Prolonged QTc Interval Predicts Poststroke Paroxysmal Atrial Fibrillation

Takao Hoshino, MD, PhD; Takehiko Nagao, MD, PhD; Tsuyoshi Shiga, MD, PhD; Kenji Maruyama, MD, PhD; Sono Toi, MD, PhD; Satoko Mizuno, MD; Kentaro Ishizuka, MD; Satoru Shimizu, MD, PhD; Shinichiro Uchiyama, MD, PhD; Kazuo Kitagawa, MD, PhD

Background and Purpose—Paroxysmal atrial fibrillation (PAF) is often difficult to detect in patients with acute ischemic stroke. We aimed to assess the predictive value of a prolonged QT interval corrected for heart rate (QTc) in PAF detection after acute ischemic stroke.

Methods—We enrolled 972 patients with acute ischemic stroke consecutively extracted from our observational stroke registry system. Exclusion criteria were as follows: (1) AF on the initial 12-lead ECG (n=171); (2) previously diagnosed PAF (n=47); and (3) the use of a cardiac pacemaker (n=10). Of the 972 patients, 744 (mean age, 67.6 years; men, 62.6%) were eligible for analysis. The clinical characteristics and 12-lead ECG findings of the patients with and without PAF were compared, and multiple logistic regression analysis was performed to identify predictors of poststroke PAF.

Results—The poststroke cardiac work-up yielded 69 (9.3%) de novo PAF cases among the 744 patients. The QT interval was significantly longer in patients with PAF than in those without PAF (436 versus 417 ms; \(P<0.001\)). Each 10-ms increase in the QTc interval was associated with an increased risk of PAF after multivariate adjustments (odds ratio, 1.41; 95% confidence interval, 1.24–1.61; \(P<0.001\)). The optimal threshold value of QTc interval calculated by a receiver-operating characteristic curve was 438 ms, and the area under the curve was 0.73 in this data set.

Conclusions—The QTc interval prolongation is potentially a strong and useful predictor for poststroke PAF.

Key Words: atrial fibrillation ■ electrocardiography ■ stroke
incomplete clinical investigations or missing data, 972 patients were enrolled. Furthermore, we have excluded patients with the following characteristics: (1) AF on the initial 12-lead ECG (n=171); (2) previous PAF diagnosis before stroke (n=47); and (3) the use of cardiac pacemakers (n=10). Of the 972 patients, 744 were eligible for analysis. All patients were of East Asian ethnicity.

All patients with stroke were diagnosed by a board-certified stroke neurologist on the basis of the findings from neurological examination, cranial ultrasound, and MRI or computed tomography. Stroke severity was assessed according to the National Institute of Health Stroke Scale.

Cardiac Evaluations

Baseline resting standard 12-lead ECG was performed at the time of hospital admission. Twelve-lead ECG was recorded using a standard digital recorder (CardiofaxV; Nihon Kohden Co, Tokyo, Japan) at a gain of 10 mm/mV and a speed of 25 mm/s. ECG interpretation was conducted using Electro Cardiograph Analysis Program System 12 (Nihon Kohden Co). Electro Cardiograph Analysis Program System generates an additionally averaged ECG wave form from the beats obtained during a 10-s recording time. The QT interval is then automatically determined in the processed wave form and corrected for heart rate using the following formula: QTc=QT+(1000–RR)/7, on the basis of linear regression techniques. Electro Cardiograph Analysis Program System correction has been confirmed comparable with other formulae and shows similar tendency to Framingham correction (in-house data by Nihon Kohden Co). The linear regression formulae, including Electro Cardiograph Analysis Program System and Framingham, were reported to correct QT more reliably when compared with the nonlinear formulae, such as Bazetts. Considering the diurnal variation of QTc interval, in analyzing QTc, we further divided the subjects into 2 groups according to time of admission: daytime (6:00 AM–6:00 PM; n=518) and nighttime (6:00 PM–6:00 AM; n=226).

All patients routinely underwent continuous bedside ECG monitoring for 48 hours immediately after admission, with the monitoring period extended depending on the case. We also routinely performed 24-hour Holter ECG. Therefore, ≥72 hours of ECG monitoring was conducted on every patient. PAF was defined as a self-terminating sequence of ≥30 s RR intervals and the presence of fibrillatory P waves. The presence of PAF (or atrial flutter) was determined on the basis of cardiac monitoring by inpatient telemetry and 24-hour Holter ECG. Moreover, each patient underwent transthoracic echocardiography without presuming the cause of stroke. All measurements and calculations were performed in accordance with the recommendations of the Japanese Circulation Society. Independent board-certified cardiologists reported all the 24-hour Holter ECG and transthoracic echocardiography results.

