Role of preoperative electrocardiography in predicting cardiovascular complications in proximal femur surgery

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OBJECTIVE: To evaluate whether a complete analysis of electrocardiograms (ECGs) taken before hip fracture surgery could provide prognostic data regarding in-hospital perioperative cardiovascular complications (PCVCs).
METHODS: Elderly patients who underwent surgery using a proximal femoral nail due to peritrochanteric fracture between 2009 and 2013 were retrospectively evaluated. Patients' 12-lead preoperative ECGs were analyzed and corrected QT intervals (QTcs) were calculated. Following analysis, ECGs with atrial fibrillation, left or right bundle branch block, ventricular premature beats, Q-waves, ventricular strain, sinus bradycardia or tachycardia were designated as abnormal. The relationship between observed ECG abnormalities and calculated QTc interval, and the development of in-hospital PCVC was evaluated.
RESULTS: In total, 190 male and 232 female patients were included in the study. Two hundred nineteen (51.9%) patients had a fractured right hip and 203 (48.1%) had a fractured left hip. ECGs of 133 patients were abnormal. Seventeen patients (4.02%) died and 62 patients (14.6%) developed PCVCs. There was a statistically significant increase (P=0.0183) in PCVC as perioperative cardiac risk factors increased. Of the abnormal ECG changes, only atrial fibrillation, paced rhythm and ventricular strain were found to be related to PCVCs (P<0.001, P<0.03 and P<0.001, respectively). It was found that PCVCs increased significantly as the QT interval increased (P<0.0001). QTc prolongation was correlated with PCVC.
CONCLUSION: ECG changes before hip fracture surgery, especially QTc prolongation, was found to be closely linked to PCVCs.

Key Words: *Electrocardiogram; Perioperative cardiovascular complications; Proximal femur fracture*

Electrocardiography (ECG) is commonly performed on patients scheduled for noncardiac surgery as part of risk evaluation. Whereas ECG has been shown to be ineffective in determining perioperative cardiac risk in low-risk surgeries, routine ECG is recommended before intermediate-risk surgeries where there are ≥1 clinical risk factors or an existing vascular disease in the patient history (1). Cardiac complications that lead to mortality and morbidity develop in approximately 5% of orthopedic surgeries in patients who are at intermediate risk in terms of perioperative cardiovascular complications (PCVCs) (2). Because most cardiac complications are treatable, prediction and/or early diagnosis are vital.

Currently, proximal femur fractures comprise 30% of all fractures presenting to hospital. Increases in the elderly population and, thus, increases in senile osteoporosis and post-menopausal status has led to an increase in incidences of proximal femur fractures requiring priority treatment (3). A significant proportion of patients with hip fractures have cardiovascular diseases. Hip fractures are an important cause of morbidity and mortality among elderly patients. Mortality in the first three months following a hip fracture has been found to be 7.95% for elderly men and 5.75% for elderly women (4). Although reduction of perioperative and postoperative mortality are the priority target of the surgical team, these are closely linked to the accurate assessment of the patient's operative and cardiac risk.

While PCVC risk evaluation in patients who are undergoing vascular operations has been widely studied in the literature, the incidence and predictors of this risk have not sufficiently been explored in patients with hip fractures, which are increasingly more common. Therefore, we retrospectively evaluated whether a complete analysis of ECGs obtained before hip fracture surgery could provide prognostic data regarding in-hospital PCVCs.

