



Electrocardiographic Abnormalities of Acute Pneumonia and Bronchiolitis in Children

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Background: This prospective study was performed to determine the frequency and characteristics of electrocardiographic abnormalities in pneumonia and bronchiolitis.

Patients and method: Study included 48 children (27 male) with a mean age of 25.8 months (2-168), who were admitted due to pneumonia and bronchiolitis.

Results: The most common changes on electrocardiography were prolongation in QTc interval (89.3%), rightward deviation of QRS axis (85.4%), enhance in right ventricular forces (70.5%), tachycardia (64.5%), elevation in P voltage (54.1%), and suppression in T voltage (52.1%). Three patients had right axis deviation (according to age), three patients had p pulmonale (p voltage >2.5 mm) and 12 patients had QTc prolongation (QTc >440 ms) on their first electrocardiographies. Rightward deviation in QRS axis, increase in P wave voltage and elevation of V1R/S ratio were more common in infants with pneumonia compared to those with bronchiolitis.

Conclusion: Electrocardiographic abnormalities are common but completely reversible in respiratory tract infections. While evaluating cardiovascular status of a child with respiratory disease, it is advisable to reinterpret the electrocardiography after recovery.

Key Words: Bronchiolitis, Child, Electrocardiography, Infection, Pneumonia

Akut Pnömoni ve Bronşiyolitli Çocuklarda Elektrokardiyografik Anormallikler

Amaç: Bu prospektif çalışmada; pnömoni ve bronşiyolitli çocuklarda elektrokardiyografik değişikliklerin sıklık ve özelliklerini araştırmayı amaçladık.

Hastalar ve yöntem: Çalışmaya ortalama yaşları 25.8 ay (2-168) olan 48 alt solunum yolu enfeksiyonlu çocuk (27 erkek) dahil edildi.

Bulgular: Elektrokardiyografideki en yaygın değişiklikler; QTc intervalinde uzama (%89.3), QRS aksında sağa kayma (%85.4), sağ ventrikül güçlerinde artış (%70.5), taşikardi (%64.5), P voltajında artma (%54.1) ve T supresyonu (%52.1) idi. Üç hastada sağ aks deviasyonu, üç hastada p pulmonale ve 12 hastada da QTc'de uzama gözlemlendi. QRS aksında sağa sapma, p pulmonale ve V1R/S oranında artış pnömonili çocuklarda bronşiyolitli olanlara göre daha fazla oranda saptandı.

Sonuç: Elektrokardiyografik değişikliklerin çocukluk çağı alt solunum yolu enfeksiyonlarında yaygın ancak tamamen geri dönüşümlü olduğunu gösterdik. Akut alt solunum yolu enfeksiyonlu çocuklarda kardiyak bulguları değerlendirirken, enfeksiyon düzeldikten sonraki elektrokardiyografi ile karşılaştırılması uygun olacaktır.

Anahtar Kelimeler: Bronşiyolit, Çocuk, Elektrokardiyografi, Enfeksiyon, Pnömoni

It is not uncommon to detect cardiovascular disturbances during respiratory tract infections. Many hospitalized children with respiratory tract infection are consulted for cardiac evaluation because of tachycardia and/or cardiac murmur which are generally exaggerated by infection and/or fever.

In those patients, electrocardiography (ECG), which is done as a first step to evaluate the cardiovascular status, usually shows some abnormal findings leading to consideration of a concomitant heart disease.

Performing echocardiography is usually difficult in

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infants, especially in patients with respiratory tract infection. This observation suggested us the need for electrocardiographic study during two common respiratory tract infections, pneumonia and bronchiolitis. This prospective study aimed to determine the frequency and characteristics of ECG changes in the course of pneumonia and bronchiolitis and to compare their ECG findings.

PATIENTS AND METHODS

We prospectively evaluated children presented with clinical signs and symptoms of pneumonia or bronchiolitis requiring hospitalization. Written informed consent was obtained from all parents.

Patients with any documented underlying disease such as malnutrition, cardiorespiratory illness, recurrent respiratory disorders, and children who had been ill for more than 1 week were excluded.

None of the patients was on medications or had a medical condition that could affect the ECG findings. Patients were classified as pneumonia or bronchiolitis, according to the history, physical, laboratory, and chest x-ray findings. The decision to design the therapy was made based on the clinical guidelines for the treatment of pneumonia and bronchiolitis, and was made independent of the study. The age, gender, medical history, medications, and body weight of each patient were documented as well as the vital signs. Blood samples were drawn for complete blood count, complete metabolic panel, blood gas, creatinine kinase MB fraction (CK-MB), lactic dehydrogenase level, and blood culture. In addition, chest x-ray and ECG were obtained in all patients on admission. All of the ECG results were obtained using a Nikon Kohdon Cardiofax V ECG 9320 K machine.