Baseline Risk Factors

Hypertensive patients were defined as those who were receiving antihypertensive treatment at the time of the event or those with consistently high systolic blood pressure (≥140 mm Hg) or diastolic blood pressure (≥90 mm Hg) for ≥1 week after admission. Patients with diabetes mellitus were defined as those who had previously been diagnosed with type 1 or 2 diabetes mellitus, or those with fasting blood glucose levels ≥126 mg/dL or blood glucose levels ≥200 mg/dL based on 2 random measurements. Patients with dyslipidemia were defined as those who had been receiving lipid-lowering treatment at the time of the stroke event, or those with a serum low-density lipoprotein cholesterol level ≥140 mg/dL or high-density lipoprotein cholesterol level ≤40 mg/dL or serum triglyceride level ≥150 mg/dL. The estimated glomerular filtration rate was calculated using the Modification of Diet in Renal Disease equation for Japan; chronic kidney disease was defined as an estimated glomerular filtration rate <60 mL/min per 1.73 m². An intracranial artery stenosis of ≥50% was considered significant, as determined by MR angiography, 3-dimensional computed tomographic angiography, or digital subtraction angiography. The narrowest diameter of each stenosed vessel was measured and divided by the diameter of the normal vessel just distal to the lesion. If no suitable vessel existed beyond the lesion for measurement, the vessel proximal to it was used. Qualified neurologists checked the carotid artery ultrasounds; percent stenosis was calculated according to the European Carotid Surgery Trial (ECST) criteria, and a stenosis of ≥50% was defined as significant. The criteria of absence of vascular cause in this study were based on the absence of both intracranial and carotid artery stenosis.

Statistical Analysis

We compared the clinical parameters of the patients with and without poststroke PAF. Intergroup differences were assessed by using the χ² test for categorical variables, and Student t test or Mann–Whitney U-test for continuous variables. To identify predictors of PAF, we performed multiple logistic regression analysis based on a forward stepwise method adjusted for age, sex, and all clinical variables with P<0.1 in the univariate analysis. Given the multicollinearities, supraventricular/ventricular arrhythmia and left ventricular hypertrophy were excluded from the model. Odds ratios and 95% confidence intervals were calculated. The optimal cutoff value of the QTc interval was calculated on the basis of the receiver-operating characteristic curve. In all analyses, a value of P<0.05 was considered statistically significant.

Results

Of the 744 patients with AIS (mean age, 67.6 years; men, 62.6%; 69 (9.3%) were newly diagnosed with PAF based on the poststroke cardiac work-up. The median latency from hospital admission to PAF detection was 3 days, and in >90% of these patients, PAF was detected within 14 days after admission. Baseline characteristics of the study subjects are shown in Table 1. Patients with and without poststroke PAF showed significant differences in age (73.4 versus 67.0 years; P<0.001), absence of vascular cause (78.3% versus 54.4%; P<0.001), congestive heart failure (11.6% versus 5.5%; P=0.043), left atrial dilation on transthoracic echocardiography (37.7% versus 16.6%; P<0.001), and admission National Institute of Health Stroke Scale score (10 versus 6; P<0.001). With regard to the initial 12-lead ECG findings, the QTc interval in patients with PAF was significantly longer than in those without PAF (436 versus 417 ms; P<0.001). Even when classified by time of admission, QTc interval was still prolonged in patients with PAF when compared with those without PAF by a significant difference (cases of daytime admission: 439 versus 417 ms; P<0.001; nighttime admission, 432 versus 418 ms; P<0.001). In addition, patients with PAF presented more frequently with AV conduction block (17.4% versus 9.0%; P=0.040) and premature atrial contraction (13.0% versus 3.7%; P=0.003) than those without PAF.

The Figure shows the prevalence of patients with poststroke PAF stratified by QTc interval. The prevalence of PAF was significantly higher in patients with QTc >450 and >440 ms than in those with ≤450 and ≤440 ms, respectively (34.5% versus 7.1%; P=0.001 and 27.5% versus 5.8%; P=0.001, respectively). A trend of slight increase in the prevalence of PAF was found in the short QTc interval subgroup; however, the difference was not statistically significant.

