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Prognostic value of strain and strain rate in the prediction of postoperative atrial fibrillation in patients undergoing coronary artery bypass grafting: a systematic literature review

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ABSTRACT

Introduction: Atrial fibrillation (AF) is a common dysrhythmia postoperatively after coronary artery bypass grafting (CABG). Myocardial strain and strain-rate imaging is used for the assessment of postoperative atrial fibrillation (POAF) as a new echocardiographic method.
Methods: PubMed and Scopus were searched thoroughly using the following search terms: (strain and strain rate) AND (atrial fibrillation OR AF) on March 2015 to find English articles in which the strain and strain-rate echocardiographic imaging had been used for the evaluation of AF in patients undergone CABG. Full text of the relevant papers was fully reviewed for data extraction.
Result: Of overall 6 articles found in PubMed, 10 records found in Scopus and 4 articles found through reference list search, only 6 papers fully met the inclusion criteria for further assessment and data extraction. The results of strain and strain-rate assessment showed that in total of 542 patients undergoing CABG, POAF occurred in 106 patients. Studies showed that the reduction of left atrial (LA) strain rate is correlated with AF. Consistently, the results of present review showed that LA strain and strain-rate in patients who developed AF postoperatively after CABG are significantly reduced, suggesting that strain and strain-rate could be a predictor of POAF.
Conclusion: Based on the obtained results, strain and strain-rate is a suitable and accurate echocardiographic technique in the assessment of left atrial function , and it might be helpful to detect the patients who are at high risk of POAF.

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Introduction

Atrial fibrillation (AF) is a common postoperative arrhythmia, which may occur after cardiac surgery. Although the true incidence of postoperative AF is not clear, the reported cases varied between 10% and 65% among studies (1-3). This arrhythmia may increase postoperative complications, and leads to severe cardiac problems. As well, it may increase the risk of thrombotic events, hospital costs, use of financial resources, and the length of hospital stay (4,5). As the name suggests, AF originates from the atrium. Previously, it was thought that this arrhythmia was benign, but now it is believed that this arrhythmia is not so benign and may increase the rate of morbidity and mortality, especially in the elderly. Moreover, AF may lead to hemodynamic instability, heart attack, stroke, and other thromboembolic

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events (6,7). Findings show that the incidence of AF after coronary artery bypass grafting (CABG) surgery is a common postoperative cardiac dysrhythmia that might increases the risk of cardiac-related mortality and stroke. Therefore, identifying patients who are at high risk of AF after surgery requires special attention (8,9).

AF is clinically divided into three categories, including paroxysmal, persistent, and permanent. Atrial fibrillation is permanent, when the AF remains in sinus rhythm after electrical cardioversion. While in persistent type, the sinus rhythm lasts for more than a week. In the paroxysmal, the fibrillation rhythm is spontaneously converted to sinus rhythm. It is suggested that all three types of arrhythmias could increase the rate of mortality. Left atrial function (LAF) is usually impaired in patients with coronary artery disease (CAD). As a result, evaluation of atrial function postoperatively might be helpful to prevent future cardiovascular complications.

So far, several predictive factors for cardiovascular disease have been identified in different studies (10,11). Furthermore, it is evident that valuable clinical information about the risk of cardiovascular disease could be obtained through the assessment of these factors. Thus, it is possible to prevent the incidence of arrhythmias and subsequent cardiovascular disease through the identification of at risk individuals by these methods or other preventive measures. One of the important factors of risk assessments is a measurement of specific echocardiographic parameters, especially the size of the left atrium (LA), myocardial tissue velocities, and determination of LA strain-rate. Echocardiographic criteria are of the most important predictors of AF. Left atrial function has a relatively great importance in the prediction of postoperative atrial fibrillation (POAF) after CABG (12,13). Therefore, since there is relationship between the size of LA and POAF, and the reduction of LA strain rate is suggested to be associated with AF, strain and strain-rate as a novel and non-invasive echocardiographic method is used for the assessment of LAF (14-17). Therefore, in the presents study, we aim to systematically review the literatures in which the AF is evaluated by strain and strain rate echocardiographic methods in patients undergoing CABG.

Methods

Literature search strategy

Scopus and PubMed were searched comprehensively for articles in which the strain and strain rate echocardiographic method had been used for the evaluation of AF in patients who had undergone CABG. Literature search was performed by two reviewers independently using the key terms, “strain and strain rate”, “atrial fibrillation” and “coronary artery bypass grafting” in the title, keywords, and abstract. All possible relevant articles with the following search terms (strain and strain rate) AND (atrial fibrillation OR AF) were selected and analyzed for data extraction. The search strategy was customized by limiting the records to those patients who had undergone CABG. The databases were searched with the last update on 1 March 2013. Google Scholar was also searched using the previously described search terms to relevant papers in the early stages of article selecion. Studies conducted on animals were also miimize the possibility of any missing documents. Additionally, we searched the reference list of included papers to include other potentially related articles. Papers were omitted in different steps of selection process, if they were inappropriate and unrelated to the main purpose of this review.

