ORIGINAL ARTICLE

ECG ABNORMALITIES IN PATIENTS WITH CHRONIC KIDNEY DISEASE

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Background: Chronic kidney disease (CKD) is associated with increased risk of cardiovascular disease. Electrocardiographic (ECG) abnormalities are common in CKD patients. However, there is variation in literature regarding frequency of ECG abnormalities in CKD patients and limited information in local population. **Methods:** The study design was cross-sectional in nature. All patients between ages of 20–80 years with CKD not previously on renal replacement therapy who were admitted to nephrology ward at a tertiary care facility over a 6-month period were included. All patients underwent 12 lead electrocardiograms (ECG). ECG abnormalities were defined based on accepted standard criteria. **Results:** Total number of patients included in the study was 124. Mean age of all patients was 49.9±13.8 years, 106 (84.8%) had hypertension, 84 (70%) had diabetes mellitus, and 35 (29.9%) had known cardiovascular disease. Mean serum creatinine was 7.2±3.4 mg/dl, mean eGFR was 10.6±9.2 ml/min/1.73 m^2. Overall 78.4% of all CKD patients have one or more ECG abnormality. Left ventricular hypertrophy (40%), Q waves (27.2%), ST segment elevation or depression (23.4%), prolonged QRS duration (19.2%), tachycardia (17.6%) and left and right atrial enlargement (17.6%) were the most common abnormalities. **Conclusion:** ECG abnormalities are common in hospitalized CKD patients in local population. All hospitalized CKD patients should undergo ECG to screen for cardiovascular disease.

Keywords: Chronic Kidney Disease; ECG abnormalities; Left ventricular hypertrophy
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INTRODUCTION

Chronic kidney disease (CKD) is an established major public health problem. Prevalence of CKD has been found to be 12.5–16.6% in Pakistan.[1,2] A strong association exists between CKD and increased morbidity, mortality and rate of hospitalization.[3] CKD is associated with increased risk of cardiovascular disease and mortality.[4] Multiple risk factors are present in patients with CKD which confer an increased risk of cardiovascular disease.[5]

Despite development of modern technologies, electrocardiogram (ECG) remains an essential tool for evaluation of cardiovascular disease. ECG is important in detection of cardiac rhythm abnormalities, cardiac conduction defects and detection of myocardial ischemia.[6] Resting ECG abnormalities are common in patients with CKD and they independently predict future cardiovascular events.[7,8] However, there is wide variation in reported prevalence of various ECG abnormalities in different studies.[8–15] Left ventricular hypertrophy (LVH) has been found in 27.6–83% percent of CKD population.[10–14] Similarly prolonged corrected QT interval (QTc) was found in 16.9–66%.[8,9], right bundle branch block (RBBB) in 2.2–12.8%, left bundle branch block (LBBB) in 6.0–9.6%[8,12] and left atrial enlargement in 21.6–30% of CKD patients in different studies[10,14].

There is limited information regarding frequency of ECG changes in local CKD population. Patients with CKD in Pakistan seek medical advice at a much later stage due of lack of awareness, education, medical facilities and financial constraints.[16] Therefore; frequency of ECG abnormalities in CKD patients in Pakistan may differ from reported literature.

The aim of this study is to determine frequency of various ECG abnormalities in patients with CKD presenting to a tertiary care facility

MATERIAL AND METHODS

The study design was cross-sectional in nature. All patients between ages of 20–80 years known or newly diagnosed CKD excluding patients on haemodialysis or peritoneal dialysis, who were admitted to nephrology ward at Sharif Medical City Hospital, Lahore, were included. Study was conducted over a 6-month period from April–September 2015. Patients were excluded if they had an implantable pacemaker in place or if they have severe hyperkalaemia (serum potassium >6.0 meq/L), severe hypokalaemia (serum potassium <3.0 meq/L) and hypocalcaemia (correct serum calcium <8.0 mg/dl). Informed consent was obtained from all participating patients. Sampling technique was non-probability consecutive sampling. Sample size of 100 was calculated with 95% confidence level, 10% margin of error and taking expected percentage of CKD patients with electrocardiographic abnormalities as roughly 50%.[8–15] Institutional ethics and research committee approved the study.