METHODS

Elderly patients who underwent surgery using a proximal femoral nail due to peritrochanteric fracture between 2009 and 2013 were retrospectively evaluated. Emergency cases and patients who were not expected to live after 24 h without surgery due to multiple traumas were excluded. For each patient, preoperative risk factors mentioned in the revised cardiac risk index (ie, ischemic heart disease, congestive heart failure, history of cerebrovascular accident, diabetes mellitus requiring insulin treatment, preoperative kidney failure) (5), preoperative medications, patient characteristics and intraoperative techniques that could affect morbidity and mortality were retrospectively evaluated. Twelve-lead ECGs of patients recorded at 25 mm/s at the time of entry to the hospital were analyzed by two blinded researchers. All ECGs were analyzed for Minnesota classification, QRS duration, QT interval and left ventricular hypertrophy (6). QT interval was corrected for the heart rate using Bazett's formula (7). For corrected QT interval (QTc), interobserver and intraobserver variability was 8% and 7%, respectively. Following analysis, ECGs with atrial fibrillation (AF), left or right bundle branch block, ventricular premature beats, Q-waves, ventricular strain, sinus bradycardia or tachycardia were defined as abnormal.

PCVC was defined as the occurrence of severe arrhythmia requiring treatment, cardiac death (death caused by acute myocardial infarction, serious cardiac arrhythmia or deaths occurring suddenly without other explanation), acute cardiac failure, acute coronary syndrome (nonfatal acute myocardial infarction or unstable angina),

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TABLE 1
Perioperative cardiovascular complications (PCVCs)

	PCVCs, n									
	Cardiac death	Nonfatal cardiac arrest	Pulmonary embolism	Acute coronary syndrome	Stroke	Acute cardiac failure	Severe arrhythmia	None	DVT	Total
Electrocardiogram										
Normal	6	1	2	3	2	5	13	249	8	289
Abnormal	11	4	1	2	3	8	6	94	4	133
Total	17	5	3	5	5	13	19	343	12	422
Perioperative cardiac risk factors										
None	1	0	0	1	0	1	2	84	2	91
1	0	1	2	0	2	1	2	129	3	140
2	7	2	0	2	2	4	6	112	3	138
≥3	9	2	1	2	1	7	9	18	4	53
Total	17	5	3	5	5	13	19	343	12	422
Fracture type										
A2.1	6	1	1	2	2	3	4	66	3	88
A2.2	8	2	0	3	1	3	9	150	4	180
A2.3	2	1	1	0	1	5	5	106	3	124
A3.1	1	1	0	0	0	1	0	12	1	16
A3.2	0	0	0	0	1	1	0	4	1	7
A3.3	0	0	1	0	0	0	1	5	0	7
Total	17	5	3	5	5	13	19	343	12	422
American Society of Anesthesiologists score										
2	1	0	0	1	0	1	1	48	0	52
3	6	2	3	2	3	8	8	171	10	213
4	10	3	0	2	2	4	10	124	2	157
Total	17	5	3	5	5	13	19	343	12	422

DVT Deep vein thrombosis

acute pulmonary thromboembolism, nonfatal cardiac arrest and cardioembolic stroke.

Surgical method

After patients' written consent was received and optimal conditions were provided for all patients, surgical intervention was performed with the patient lying on his/her back under the scope according to standard protocols described by the producers. Prophylactic first-generation cephalosporins were administered to all patients. In the preoperative period, patients were started on 0.4 mg daily dose of subcutaneous low molecular weight heparin injections (enoxaparin) to prevent deep vein thrombosis. Postoperatively, all patients wore antiembolism compression hose. After the operation, patients were encouraged to walk putting partial pressure on the operated extremity.

Statistical analysis

Statistical analysis was performed using χ^2, Kaplan-Meier estimates and Spearman correlation. SPSS version 21.0 (IBM Corporation Inc, USA) for Windows (Microsoft Corporation, USA) package was used for all analyses. P<0.05 was considered to be statistically significant.