Study selection and inclusion/exclusion criteria

No time limitation was defined in selection process, and we only included articles in English language to minimize any possible errors during the analysis of extracted data in the subsequent data analyzing processes. We included various types of the articles with different study designs including the clinical trials, case-controls, case reports, cross-sectional, and cohort studies in this literature review. However, review articles and meta-analysis were excluded. Conference papers and letters to the editor were also excluded. Inclusion criteria were all articles in which the AF had been evaluated by strain and strain rate echocardiographic method in patients who had undergone CABG. By reviewing the title, keywords, and abstract of papers, we excluded duplicated and irrelevant papers in the early stages of article selection. Studies conducted on animals were also excluded from further assessment.

Data extraction

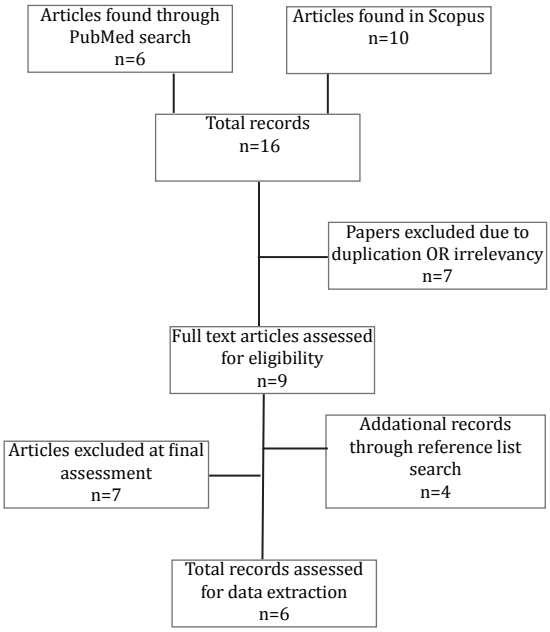
General information of the selected articles including the name of first author, publication year, country, type of study design, and critical findings were extracted and sorted based on the purpose of this literature review. Moreover, other available information including the total number of participants enrolled in the selected literatures and also demographic data were collected as possible, regarding to the inclusion and exclusion criteria. Data were sorted on the basis of the reported results in which the predictive value of strain and strain rate imaging method had been described in the prediction of POAF in patients who had undergone CABG. All processes of data extraction and study selection were based on the recommendation of PRISMA 2009 checklist (18).

Results

Study search results

From overall 6 articles found in PubMed, and 10 papers in Scopus, 7 articles were excluded in the first step due to duplication or language irrelevancy, and only 9 unique records seemed to be potentially relevant to the purpose of this study. Four additional papers were also included by manual reference skimming of the previously selected papers. After detailed sympathetically reviewing of the included articles, only 6 papers, which fully met the inclusion criteria were obtained, and the desired data were extracted concerning the main purpose of this study. Figure 1 shows the step by step process of literature search and study selection.

Figure 1. Flowchart for selection of studies



Characteristics of the included literatures

The earliest and the most recent articles included in the selected literatures were published in 2010 and 2014, respectively. The total number of participants enrolled in the selected reviewed literatures in which the AF had been evaluated postoperatively by strain and strain rate imaging method was 542 patients. Although the age of patients enrolled in the selected articles had not been mentioned in some studies, but it varied from 60 to 70 years old in those reported. In addition, minimum number of the patients in the selected articles was 53 in a prospective study, and maximum number was 176 participants in a cross-sectional study. As shown in the Table 1, the study designs of the selected literatures include prospective, respective, and cross-sectional studies.

As presented in Table 1, strain and strain rate had been evaluated by different methods in the selected studies. Because age and sex ratio had not been mentioned in some studies, data could not be categorized and analyzed based on demographic data. It was almost mentioned in all the included studies that more than half of the patients enrolled in the selected literatures were male.

Study results

Articles were selected according to the inclusion/exclusion criteria, and the desired data were extracted based on the main purpose of this survey. According to the obtained results, AF occurred postoperatively in 106 patients undergoing CABG. Comparison of the data among the studied individuals showed that POAF occurred more frequency in older patients. The value for strain and strain rate had not been mentioned in two studies; however, reduction of the values had been noted (Table 2).

