A study on effects of repeated salbutamol nebulizations on serum potassium levels and QTc on electrocardiogram in children with acute wheeze

Gitanjali Jain[1], Gautam Kumar Vasnik[2], Ankur Rawat[3]

From [1]Assist Professor, [3]Clinical Tutor, Department of Pediatrics, Armed Forces Medical College, Pune, Maharashtra, [2]Pathologist, Department of Pathology, Military Hospital, Nasirabad, Rajasthan, India

Correspondence to: Dr. Gautam Kumar Vasnik, Department of Pathology, Military Hospital, Nasirabad, Rajasthan. E-mail: gautam_vasnik@yahoo.co.in

Received - 26 October 2018 Initial Review - 22 November 2018 Accepted - 27 November 2018

ABSTRACT

Objective: Acute wheeze is a common problem in young children with respiratory disorders. This study emphasizes on whether there are any significant changes in serum potassium levels and QTc interval during repeated salbutamol nebulizations. **Methods:** A cross-sectional observational study was conducted at a tertiary care teaching hospital. The study group comprised of 41 children in the age group of 6 months–12 years. Pediatric asthma score and vital parameters (heart rate, respiratory rate, and SpO_2) were recorded at the onset and end of salbutamol nebulizations. Baseline serum potassium levels were taken at the onset and then at the end. An electrocardiogram (ECG) was taken at 1 h and another at 3 h, for those who continued to require repeated nebulizations until then. **Results:** The mean fall in serum potassium levels after repeated salbutamol nebulizations was 0.3±0.4 ($p<0.05$). The mean fall after 3, 4, 5, and 6 salbutamol nebulizations was 0.06, 0.44, 0.66, and 0.43 mEq/L, respectively. There were no significant changes in ECG patterns in these children. The mean QTc at 1 h of repeated salbutamol nebulizations was 0.41±0.02 (s) and that after 3 h (for children requiring repeated nebulizations until then) was 0.43±0.01 (s). The mean rise in QTc at 3 h was 0.004 s, which was not statistically significant ($p=0.137$). **Conclusion:** We conclude that serum potassium levels should be monitored in children receiving repeated salbutamol nebulizations for acute wheeze.

Key words: *Acute wheeze, Nebulizations, Potassium, Salbutamol*

Acute wheeze is a common problem in young children. Population studies have shown that approximately one in three children has at least one episode of wheezing by 3 years of age, and the overall prevalence of wheeze is about 50% at the age of 6 years [1-3]. Many cohort studies have been done to study the prevalence of wheeze in children. These studies show a great degree of variation and indicate that up to 10–80.3% of infants suffer at least one episode of wheezing during their 1st year of life, while 8–43.1% have three or more episodes, with lower prevalence rates in developed countries [4]. One-half of children who wheeze early in life cease to do so by 6 years of age. However, there are a few patients in which the symptoms continue. Appropriate identification of children at risk of developing asthma or future wheezing episodes and apt preventive medications can improve long-term outcomes, but the possibility to identify these children at preschool age remains limited [5].

Inhaled salbutamol is the most commonly used drugs for the management of acute wheeze. It can be given both by nebulizer and a metered dose inhaler. In cases of severe acute wheeze, continuous/repeated salbutamol nebulizations are sometimes required. The efficacy of repeated/continuous salbutamol nebulizations as compared to intermittent therapy has been established in children with severe acute wheeze [6]. The side effect such as hypokalemia, tachycardia, and possibility of cardiac arrhythmias after repeated/continuous salbutamol nebulizations is not well known. In general, these side effects are more marked when salbutamol is administered by oral or parenteral route [7].

A few studies have shown that nebulized salbutamol can induce symptomatic hypokalemia in adults and children at conventional doses [8-10]. Singhi *et al*. studied 46 children, of which hypokalemia (serum potassium<3.5 mEq/L) occurred in one-third of patients treated with three doses of salbutamol nebulizations, particularly in those who received prior treatment with oral salbutamol. The monitoring of serum potassium concentration was advised in such patients [11,12].

It is of clinical importance to explore this further since children with severe acute wheeze usually receive large doses of β2 agonists and also theophylline and steroid, which could further activate cAMP-dependent Na+/K+ ATPase and this might accentuate symptomatic hypokalemia [13]. Furthermore, children with an exacerbation of asthma often have viral infections that may cause vomiting and diarrhea, which can augment hypokalemia.

