left ventricular systolic dysfunction, and a larger LA.

The relationship between PWD and postoperative AF is controversial. Chang[21] et al found that PWD did not provide significant information in the prediction of postoperative AF. Buxton[15] et al first reported that patients developing AF after CABG had a significantly longer P-wave duration on the standard ECG. Gang[22] et al demonstrated that simple ECG indices including P-wave morphology dispersion identified patients at risk for AF after CABG. Dagdelen[23] et al showed that maximal P-wave duration and PWD parameters on surface ECG are simple and valuable indexes to predict the development of AF in patients undergoing CABG. In our study, mean P-wave durations showed no significant difference between the POD1 and POD5 ECG's. In addition to this, PWD over the 45 ms showed a strong relation with AF. One of the commonly proposed mechanisms of AF is an enlarged LA and increased atrial pressure or stretch.[24-26] A relationship between left atrial diameter and P-wave measurements has been shown in some studies,[27-30] but not in others.[12,13,31,32] In our study, LA size was larger and left ventricular ejection fraction was lower in the AF group than the SR group. Hence, it may be that atrial stretch and larger LA cause AF through the increased PWD that we observed in our present study. It is possible that the P-wave variable phenomenon that we observed is not a cause for postoperative AF, but rather a marker for some other underlying cause, such as larger LA, and left ventricular dysfunction. The electrophysiological mechanism of postoperative AF remains unclear and is probably multifactorial, it is believed to be reentry resulting from dispersion of atrial refractoriness. The PWD is a measure of regions of delayed atrial activation. It has also been advocated as a reliable measurement of the heterogeneity of atrial depolarization.[33] The more effective preventive methods, for example, amiodarone therapy, or atrial pacing, are not cost-effective for all patients. Thus, identification of patients at high risk of AF after CABG would be helpful.

In conclusion, PWD on surface ECG, and some echocardiographic parameters such as left ventricle ejection fraction and left atrial diameter are simple and reliable indexes to predict the development of postoperative AF in patients undergoing CABG. This prospective study demonstrated that in addition to clinical conditions, there might be an electrophysiologic basis to explain why some patients may be at risk for postoperative AF. The main limitations of our study were manual ECG measurements with the help of a magnifying lens without using computer software, age differences between the groups, and the relatively small sample size. A larger cohort would be desirable to improve the prognostic power of the study.

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