According to the multiple logistic regression analysis, the prolonged QTc interval was an independent predictor for PAF (QTc per 10-ms increase; odds ratio, 1.41; 95% confidence interval, 1.24–1.61; P<0.001; Table 2). The optimal threshold value of the QTc interval calculated by a receiver-operating characteristic curve was 438 ms (sensitivity, 59.4%; specificity, 83.7%), and the area under the curve was 0.73.
Discussion

The present study showed that patients with AIS and a prolonged QTc interval on the initial 12-lead ECG had an increased risk of poststroke PAF. This relationship persisted after multivariable adjustment for possible confounding factors. According to the receiver-operating characteristic analysis, QTc interval seems to be an acceptable screening test at an early time point for detecting PAF in patients with AIS. QTc prolongation was still associated with PAF based on analysis, including the patients with premorbid PAF (Figure I in the online-only Data Supplement). Our findings suggest that QTc prolongation might be a rapid, inexpensive, and useful marker for improving the detection rate of poststroke PAF.

Previous population-based studies have shown that individuals with a prolonged QTc interval have a high risk of developing PAF. Mandyam et al reported a hazard ratio of 1.11 per 10-ms increase of QTc interval for incident PAF. An increased risk of developing PAF has also been demonstrated in patients with congenital LQTS. These findings seem consistent with our results. In addition, Nielsen et al showed the possibility of a higher risk of PAF in patients with shorter QTc interval, a similar tendency was also seen among our cohort.

The association of QTc interval prolongation with PAF may suggest that the duration of the ventricular action potential represents an easily identifiable marker of PAF, which may provide insights into the pathophysiology of this arrhythmia.
To our knowledge, there is a lack of strong evidence of the direct correlation between the atrial and ventricular action potential durations. However, Ordög et al.17 have investigated the mRNA expressions of several representative panels of cardiac ion channels in healthy human hearts and found that some important channels involved in cardiac repolarization are commonly abundant between the atrial and the ventricular tissues. Given that the expression level of the ion channel subunit-encoding mRNA is closely related to the electrophysiological behavior in the cardiac tissues, the duration of the atrial and ventricular repolarizations is potentially related. As discussed by Nielsen et al.8 and Mandyam et al.9 the association between the QTc prolongation and AF may be explained by a mechanism of atrial torsades de pointes, which has been first recognized in the congenital LQTS—characterized by a susceptibility to ventricular tachyarrhythmias known as torsades de pointes.18 Apparently, disordered repolarization is not confined to the ventricular myocardium because it also affects the atrial myocardium. In patients with LQTS, the duration of monophasic atrial action potentials was found to be prolonged; furthermore, after depolarizations in the atrium, similar to ventricular torsade de pointes, preceded the polymorphic atrial tachyarrhythmias.18 Moreover, the murine LQTS model study showed that prolongation of the duration of the atrial action potential secondary to increased Na+ current, caused by an impaired inactivation of the gate function, is sufficient to provoke early after depolarizations, which promote AF.19

Interestingly, the QTc interval prolongation is associated with an increased risk of stroke,20,21 as well as the poststroke short- and long-term prognosis.22,23 However, the mechanism for these associations remains unclear. We speculated that this may be because of a higher prevalence of occult PAF in patients with a prolonged QTc interval and the higher likelihood of a severe or fatal cardioembolic stroke in patients with AF than in those without AF.24

Limitations
It is important to acknowledge several limitations in our study mainly related to the retrospective design, generalizability, and low statistical power. Although the baseline ECGs were retrospectively collected, they were analyzed digitally using clinically validated software, to avoid any intraobserver or interobserver variability. With regard to the measurement of carotid artery stenosis by ultrasound, ECST criteria were adopted in our stroke registry system. Because ECST methodology tends to overestimate the degree of stenosis,25 the number of patients with true absence of vascular cause might be higher than shown in Table 1.

It should be noted that QTc interval can be modulated by several factors, such as the circadian rhythm, meals, smoking, physical activities, serum electrolytes, and medication.15,26,27 Even at the same time of the day, the parasympathetic and sympathetic nervous system modulate QTc interval to different degrees.28 To complicate matters further, AIS itself, particularly in the right insula29,30 or posterior circulation regions,31 may prolong QTc interval. Although intraindividual QTc variability should have compensated to avoid possible bias, it was difficult to determine the relative influence of all above-mentioned factors. Furthermore, there is also considerable ethnic variability in QTc interval.32,33 However, bias because of ethnic variability is perceived to be small in the current study because we included only East Asian subjects.