Beta2-agonists are also known to induce tachycardia and other electrocardiogram (ECG) changes. It has been seen that salbutamol can prolong QTc by 23±15 ms after three repeated nebulizations [14]. Another study demonstrated that a large

therapeutic single dose (600 mcg) of inhaled salbutamol has a profound effect on cardiovascular autonomic regulation in prepubertal children with bronchial asthma. It was seen that this dose of inhaled salbutamol markedly decreased beat to beat variability of RR interval [15]. However, the dose of inhaled salbutamol which can cause life-threatening arrhythmias, especially during repeated nebulizations and above which one should do careful cardiac monitoring is not yet established.

Keeping in view the requirement of repeated salbutamol nebulizations in a child with acute wheeze, this study was done to find whether there are any significant changes in serum potassium levels during this time so that recommendations regarding routine potassium supplementation (orally or intravenous) during this period can be made in future. Furthermore, secondary objective of the study was whether there are any significant ECG changes in the form of QTc prolongation during this therapy.

METHODS

This cross-sectional observational study was conducted from January 2015 to September 2016 at pediatric ward of a tertiary care teaching hospital. The study was cleared by the institutional ethics committee. A total of 41 children aged from 6 months to 12 years requiring repeated nebulizations (three or more) with salbutamol within a period of 1–2 h for acute wheeze were enrolled. Exclusion criteria were children with high risk for hypokalemia such as acute gastroenteritis, diabetic ketoacidosis, and Cushing syndrome and those on drugs such as diuretics, systemic steroids, and systemic β2-agonists.

Pediatric asthma score (PAS) was performed to assess the severity of wheeze and to decide management. Baseline vital parameters (heart rate, respiratory rate, and spO_2) were recorded. Children who had PAS of >3 were considered in this study as they would require repeated salbutamol nebulizations. The sample was collected for baseline serum potassium levels at the onset of nebulizations and dispatched to hospital laboratory. Then, the study population was given repeated salbutamol nebulizations at a dose of 0.15 mg/kg/nebulization as often as every 15–20 min as required depending on the clinical response (for maximum up to 4 h). Another blood sample for serum potassium level was taken at the end of repeated nebulizations within 1–2 h (before starting intermittent nebulizations).

Number and duration of repeated nebulizations were documented, and post-nebulizations vital parameters such as heart rate, respiratory rate, spO_2, and PAS were also documented. A 12-lead ECG was taken at the end of 1st h for all children and then at 3 h if the child continued to receive repeated nebulizations until then. We studied QTc on each ECG and a corrected Q-T interval was calculated using Fridericia's formula (observed QT interval in lead II divided by cube root of R-R interval in second). Statistical package used for the analysis was SPSS 23.

RESULTS

A total of 41 children aged from 6 months to 12 years presenting with acute wheeze and fitting into eligibility criteria were analyzed in the present study. The mean age of the study population was 3.1 years. Of the 41 cases, 58.5% were male and 41.5% were females.

Baseline clinical parameters of the children presenting with acute wheeze are shown in Table 1. The study population required 3–6 repeated nebulizations over 90–230 min on acute presentation before they were treated with intermittent nebulizations. The mean number of repeated nebulizations required was 3.9±1.0 over a mean period of 140.9±47.9 (min). Clinical parameters at the end of repeated salbutamol nebulizations are also shown in Table 1.

The difference in clinical parameters at the onset and at the end of repeated salbutamol nebulizations is depicted in Table 2. The mean difference in heart rate pre- and post-repeated

Table 1: Clinical parameters of the patients

Characteristic	Baseline clinical parameters	Clinical parameters at the end of repeated salbutamol nebulizations
	Mean±SD (range)	Mean±SD (range)
Heart rate (beats per min)	122.7±10.4 9 (102–144)	138.3±13.2 (114–168)
Respiratory rate (per min)	47.9±15.9 (24–75)	40.2±13.4 (20.0–65.0)
PAS	6.7±2.6 (4–15)	4.9±1.8 (3.0–9.0)

PAS: Pediatric asthma score

Table 2: Difference in clinical parameters at the onset and at the end of repeated salbutamol nebulizations

Parameters	Mean difference	SD	95% Confidence interval of the difference		p value
			Lower	Upper	
Pair 1					
Heart rate difference	−15.6	5.2	−17.2	−13.9	<0.0001
Pair 2					
Respiratory rate difference	7.7	4.0	6.5	9.0	<0.0001
Pair 3					
PAS difference	3.6	1.1	3.2	3.9	<0.0001