The same machine was employed for subsequent measurements, and the position of the electrodes was marked on the patients' chest walls using an indelible pen. Dipolar, unipolar and precordial leads were analyzed. Rhythm, heart rate, atrial and ventricular hypertrophy, QRS axis, intraventricular conduction, and ventricular repolarization were evaluated.

All the ECG complexes and intervals were measured manually. P and T wave voltages, QRS complex voltages, and QTc intervals were measured on derivation II, QRS interval was measured on derivation V5. The QT interval was corrected for heart rate using Bazett's Formula. The values were presented as mean \pm standard deviation. The 12 lead ECG was repeated at the end of the hospitalization. Finally, all the first and second electrocardiographic findings of every patient were compared.

The difference between the first and second ECG values in the same patient was thought to be the effect of respiratory tract infection on cardiovascular status. Echocardiography was performed on 16 of 18 patients who had physical findings suggesting congestive heart failure. Echocardiographic studies were done using a Toshiba Powervision 6000 echocardiograph with 3.75 and 5 MHz transducers. Left ventricular systolic and diastolic diameters, shortening and ejection fractions, right ventricular diastolic diameters were measured. Systolic pulmonary artery pressure was measured non-invasively using Doppler flow velocity by measuring peak regurgitant velocity in patients with tricuspid incompetence and adding estimated right atrial pressure to the tricuspid gradient.

Statistical analysis were performed Statistical Package for the Social Science Program (SPSS) for Windows version 13.0 program. Continuous variables were reported as mean \pm standard deviation. Normality for continuous variables in groups was determined by the Shapiro Wilk test. The variables did not show normal distribution ($p < 0.05$). So, Wilcoxon signed ranks test was used for comparison of variables between the first and second values. Chi-square test was used categorical variables. Any p value < 0.05 was considered to be statistically significant.

RESULTS

The study enrolled 48 patients (27 males, 21 females) with acute respiratory tract infection, aged 2-168 months (mean 25.8 months). Pneumonia was diagnosed in 32 (66.6%) patients and the diagnosis of acute bronchiolitis was made in 16 (33.3%) patients. Three groups were formed according to the age and clinical diagnosis. Group I is composed of patients with pneumonia under 24 months old, Group II compromised patients with bronchiolitis under 24 months old and, Group III compromised patients with pneumonia older than 24 months. Thirty-nine patients were under two years of age; 23 of them had pneumonia (Group I), and the remaining 16 had bronchiolitis (Group II). All patients who were older than two years ($n=9$) had pneumonia (Group III). The mean hospitalization stay was 9.1 days (2-53 days).

All patients recovered at the end of the hospitalization and there was no death. Anemia was observed in 17 patients (35.4%), leucocytosis in 18 (37.5%), elevated sedimentation rate in 37 (77.1%), elevated C-reactive protein in 34 (70.8%), elevated CK-MB level in 28 (58.3%) (159 ± 237 U/L; min: 30; max: 1045) (normal < 28 U/L), and acidosis in 8 (16.7%) patients. Twenty-three patients had a reduced oxyhemoglobin saturation ($81 \pm 10\%$; min: 43%; max: 91%) (normal $> 92\%$) that was ascertained by blood gases and by pulse oximetry in 6 patients. There were no electrolyte disturbances. All but three of the blood cultures were negative; blood culture revealed coagulase negative staphylococci in two children, and pneumococcus in one child. The ECG findings performed on admission and at recovery of the same patient were compared. The most common changes were prolongation in QTc interval observed in 89.3% of the patients, rightward deviation of QRS axis in 85.4%, elevation in right ventricular forces in 70.5%, sinus tachycardia in 64.5%, followed by increase in P wave voltage in 54.1% and T wave voltage suppression in 52.1% on the first ECGs (Table 1).

Other changes included sinus arrhythmia ($n=3$) and ventricular extra systoles ($n=2$). Three patients had right

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axis deviation (according to age), three patients had p pulmonale (p voltage > 2.5 mm) and 12 patients had QTc prolongation (QTc > 440 ms) on their first ECGs. Table 2 compares the ECG changes of pneumonia and bronchiolitis.

The only difference between the first and last electrocardiograms of Group III was prolongation in QTc interval. Group I patients had the same differences as the general patient population except T wave suppression. Patients with bronchiolitis had prolongation in QTc interval, rightward deviation of QRS axis, and suppression of T voltage on their first electrocardiograms.