The procedure for the poststroke cardiac work-up might also have some limitations. In the present study, all patients underwent 24-hour Holter ECG monitoring and continuous bedside monitoring for ≥48 hours. The duration of the bedside monitoring was further extended depending on the case, particularly in cases of cryptogenic stroke; it was not consistent among studied patients. This is potentially a vital bias because of the retrospective settings and might also lessen the comparability
with relevant past reports. In a future prospective study, we plan to set a more standardized protocol of cardiac tests.

As mentioned above, we conducted 272 hours of ECG monitoring on every patient. According to a previous review, 24-hour Holter ECG monitoring, which is the most widely used screening test, led to the identification of PAF in only ≈5% of patients with AIS. Seventy-two–hour ECG monitoring improved the PAF detection when compared with standard 24-hour Holter ECG; the number of patients in whom PAF was detected nearly doubled. More recent evidence revealed that weeks 36 and years 37 of extended ECG monitoring yield much better results. Although a standard protocol for ECG monitoring with longer period would have been useful to avoid a possible bias of results, a complete cardiac evaluation for all patients with AIS in the same way would not be cost-effective. In clinical practice, we should first identify patients with a high possibility of latent PAF and then conduct intensive investigations on them. We have previously reported that several other ECG parameters, including premature atrial beats, P wave duration, P wave morphology, incomplete right bundle branch block, and left ventricular hypertrophy are associated with silent PAF. These ECG factors might be comprehensively considered in a future study.

Conclusions
We showed the possibility of using QTc interval on initial 12-lead ECG for poststroke PAF prediction. The present study may provide an important and useful information for the management of cryptogenic stroke and guide future prospective studies with larger multicenter cohorts aimed at validating our findings.

Disclosures
None.

References
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**Abstract**

Prolonged QTc Interval Predicts Poststroke Paroxysmal Atrial Fibrillation

Takao Hoshino, MD, PhD; Takehiko Nagao, MD, PhD; Tsuyoshi Shiga, MD, PhD, et al.

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背景および目的：発作性心房細動（PAF）の検出は、急性虚血性脳卒中患者ではしばしば困難である。本研究では、急性虚血性脳卒中後の PAF の検出における心拍数で補正した QT（QTc）間隔延長の的中率を評価した。

方法：本研究には、我々の脳卒中臨床登録システムから連続的に抽出した急性虚血性脳卒中患者 972 例を登録した。除外基準は、（1）1 回目の 12 誘導心電図（ECG）における心房細動（AF）(n = 171)，（2）過去の PAF の診断 (n = 47)，および（3）心臓ベースユーザーの使用 (n = 10) とした。972 例中 744 例（平均年齢 67.6 歳、男性：62.6％）を解析対象とした。PAF 患者と非 PAF 患者で臨床的特徴と 12 誘導 ECG 所見を比較し、多重ロジスティックス回帰分析を行った脳卒中後の PAF の予測因子を同定した。

結果：脳卒中後の心臓の精密検査により、744 例中 69 例（9.3％）の新規 PAF 症例が明らかになった。QTc 間隔は PAF 患者の方が非 PAF 患者よりも有意に長かった（436 ms 対 417 ms； p < 0.001）。多変量補正後では、QTc 間隔の 10 ms 毎の増加が PAF のリスク増加と関連していた (オッズ比 = 1.41；95% 信頼区間：1.24 ～ 1.61；p < 0.001)。このデータセットでは、受信者動作特性曲線で計算した QTc 間隔の最適閾値は 438 ms で、曲線下面積は 0.73 であった。

結論：QTc 間隔延長は、脳卒中後の PAF 発症の強力かつ有益な予測因子と考えられる。

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**表 2** 脳卒中後の発作性心房細動の多重ロジスティックス回帰分析