PAS: Pediatric asthma score

salbutamol nebulizations was −15.6±5.2 (negative value because post nebulization figure is higher, i.e., there is a significant rise in heart rate post-repeated nebulizations) ($p<0.05$, paired t-test). The mean change in respiratory rate was 7.7±4.0 (value is positive because post nebulization figure is lower; i.e., there is a significant fall in respiratory rate post-repeated nebulizations) ($p<0.05$, paired t-test). The mean change in PAS before and after repeated salbutamol nebulizations was 3.6±1.1 ($p<0.05$, paired t-test), i.e., there was a significant fall in the severity of wheeze post-repeated salbutamol nebulizations.

The mean serum potassium concentration before and after repeated salbutamol nebulizations was 4.3±0.5 and 4.0±0.5, respectively. The mean fall was 0.3±0.4 ($p<0.05$, paired test). The fall in mean serum potassium was not clinically significant; a fall in serum potassium was seen in 32 (78%) patients. However, none of the patients had severe hypokalemia (serum potassium levels <2.5 mEq/L) and only three patients had asymptomatic hypokalemia (serum potassium levels <3.5 mEq/L). Correlation of change in serum potassium levels with various parameters is depicted in Table 3.

As shown in Table 3, salbutamol-induced decrease in serum potassium concentration was significantly correlated to the number of nebulizations ($r=-0.49$, $p<0.05$; Fig. 1) and also duration of repeated nebulizations ($r=-0.52$, $p<0.05$; Fig. 2), i.e., as the number and duration of salbutamol nebulizations increased, negative change in serum potassium levels increased. Furthermore, more severe the episode of acute wheeze, i.e., more the PAS at the onset, greater was the change in serum potassium levels ($r=-0.43$, $p<0.05$) (probably because they required greater number and duration of repeated salbutamol nebulizations). Change in heart rate was also significantly correlated to change in serum potassium levels ($r=-0.37$, $p<0.05$). Age, however, had no bearing on change in potassium levels ($p=0.66$). The mean change after various number of repeated nebulizations is shown in Fig. 3.

The mean QTc at the end of 1 h and 3 h of repeated nebulizations was 0.41±0.02 s (ranged from 0.37 to 0.44 s) and 0.43±0.01 s (ranged from 0.42 to 0.44 s), respectively. The mean increase in QTc at 3 h was 0.004±0.01 (p value: 0.137, paired t-test). No correlation was found between change in QTc at 3 h of repeated nebulizations and number/duration of salbutamol nebulizations and change in heart rate or change in serum potassium levels. However, a significant correlation was found between the severity of acute wheeze at onset and change in QTc at 3 h ($r=0.564$, $p<0.05$) as shown in Table 4.

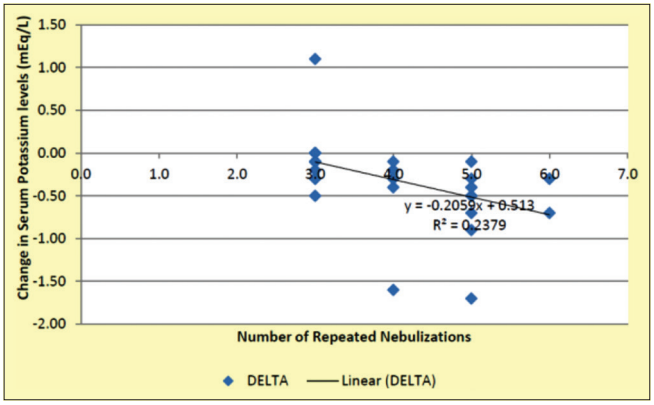

Figure 1: Correlation between change in serum potassium levels and number of nebulizations

DISCUSSION

We conducted this study because though children are offered repeated salbutamol nebulizations for acute wheeze, there are

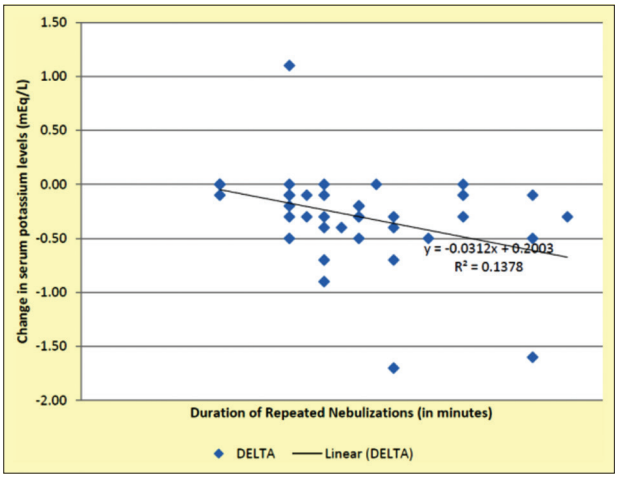

Figure 2: Correlation between change in serum potassium levels and duration of nebulizations