Table 1. General characteristics of the included articles

No	Author Reference	Year	Country	Number of patients	Study design	Method of assessment
1	Tayyareci (19)	2010	Turkey	96	Prospective	TDI[1]
2	Gabrielli (20)	2011	Chile	70	Cross-sectional study	STE[2]
3	Albers (21)	2011	Germany	73	Postoperative	DE[3]
4	Her (22)	2013	Korea	53	Prospective	STE
5	Machino-Ohtsuka (23)	2013	Japan	74	Respective cohort study	TDI
6	Parsaee (24)	2014	Iran	176	Cross-sectional study	2D-VVI[4]

[1]TDI: tissue Doppler imaging; [2]STE: Speckle tracking echocardiography; [3]DE: Doppler echocardiography; [4]2D-VVI: 2-dimensional velocity vector imaging

The results of the present review also demonstrate that strain and strain rate is relatively low in patients with POAF compared to those with normal sinus rhythm. Table 2 shows the postoperative values of strain and strain rate in patients undergoing CABG.

Table 2. Echocardiographic characteristics of patients enrolled in the selected studies

No	Author	Strain	Strain rate (S^{-1})	Observed POAF ®
1	Tayyareci	38.9	1.5	25 (26%)
2	Gabrielli	10	0.6	18 (26%)
3	Albers	10.5	1.5	11 (15.1%)
4	Her	25.4	1.2	13 (24.6%)
5	Machino-Ohtsuka	NM *	NM	20 (27%)
6	Parsaee	NM	1.36	19 (12.7%)

® Number of patients with atrial fibrillation after coronary artery bypass grafting. * NM: Not mentioned.

Discussion

As previously described, AF is a common postoperative dysrhythmia after CABG, and is a leading cause of mortality due to cardiac- related disease (25,26). Due to the potential risks of this type of heart irregularities in the incidence of irreversible heart damage, development of a non-invasive and a more accurate technique seems very important to evaluate the biochemical and physical markers of cardiac disease, especially LAF. Several prognostic methods have been developed to predict upcoming cardiovascular disease by the evaluation of left ventricular dimension, LAF, ventricular mass, and systolic and diastolic blood pressures. Among them, strain and strain rate is thought to be more accurate and suitable for the evaluation of cardiac function. According to reported values, the normal range for strain and strain rate is 15% to 25% and 1.0 S-1 to 1.4 S-1, respectively (27). Comparison of the data among patients with cardiac abnormalities and healthy individuals showed that strain and strain rate deviated from normal range in response to physiological changes in the heart (28). Prognostic value of strain and strain rate imaging, as a noninvasive and quantitative technique in acute myocardial infarction, ischemic mitral regurgitation, amyloidosis and other myocardial functional abnormalities, has been demonstrated in several studies (28-31).

Strain and strain rate imaging technique could facilitate and accelerate comprehensive assessment of LA function, AF, and other cardiovascular functions. As well, LA strain and strain rate is suggested as a powerful predictor of postoperative AF (32). The results of studies on LA strain and strain rate of patients with prior CABG showed that the reduction of LA strain rate was closely associated with paroxysmal AF (16). Moreover, it was shown that strain and strain rate significantly decreased in patients with AF (20). In consistent with the reported findings, the results of all included literatures show that LA strain and strain rate markedly reduced compared to those in patients with normal sinus rhythm in patients who developed AF after CABG, suggesting that strain and strain rate of LA could be considered as an independent predictor of postoperative AF after CABG. Moreover, the results of this study suggest that strain and strain rate could be used to identify the patients with abnormal postoperative cardiac function.

The results of included studies showed that the strain imaging might have a prognostic value in the assessment of potential upcoming cardiovascular risks, cardiac dysrhythmia, and AF. Furthermore, this method might be useful in identifying the patients who are at higher risk of POAF. Therefore, this type of echocardiographic imaging could be used as a valuable diagnostic method for the prediction and evaluation of cardiac function, particularly in older patients.

Limitations of this systematic review include the small number of studies in the related subject. Moreover, demographic data were missed in some studies; therefore, the results could not be sorted and analyzed according to sex and age. Small number of patients in the selected articles was another limitation to the assessment and analysis of the literature that might lead to the insignificant results.

Conclusion

According to the results of the selected literatures, strain and strain rate imaging is a suitable and accurate echocardiographic technique for the assessment of LAF. The findings

suggest that strain and strain rate could be considered as an independent predictors of POAF after CABG. Moreover, it is suggested that strain and strain rate imaging might be helpful in clinical practice to detect the patients who are at high risk of POAF.

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Conflict of Interest

The authors declare no conflict of interest.

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