<table>
<thead>
<tr>
<th></th>
<th>OR (95%CI)</th>
<th>p 値</th>
</tr>
</thead>
<tbody>
<tr>
<td>年齢（歳）</td>
<td>1.02 (0.99-1.04)</td>
<td>0.13</td>
</tr>
<tr>
<td>男性</td>
<td>0.91 (0.68-1.23)</td>
<td>0.55</td>
</tr>
<tr>
<td>頭盖骨内腔</td>
<td>0.83 (0.62-1.11)</td>
<td>0.23</td>
</tr>
<tr>
<td>血管性原因なし</td>
<td>2.20 (1.59-3.14)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>うっ血性心不全</td>
<td>0.86 (0.50-1.39)</td>
<td>0.57</td>
</tr>
<tr>
<td>TTE で認められた左房径拡大</td>
<td>1.98 (1.43-2.74)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>入院時 NIHSS の 1 ポイント増加</td>
<td>1.12 (1.08-1.17)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>AV 伝導ブロック</td>
<td>1.25 (0.82-1.86)</td>
<td>0.29</td>
</tr>
<tr>
<td>QTc 間隔の 10 ms 毎の増加</td>
<td>1.41 (1.24-1.61)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

CI：信頼区間、LAD：左主幹、NIHSS：米国国立衛生研究所脳卒中スケール、OR：オッズ比、TTE：超音波心エコー。

図 QTc 間隔で層別化した発作性心房細動（PAF）患者と非 PAF 患者の分布。組グラフ内の数値は PAF 患者（黒）と非 PAF 患者（灰色）の数。*p < 0.001。
결과

배경과 목적

반작성 심방세동(paroxysmal atrial fibrillation, PAF)은 급성허혈뇌졸중 환자에서 때때로 발견하기 어렵다. 이 연구는 심박수로 보정한 QT 간격(QT interval corrected for heart rate, QTc interval) 연장의 급성허혈뇌졸중 이후 PAF 발전에 대한 예측도 (predictive value)를 평가하는 것을 목표로 하였다.

방법

관찰 뇌졸중 환자등록자료로부터 연속적으로 추출한 972명의 급성허혈뇌졸중 환자를 동록하였다. 제외기준은 다음과 같았다: (1) 초기 12~24시간 간에도 PAF를 보이지 않은 환자(n=171); (2) 1차 진단에 PAF가 아닌 다른 진단을 받은 환자(n=47); (3) 심장박동조절기 사용(n=10). 환자 972명 중 744명(평균 연령, 67.6세; 남성, 62.0%)을 분석 대상으로 하였다. 환자의 임상전적 양상은 심전도에서 PAF 유무에 따른 12~24시간 간의 결과를 비교하여, 뇌졸중 이후 PAF의 예측 인자를 판별하기 위한 다중 로지스틱 회귀분석을 시행하였다.

결과

뇌졸중 이후 심장 조사로 환자 744명 중 69명(9.3%)에서 새로운 PAF 증례를 관찰할 수 있었다. QTc 간격은 PAF가 있는 환자에서 PAF가 없는 환자에 비하여 유의하게 길었다(436 대 417 ms; 0.0057).
P<0.001). QTc 간격의 평균 10-ms 연장은 다변량 보정 이후에도 PAF의 위험증가와 관련이 있었다(OR, 1.41; 95% CI, 1.24-1.61; P<0.001). 수신자조작특성(receiver-operating characteristics, ROC) 곡선에 의해 계산된 QTc 간격의 최적 임계값(optimal threshold value)은 438 ms이었고, 곡선하면적(area under the curve)은 이 데이터 세트에서 0.73이었다.

결론
QTc 간격 연장은 잠재적으로 뇌졸중 이후 PAF의 강력하고 유용한 예측 인자이다.

Abstract 4
무증상 경동맥 협착 환자가에서 시행한 경동맥 스텐트 삽입술 및 동맥내막절제술 이후 조기 결과

Early Outcomes After Carotid Artery Stenting Compared With Endarterectomy for Asymptomatic Carotid Stenosis
Jay Chol Choi, MD; S. Claiborne Johnston, MD, PhD; Anthony S. Kim, MD, MAS
(Stroke. 2015;46:120-125.)

Key Words: carotid stenosis ■ endarterectomy, carotid ■ propensity score ■ stents ■ stroke

배경과 목적
무증상 경동맥 협착에 대한 경동맥 스텐트 삽입술(carotid artery stenting, CAS)과 경동맥내막절제술(carotid endarterectomy, CEA) 사이의 상호 비교 효과에 대하여 결론을 내릴 수 있는 무작위향상 임상 시험 결과가 현재로서는 발표되지 않았다. 그러나 CAS는 임상 널리 확산되고 있어, 미국의 일부 지역에서는 CEA를 사사당 대체하고 있다.