All the ECG changes were reversible and all survivors had a normal ECG on discharge from hospital. All 16 patients who had echocardiographic imaging had normal values of left ventricular ejection fraction and fractional shortening (70.6±6.2 and 36.3±4.2 respectively). Left ventricular diastolic diameters were in normal limits; right ventricular diastolic diameter was elevated in 13 patients. Pulmonary artery systolic pressure was measured in 13 of 16 patients, 12 of them had pulmonary hypertension (mean systolic pressure 47±7.5 mmHg).

DISCUSSION

Although ECG changes in acute respiratory tract infections have been described in adults, they have been rarely reported in children with pneumonia; furthermore there is no data in children with bronchiolitis.¹⁻⁸ Clockwise rotation, p pulmonale, right axis deviation, depression of ST segment, T wave inversion, right bundle branch block and rhythm disorders have been reported in adult patients with pneumonia.^{1-5,6} ECG abnormalities observed in adults mainly included features of acute cor pulmonale and ST-T wave changes compatible with myocardial ischemia.¹

The present study suggests that ECG changes in children with acute community-acquired pneumonia and bronchiolitis are more frequent than adults, at least one change in ECG parameters occurred in all children. In a study performed on adult patients with pneumonia, electrocardiographic changes occurred in 31% of patients.¹ The most common abnormalities were prolongation in QTc interval, rightward deviation of QRS axis, and increase in V1R/S ratio. Other changes included tachycardia, increase in P wave voltage and T wave suppression. We observed that these changes generally reflected characteristics of acute cor pulmonale as previously reported in adults.^{1,2}

Rightward deviation of QRS axis, elevation in right ventricular forces, and increase in P wave voltage seen in this study seem to reflect right ventricular strain secondary to acute pulmonary hypertension (PHT). It is well known that disorders that affect either the structure or the function of the lungs will result in cardiac (right ventricle) hypertrophy or dilation. However, in acute pneumonia or in bronchiolitis right ventricular overload develops rapidly, the ventricle dilates and fails without time for compensatory hypertrophy to occur.⁹

The main cause of acute PHT is hypoxia that leads pulmonary vasoconstriction.¹⁰⁻¹² PHT increases the wall stress of right ventricle, results in a greater demand for coronary blood flow which is generally reduced because of inadequate diastole.^{13,14} Subendocardial ischemia and right ventricular failure will develop as a result of inadequate perfusion pressure.^{13,14} Almost half of our patients had hypoxia and among 13 patients whose pulmonary artery pressures were measured by echocardiography, 12 had PHT. These findings suggest that ECG changes compatible with right heart disease are mainly secondary to acute PHT.

Prolongation in QTc interval, a predictor of myocardial damage, was observed in 89% of our patients. T wave voltage suppression which we observed in 52 % of our

Table 1. Mean values* of the ECG findings at admission and after recovery.

| ECG | at admission | after recovery | p |
|---------------------|--------------|----------------|--------|
| HR (beat/min) | 150,5±29,26 | 140,9±33,63 | 0,048 |
| QRS axis | 72,89±36,59 | 55,68±31,06 | 0,0001 |
| P voltage (mm) | 1,725±0,80 | 1,35±0,50 | 0,01 |
| QRS voltage (mm) | 13,08±5,19 | 13,62±5,80 | >0,05 |
| QTc interval (msec) | 428,4±35,29 | 393,6±30,81 | 0,0001 |
| T voltage (mm) | 2,283±1,24 | 2,865±1,62 | 0,001 |
| QRS duration (msec) | 52,0±11,92 | 53,17±12,53 | >0,05 |
| V1 R/S | 2,591±2,81 | 1,795±2,07 | 0,027 |
| V6 R/S | 6,864±5,96 | 6,592±4,22 | >0,05 |

*Values are presented as mean±standard deviation; ECG, electrocardiography; HR, heart rate.

patients may be a sign of subendocardial ischemia or myocarditis. QTc prolongation together with T wave voltage suppression may be a result of subclinical myocarditis or hypoxia/ischemia induced myocardial disease. Arrhythmia, another sign of myocarditis, was observed only in two patients as isolated ventricular extrasystoles. We measured CK-MB levels in order to detect possible myocardial cell damage and found that 58% of our patients had elevated CK-MB level. The exact mechanism of myocardial injury in these patients is not understood, it may be due to the direct toxic effect of the organism, mediator damage as part of immune-mediated injury, or hypoxia which has a direct myocardial depressant effect.¹⁵⁻¹⁹ Indirectly, myocardial ischemia occurs secondary to hypoxia induced vasoconstrictive PHT and increased right ventricular afterload.^{20,21} In the present study, none of the 16 patients with congestive heart failure had left ventricular dilation or systolic dysfunction in echocardiographic evaluation.