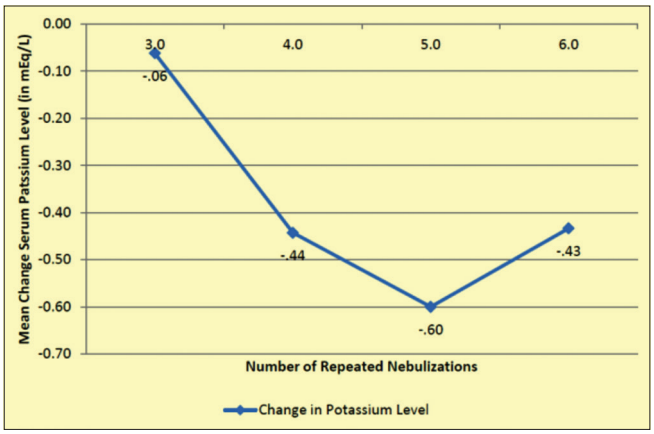

Figure 3: Variation in mean change in serum potassium levels with various number of nebulizations

Table 3: Correlation of change in serum potassium levels with various parameters

Parameters	Change in potassium level	
	Pearson correlation (r)	p value
Number of repeated nebulizations received	−0.49	0.001
Duration of repeated nebulizations (min)	−0.52	0.001
Change in heart rate	−0.37	0.017
Severity of acute wheeze (PAS at the onset)	−0.43	0.005
Age (years)	0.07	0.675

PAS: Pediatric asthma score

Table 4: Correlation of change in QTc (at 3 h) with various parameters

Parameters	Change in QTc	
	Pearson correlation (r)	p value
Number of repeated nebulizations received	0.19	0.545
Duration of repeated nebulizations (min)	0.16	0.598
Change in heart rate	−0.17	0.588
Change in serum potassium levels	0.15	0.636
Severity of acute wheeze (PAS at the onset)	0.56	0.045

PAS: Pediatric asthma score

only a few studies on change in serum potassium levels in them. Furthermore, most of the studies done in the past have studied children receiving up to three repeated salbutamol nebulizations, whereas many a times, children with acute wheeze require a larger number of repeated salbutamol nebulizations for the alleviation of symptoms [11,12]. In this study, the change in serum potassium levels was studied in children requiring repeated salbutamol nebulizations ranging from 3 to 6 over a period of up to 90–230 min. Furthermore, there are only a few studies on beta2-agonist-induced QTc prolongation on ECG in such children [16-18]. The severity of wheeze in these children was objectively assessed by doing a PAS at presentation [19].

In the demographic characteristics, the mean age of the study population was 3.1±3.0 (mean±SD) (years). Of the 41 children studied, 58.5% were boys and 41.5% were girls. The gender distribution and mean age in our study were slightly different from the one done by Singhi *et al*. [11] where they studied 46 children in the age group of 10 months–12 years, of which 41 (89%) were male and only 5 (11%) were females. The mean age of children in their study was 7.5±1.5 (mean±SD) (years). Hung *et a*l. [12] studied 17 children with acute asthma in the age group of 3–14 years, 12 (70.5%) were male and 5 (29.5%) were females. The mean age of children in their study was 7.82±2.90 (mean±SD) (years). Although, in our study, the number of male children presenting with acute wheeze was more as compared to females, the gender difference was less as compared to other studies [11,12].