Table 1. Baseline Characteristics of Patients With and Without PAF

<table>
<thead>
<tr>
<th></th>
<th>Overall (n=744)</th>
<th>PAF (n=69)</th>
<th>No PAF (n=675)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y, mean (SD)</td>
<td>67.6 (14.1)</td>
<td>73.4 (12.3)</td>
<td>67.0 (14.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Men</td>
<td>466 (62.6)</td>
<td>40 (58.0)</td>
<td>426 (63.1)</td>
<td>0.40</td>
</tr>
<tr>
<td>Hypertension</td>
<td>508 (68.3)</td>
<td>51 (73.9)</td>
<td>457 (67.7)</td>
<td>0.28</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>299 (40.0)</td>
<td>25 (36.2)</td>
<td>274 (40.0)</td>
<td>0.48</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>363 (48.8)</td>
<td>26 (37.7)</td>
<td>337 (49.9)</td>
<td>0.051</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
<td>200 (26.9)</td>
<td>17 (24.6)</td>
<td>183 (27.1)</td>
<td>0.66</td>
</tr>
<tr>
<td>Absence of vascular cause</td>
<td>421 (56.7)</td>
<td>54 (78.3)</td>
<td>367 (54.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>40 (5.5)</td>
<td>8 (11.6)</td>
<td>32 (4.8)</td>
<td>0.043</td>
</tr>
<tr>
<td>Previous coronary artery disease</td>
<td>133 (16.8)</td>
<td>10 (14.5)</td>
<td>123 (18.6)</td>
<td>0.64</td>
</tr>
<tr>
<td>LAD dilation on TTE</td>
<td>138 (18.5)</td>
<td>26 (37.7)</td>
<td>112 (16.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age, y, mean (SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QTc interval, ms, mean (SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall patients</td>
<td>419 (21.9)</td>
<td>436 (26.8)</td>
<td>417 (20.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patients admitted in the daytime*</td>
<td>418 (22.9)</td>
<td>439 (28.8)</td>
<td>417 (21.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pathological ECG findings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AV conduction block</td>
<td>73 (7.4)</td>
<td>12 (17.4)</td>
<td>61 (9.9)</td>
<td>0.040</td>
</tr>
<tr>
<td>Q wave</td>
<td>57 (7.7)</td>
<td>7 (10.1)</td>
<td>50 (7.4)</td>
<td>0.43</td>
</tr>
<tr>
<td>ST segment</td>
<td>90 (12.1)</td>
<td>11 (15.9)</td>
<td>79 (11.7)</td>
<td>0.32</td>
</tr>
<tr>
<td>T wave</td>
<td>90 (12.1)</td>
<td>11 (15.9)</td>
<td>79 (11.7)</td>
<td>0.32</td>
</tr>
<tr>
<td>Right bundle branch block</td>
<td>49 (6.6)</td>
<td>6 (8.7)</td>
<td>43 (6.4)</td>
<td>0.48</td>
</tr>
<tr>
<td>Left bundle branch block</td>
<td>18 (2.4)</td>
<td>3 (4.4)</td>
<td>15 (2.2)</td>
<td>0.32</td>
</tr>
<tr>
<td>Left ventricular hypertrophy</td>
<td>52 (7.0)</td>
<td>9 (13.0)</td>
<td>43 (6.4)</td>
<td>0.050</td>
</tr>
<tr>
<td>Premature atrial contraction</td>
<td>34 (4.5)</td>
<td>9 (13.0)</td>
<td>25 (3.7)</td>
<td>0.063</td>
</tr>
<tr>
<td>Premature ventricular contraction</td>
<td>40 (5.4)</td>
<td>7 (10.1)</td>
<td>33 (4.9)</td>
<td>0.034</td>
</tr>
</tbody>
</table>

*Unless otherwise indicated, figures are expressed as n (%). ACEI indicates angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; IQR, interquartile range; LAD, left atrial dimension; NIHSS, National Institute of Health Stroke Scale; PAF, paroxysmal atrial fibrillation; and TTE, transthoracic echocardiography.

University HealthSystem Consortium에 참여하는 모든 수련 병원의 퇴원기록을 조사하여, 2010년 1월부터 2012년 12월까지 무증상 경동맥 협착으로 CEA 혹은 CAS를 받은 환자의 기록을 수집하였다. CAS 및 CEA 이후의 원내 사망 및 수술 후 뇌졸중 발생율을 다변수 로지스틱 회귀분석, 생향 점수 매핑 및 다수변 혼합 효과 모형(multilevel mixed-effect model)을 이용하여 해당 시험을 받은 환자의 기초적 특성의 영향을 보정하였다.