Patient was considered to have CKD if estimated GFR (eGFR) was less than <60 ml/min/1.73m^2 or if there was persistent proteinuria for

3 or more months.[17] EGFR was calculated by CKD-EPI formula.[18]

Patient's history, medical records and laboratory information were reviewed to obtain data on patient's age, sex, history of diabetes mellitus, hypertension, duration of hypertension and diabetes mellitus cardiovascular disease, heart rate, blood pressure, serum creatinine, eGFR and urine protein to creatinine ratio. Patient was considered to have cardiovascular disease if history or review of prior medical records revealed that patient has known prior history of cerebrovascular disease, coronary artery disease or peripheral vascular disease.

All patients underwent 12 lead electrocardiograms (ECG) at the time of admission. Subsequent ECGs if done were not analysed for study purpose. ECG was interpreted by a qualified physician trained in interpretation of ECG abnormalities. ECG abnormalities were defined based on accepted standard criteria.[19–21]

PR interval was considered to be prolonged if it was above 200 msec. Thresh hold criterial for prolonged QRS duration was above 100 msec. Corrected QT interval (QTc) was calculated by using following formula: QTc=QT interval divided by square root of RR interval (in seconds). QTc was considered prolonged if it was above 446msec in females and 444 msec in males. Tachycardia was defined as heart rate above 100 beats/min and bradycardia was defined as heart rate less than 60 beats/min respectively. Right axis was defined as presence of negative QRS deflection in lead I and positive QRS deflection in lead aVF. Left axis was defined as presence of positive deflection of QRS complex in lead I and negative deflection in lead II. ST segment depression was considered to be present if there was down word or horizontal sloping of ST segment greater than 0.05 mV below baseline measured at 0.08 second after J point in two contiguous leads.

ST segment elevation was considered to be present if ST segment elevation was present by equal or greater than 0.1 mV and by equal or greater than 0.2 mV in leads V2 and V3, measured at the J point. Q wave was considered to be present if there was any Q-wave in leads V2–V3 equal or more than 0.02 s or Q-wave equal or more than 0.03 s in other leads. Skolow-Lyon indices were used to establish left ventricular hypertrophy.[18] Right ventricular hypertrophy (RVH), left and right atrial enlargement, left and right bundle branch blocks and bifascicular blocks were identified using accepted standard criteria.[20]

Mean±standard deviation was used to express continuous parametric variables. Categorical variables were expressed as percentages. All statistical analyses were performed using SPSS-20.

RESULTS

Total number of patients included in the study was 124. Mean age of patients was 49.9±13.8 years. Of these patients, 72 (58.1%) were males, 106 (84.8%) had hypertension, 84 (70%) had diabetes mellitus, 32 (26.7%) were smokers, 22 (18.3%) had dyslipidaemia and 35 (29.9%) had known cardiovascular disease. Mean serum creatinine was 7.2±3.4 mg/dl, mean eGFR was 10.6±9.2 ml/min/1.73m^2 and mean urine protein to creatinine ratio was 3.8±3.9. Of all patients 85.7% had stage V CKD, 7.6% had stage IV CKD and 5.9% had stage III CKD. Mean duration of CKD of 2.5±6 months. Overall 78.4% of all CKD patients have one or more ECG abnormality. Mean heart rate and various intervals including PR interval, QRS duration and corrected QT intervals are shown in table-1.

Table-2 depicts percentage of patients with tachycardia, bradycardia prolonged PR interval, QRS duration and corrected QT interval. Prolonged QRS duration was the most common prolonged interval, found in 19.2% of all patients with CKD. Proportion of patients with abnormal findings on ECG is shown in table-3. Left ventricular hypertrophy was the most common abnormal finding found in 40.8% of all patients. ECG findings suggestive of old infarction and ischemia were found in 27.2% and 23.4% of all patients respectively.