RESULTS

In total, 190 male and 232 female patients were included in the study. Of these, 219 (51.9%) had a right hip fracture and 203 (48.1%) had a left hip fracture. Mean (± SD) age was 77.68±7.67 years, mean hospital stay was 10.66±4.02 days and mean preoperative period was 3.48±1.99 days. Thirty-one (7.34%) patients received general anesthetic and 391 (92.66%) patients received regional anesthesia. ECGs of 133 patients were abnormal. Mean QTc interval was found to be 426.45±16.07 ms. Of the 422 patients, 101 did not have any preoperative cardiac risk factors and 25 had ≥3. Seventeen patients (4.02%) died and 62 (14.6%) developed PCVCs. Twelve patients developed superficial surgical site infection and 14 patients developed urinary tract infection. Treatment for infection was provided through appropriate care and antibiotics. Two patients experienced deep surgical site infection; despite debridement and antibiotics, infection could not be controlled and, thus, the implant was removed. Treatment for infection and the fracture was performed with an external fixator device. Three patients underwent reoperation due to nonunion and 13 due to cut out.

No statistically significant link between PCVC and sex, fracture type or fracture side was found (P>0.05) (Table 1). Median patient age (78 years) was used as a cut-off point; it was determined that there was a statisictally significant increase in PCVCs in patients older than 78 years (P<0.0001). Furthermore, increased preoperative cardiac risk factors were associated with increased PCVCs (P=0.018).

When patients were evaluated in terms of the methods of anesthesia and American Society of Anesthesiologists (ASA) physical status classification system scores, it was seen that while method of anesthesia did not significantly impact PCVCs, there was a significant relationship between higher ASA score (scores of 3 and 4) and PCVCs (P<0.001).

Of the abnormal ECG changes, only AF, paced rhythm and ventricular strain were found to be related to PCVCs (P<0.001, P<0.03 and P<0.001, respectively) (Table 2). It was found that as QT interval increased, PCVCs increased statistically (P<0.0001). In patients with abnormal ECGs and QT intervals above the median limit of 426.45 ms, PCVC ratio was found to be 1.8 times higher. The prolongation of the QT interval was found to be correlated to PCVC (r=0.365; P<0.001).

DISCUSSION

Results of the present study have shown that standard preoperative ECGs can predict postoperative PCVCs that may develop following proximal femur fracture surgeries (which are classified as intermediate-risk surgery for cardiac-related events). Preoperative cardiac risk factors are closely related to perioperative cardiac mortality and morbidity in elderly femur fracture patients. In addition, a prolonged QTc interval, which can easily be calculated from an ECG, is an independent risk indicator for PCVCs that may develop following proximal femur fracture surgeries. Moreover, patients with abnormal ECGs and/or prolonged QTc intervals but no other history of preoperative cardiac

risk factors represent an important group because of the potential for risk-reduction intervention.

As the human lifespan increases, incidence of hip fractures increases. The one-year mortality rate in hip fracture patients is between 12% and 36%, and is highest during the first month (8). It has been proven that cardiovascular comorbidity has an important effect on patient survival. Moreover, it is known that important postoperative complications that may affect lifespan are closely linked to preoperative cardiac risk factors (9). Although early surgical intervention reduces mortality in patients with multiple cardiac risk factors, determining cardiac risk accurately and quickly, and preventing PCVCs may reduce additional mortality and morbidity. However, especially in elderly patients, in addition to patient's medical histories, unnecessary, expensive and time-consuming tests conducted to determine preoperative cardiac risk may put patients in unexpected risk by delaying surgery.

There are various views on the role of routine preoperative ECGs in predicting PCVCs before surgical procedures with intermediate or high cardiac risk such as proximal femur surgeries. Incidence of abnormal ECGs are higher in elderly patients due to increasing morbidity. In a large patient series (n=23,036), preoperative ECG was found to predict early cardiovascular mortality in addition to cardiac risk factors (10). Each abnormal ECG change provided similar results, and even after age was included in the regression model, preoperative ECG changes remained meaningful. Similarly, Van Klei et al (11) reported that the bundle branch block was related to postoperative myocardial infarction. Correll et al (12) reported an association between abnormal ECG, postoperative cardiovascular complications and death due to all causes. In contrast, in a study involving patients older than 70 years, the role of preoperative ECG in predicting perioperative cardiac complications was shown to be small (13). However, PCVC was limited in this study and 22 ECG variabilities were analyzed, which may have decreased specificity. Moreover, in this study, QTc intervals were not considered. In our study, QTc prolongation predicted PCVCs. None of the patients used any medication before inclusion that may have affected QT interval. Furthermore, the prophylactic cephalosporin antibiotics used in the present study do not have any reported effect on QT interval.