Thus, global myocardial depression secondary to hypoxia/ischemia or myocarditis are unlikely mechanisms. Ilten et al. found high CK-MB levels in 68 % of children with pneumonia and they suggested that high CK-MB levels could be the only sign of subclinical myocarditis despite the lack of electrocardiographic and echocardiographic changes.⁷ On the contrary, in a study revealing pathological examination of myocardium which is the gold standard in the diagnosis of myocarditis, histologic evidence of myocarditis was found in only 5 of 71 fatal cases of pneumonia in children.¹⁷ In our patients, it is obvious that there was no overt myocarditis but we still can not exclude subclinical myocarditis. We found PHT in 12 of 13 patients and right ventricular dilation in 13 of 16 patients who had echocardiographic evaluation. These findings suggest that elevated CK-MB levels in these patients are mainly right ventricular in origin, and hypoxic-ischemic injury seems to be the reason rather than direct myocardial damage. Shann et al. studied cardiac failure in children with pneumonia and showed

that myocardial depression from sepsis is not an important factor in the development of heart failure, but right ventricular failure is common and is mainly secondary to PHT.¹⁶ In summary, electrocardiographic changes compatible with myocardial damage in patients with pneumonia seems to be multifactorial and needs further evaluation. When we interpret the ECG changes in different groups; the only abnormality we observed in Group III was prolongation in QTc interval. In patients with pneumonia and bronchiolitis under 2 years, prolongation in QTc interval was more common than in patients with pneumonia older than 2 years ($p<0,0001$, $p<0,002$, and $p=0,022$, respectively).

This is probably the result of an age dependency of the degree of vascular constrictive response to hypoxia which is more profound in infants than in adults.^{10,13} In addition, there were only two patients with hypoxia in Group III. Patients in this group had no ECG findings related to pulmonary right heart disease. We did not observe ST, T changes and arrhythmia, which occur in adults with pneumonia, in this group. This may be a result of underlying chronic vascular disorders in adults. We conclude that the cardiovascular system suffers less in acute respiratory infections in children older than 2 years.

Electrocardiographic changes have been documented in patients with acute asthmatic attacks but there is no study performed in children with bronchiolitis.^{22,23} In obstructive lung disorders, hypoxemia develops mainly as a result of mismatching between alveolar ventilation and pulmonary capillary blood flow. We detected hypoxia in 50% of infants with bronchiolitis on admission. Rightward QRS axis deviation, increased P wave voltage, and elevation of V1R/S ratio were more demonstrable in infants with pneumonia than in infants with bronchiolitis. This finding suggests that the right ventricle is much more affected in pneumonia rather than in bronchiolitis. On the other hand, T wave voltage suppression was only observed significantly in infants with bronchiolitis, and 81 % of patients in this

Table 2. P values of ECG parameters taken at admission and after clinical recovery according to the groups.

| ECG | Group I | Group II | Group III |
|--------------|---------|----------|-----------|
| HR | 0,004 | 0,8 | 0,186 |
| QRS axis | 0,0001 | 0,04 | 0,083 |
| P voltage | 0,0001 | 0,256 | 0,445 |
| QRS voltage | 0,436 | 0,052 | 0,290 |
| QTc | 0,0001 | 0,002 | 0,022 |
| T voltage | 0,144 | 0,004 | 0,278 |
| QRS duration | 0,116 | 0,774 | 0,179 |
| V1 R/S | 0,011 | 0,421 | 0,539 |
| V6 R/S | 0,883 | 0,198 | 0,378 |

ECG, electrocardiography; HR, heart rate; Group I, patients with pneumonia under 24 months olds; Group II, patients with bronchiolitis under 24 months olds; Group III, patients with pneumonia older than 24 months old.

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group had increased CK-MB levels. We can conclude that T wave voltage suppression in bronchiolitis is not a component of right ventricle disease; on the contrary it may be due to direct viral damage of myocardium. While interpreting ECG in patients with bronchiolitis, it must be kept in mind that, hyperinflated lungs may alter the electrical conductance, thus decreasing voltage and potentially limiting the interpretation of ECG²²⁻²⁴

CONCLUSIONS

Transient, non-specific ventricular repolarization disturbances together with ECG changes related to acute cor pulmonale were the most commonly observed abnormalities seen in children with acute pneumonia and bronchiolitis. The electrocardiographic changes were completely reversible and no further cardiac evaluation was needed except in patients with cardiopulmonary compromise. If a concomitant heart disease is suspected, it is advisable to evaluate the patients ECG after the respiratory infection has resolved. This approach will reduce the number of unnecessary echocardiographic evaluation.

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