Table-1: Average heart rate, PR, QRS and corrected QT interval in patients with CKD

Rate and intervals on ECG	Values
Mean heart rate (beats/min)	91.8±18.3
Mean PR interval (ms)	137.9±22.3
Mean QRS duration (ms)	93.4±22.2
Mean corrected QT interval (ms)	400.1±57.9

Table-2: CKD patients with abnormal heart rate or intervals

Abnormal rate or intervals	Proportion
Patients with tachycardia (HR > 100/min)	22 (17.6%)
Patients with bradycardia (HR<60/min)	0
Patients with prolonged PR interval	0
Patients with prolonged QRS duration	24 (19.2%)
Patients with prolonged QTc interval	10 (8%)

Table-3: CKD patients with abnormal findings on ECG

Abnormal findings on ECG	Proportion
Rhythms other than sinus	1 (0.8%)
Right axis deviation	18 (14.4%)
Left axis deviation	14 (10.4%)
ST segment depression or elevation	29 (23.4%)
Q waves	34 (27.2%)
Left ventricular hypertrophy	51 (40.8%)
Right ventricular hypertrophy	17 (13.6%)
Left atrial enlargement	22 (17.6%)
Right atrial enlargement	22 (17.6%)
Right bundle branch block	16 (12.8%)
Left bundle branch block	12 (9.6%)
Bifascicular block	1 (0.8%)
Premature atrial beats	6 (4.8%)
Premature ventricular beats	19 (15.2%)

DISCUSSION

Our study showed that ECG abnormalities are common in local CKD population with LVH being the most common ECG abnormality.

At least one ECG abnormality was noticed in 78.4% of all CKD patients. In other studies, abnormal ECG findings were noticed in 50–86% of all patients.[11,14] LVH was found in 40.8% of our patient population. Our study results are consistent with Bignotto *et al*[11] and Stewart *et al*[13]. However, in a study by Chijiokie *et al*. LVH was found in 27.6% of all patients.[14] Other studies have shown a much higher prevalence of LVH (66–83%) in CKD patients.[10,12] However, the later study showing significantly higher prevalence of LVH was done in haemodialysis patients. Our study population entirely comprised of pre-dialysis CKD patients. Finding of LVH on ECG is significant as it is independently associated with adverse cardiovascular outcomes.[22] Left atrial enlargement was found in 17.6% of our patients compared to other studies which have reported a frequency of 21.6–30%.[10,14]

In our study, frequency of RBBB and LBBB was found to be 12.8% and 9.6% respectively. Our results are consistent with Nwanko *et al* which showed a frequency of 15.1% and 10.1% respectively.[12] Kestenbaum B *et al*. found a lower frequency of RBBB as 2.2% and LBBB as 6.0%.[8] Presence of Q waves and ST segment deviation were found in 23.4% and 27.2% in our study similar to frequency of myocardial ischemia/infarction as 28% in another study.[10]

Widening of QRS complex was found in 19.2% of our patients. Prolonged QTc was found in only 8% of our patients. Other studies have reported a significantly higher frequency of prolonged QTc ranging from 16.9% to roughly 2/3rd of CKD patients.[8,9] Reason for lower frequency of prolonged QTc in our patient population is not clear but it may be due to difference in patient population, relatively younger age, exclusion of patients with electrolyte abnormalities and infrequent use of medications associated with prolonged QT interval in our patient population.

ECG abnormalities in CKD patients have been found to independently predict cardiovascular event and mortality.[7,8] CKD patients with ECG abnormalities may benefit from close follow up and consultation with cardiologist to help reduce cardiovascular event or mortality.

Our study has several limitations including relative small sample size, single centre and cross-sectional study design. In addition, our study was conducted in hospital setting with large proportion of patients with advanced CKD. This may have resulted in over-estimation of frequency of ECG abnormalities in CKD patients. However, our study population's characteristics are reflective of patient's profiles in tertiary care facilities in Pakistan.

CONCLUSION

In summary, our study shows that resting ECG abnormalities are common in CKD patients who were hospitalized. LVH is the most common electrocardiographic abnormality. All hospitalized CKD patients should undergo ECG to detect any abnormal findings. Further studies are needed to see whether abnormal ECG findings predict cardiovascular events or mortality in our patient population.

AUTHORS' CONTRIBUTION

STS: Study design, literature review, statistical analysis, manuscript writing. MS, RA, WA: Data collection, interpretation, literature review TS: Manuscript writing and review

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