ASA score is a reliable assessment of physical status of an individual before the surgical procedure, and is accepted as a simple and effective tool to predict surgical short- and long-term outcomes. Higher ASA scores indicate significant perioperative morbidity. We found significant correlation between ASA grade and PCVCs, as expected. Severe systemic disturbances (ASA grade 3) and extreme systemic disorders that have already become an eminent threat to life (ASA grade 4) may be the cause of abnormal ECGs, especially altered QT interval. Moreover, Yeoh et al (14) concluded that higher ASA grade was associated with delay in surgery, longer hospital stay and higher 30-day mortality in elderly patients with femoral neck fracture.

Perioperative AF is an independent predictor of worse early and late outcomes after coronary artery bypass surgery. It also increases the risk for ischemic stroke after noncardiac surgery (15). Pace-induced mechanical dyssynchrony is an important factor that affects cardiac output. Paced ECG complicates the probable diagnosis of cardiac arrhythmias. Moreover, pacemaker malfunction not clearly diagnosed on ECGs can impair effective cardiac functions. Ventricular strain pattern on ECG is associated with stroke, heart failure development and myocardial infarction in large population studies. Strain pattern is accepted as electrocardiographic biomarker and its presence is suggested to guide management of individual patients (16).

Prolongated QTc interval is a significant predictor of cardiac-related deaths. In the general population, it is related to increased 10-year ischemic heart disease risk and sudden cardiac death risk (17-20). Hanci et al (21) reported that in patients with prolongated QTc interval, more arrhythmia was observed during anesthesia and postoperatively. The present study has shown that in patients who underwent nonvascular surgery, preoperative prolongated QTc interval was related to perioperative cardiovascular complications independent of all other factors.

TABLE 2
Predictive value of QTc interval

	QTc, ms		
	<426.45	≥426.45	P
Perioperative cardiovascular complications			
Cardiac death	5	12	0.001
Nonfatal cardiac arrest	2	3	0.001
Pulmonary embolism	1	2	0.001
Acute coronary syndrome	2	3	0.001
Stroke	1	4	0.001
Acute cardiac failure	4	9	0.001
Severe arrhythmia	13	6	0.001
Deep vein thrombosis	5	7	0.13
Fracture type			
A2.1	51	37	0.06
A2.2	111	69	0.06
A2.3	75	49	0.07
A3.1	11	5	0.16
A3.2	3	4	0.23
A3.3	6	1	0.39
American Society of Anesthesiologists score			
2	36	16	0.06
3	129	84	0.07
4	92	65	0.06
Abnormal electrocardiogram	46	87	0.001
Perioperative cardiac risk factors			
1	92	73	0.08
2	91	40	0.04
≥3	15	10	0.02

Data presented as n unless otherwise indicated. QTc Correct QT interval

Limitations

Our study was based on the data derived from only one medical centre. Patients were evaluated retrospectively from archived data. In the study, only in-hospital complications were considered. Early and later findings outside of the hospital were not included. There is a need for a prospective study where long-term follow-up is conducted on a larger group of patients.

CONCLUSION

ECG changes and, in particular, the QTc interval, before hip fracture surgery has been determined to be closely linked to PCVCs. Moreover, these ECG findings may change the ASA score, which is a predictor of all possible complications. QTc derived from preoperative ECG has additional benefits in predicting risk of complications in elderly patients with hip fracture. Such patients with prolongated QTc interval may benefit from monitoring for perioperative problems by a multidisciplinary team consisting of an orthopedist, anesthesiologist, geriatrician and cardiologist.

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