It was seen that, at the end of repeated salbutamol nebulizations, there was a significant increase in mean heart rate (15.6±5.2, $p<0.05$). This increase in heart rate is probably due to cardiac sympathetic stimulation by salbutamol. Even though alleviation of respiratory symptoms with therapy may actually decrease endogenous cardiac sympathetic activity and reduce tachycardia, this effect is probably overpowered by sympathetic stimulation of the heart by the exogenously administered salbutamol, as was evident in our study. In the study done by Hung *et al*., there was no significant increase in heart rate after salbutamol nebulization. In their study, the mean baseline heart rate was 129.58±9.04, and after single dose of 0.125 mg/kg of nebulized salbutamol, the same was 130.16±8.27 ($p>0.05$) [12]. This is in contrast to our study and is probably due to the difference in protocol. However, in a retrospective study done by Phumeetham *et al*. in children who had used high-dose continuous salbutamol nebulization (75–150 mg/h), the increment in heart rate versus initial heart rate (%) was 12.6±10.8 which was statistically significant ($p<0.05$) [20]. Respiratory rate decreased significantly with a mean fall of 7.7±4.0, $p<0.05$, after therapeutic intervention with repeated salbutamol nebulizations. In the study done by Hung *et al*., fall in respiratory rate was 7.7±3.78, $p<0.01$. This was after a single dose of 0.125 mg/kg of nebulized salbutamol [12].

In our study, the mean serum potassium level at the onset of nebulizations and at the end of repeated nebulizations was 4.3±0.5 and 4.0±0.5, respectively. The mean fall in potassium level post-repeated nebulizations was 0.3±0.4 which was statistically significant, $p<0.05$. The results yielded by our study were comparable to the study done by Singhi *et al*., where the average fall after three repeated salbutamol nebulizations given at 30 min interval was 0.2 mEq/L [11]. In our study, a fall in serum potassium was noticed in 32 patients (78%). However, none of our patients had severe hypokalemia (serum potassium <2.5 mRq/L) and only 3 (7%) had hypokalemia (serum potassium <3.5 mEq/L). This was in contrast to the study done by Singhi *et al*., where 39% of patients had hypokalemia (serum potassium <3.5 mEq/L) and the decrease in potassium level was found more often in children who had received oral salbutamol for a week or more before nebulization therapy.

In our study, we had excluded those children with acute wheeze who had taken prior oral salbutamol (as brought out in exclusion criteria). Our results were comparable to another retrospective observational study done by Hartman *et al*. on 279 children with acute asthma who were treated with salbutamol nebulizations. In their study, it was seen that only 4.7% of the children had clinically significant hypokalemia (<3.0 mEq/L) and that too was mostly seen in those children who had received a cumulative dose of 0.6 (0.39–0.76 mg/Kg/h) (median displayed with interquartile range) during management of acute asthma [21]. Phumeetham *et al*. in their retrospective study on children who had received high-dose salbutamol nebulization (75–150 mg/h) over a mean duration of 22.3 h found that hypokalemia (serum potassium <3 mEq/L) had occurred in 5 of 33 patients (15.2%) who had serum electrolytes measured while on continuous salbutamol treatment [20].

Of 41 children in our study, 21 children required three repeated salbutamol nebulizations, 7 required four repetitions, 10 required five repetitions, and 3 required six repeated nebulizations. Salbutamol-induced decrease in serum potassium levels was found to be significantly correlated to a number of nebulizations ($r=-0.49$, $p<0.05$). The mean change varied with number of nebulizations; it was 0.06 mEq/L after three, 0.44 mEq/L after four, 0.66 mEq/L after five, and 0.43 mEq/L after six nebulizations, respectively. Thus, the fall is clinically insignificant after three repeated nebulizations but becomes significant after four or more nebulizations. In a retrospective observational study done

by Hartman *et al*., children who were most frequently nebulized (>2–3 times/h for >2–3 h) showed a significantly higher incidence of hypokalemia (71.0%, *n*=31) [21]. However, more studies need to be done to study the change in serum potassium levels with >3 repeated salbutamol nebulizations.

In our study, salbutamol-induced change in potassium was significantly correlated to change (increase) in heart rate ($r=-0.37$, $p<0.05$) and severity of PAS at the onset ($r=-0.43$, $p<0.05$). Children with more severe episodes may also be having increased circulating adrenaline which can further stimulate Na-K-ATPase pumps and can lower potassium levels in additive manner with salbutamol [22].

We studied QTc interval of patients while on repeated salbutamol nebulizations. ECG was done at 1 h of repeated nebulizations for all children and at 3 h for 13 children because they required repeated nebulizations up to 3–4 h. None of our patients were found to have any arrhythmia. We studied QTc objectively as there have been case reports of a prolonged QT interval which is a marker for the likelihood of ventricular tachyarrhythmia such as torsades de pointes and also a risk factor for sudden death [17,18].

In our study, mean QTc at 1 h and 3 h of repeated nebulizations was 0.41±0.02 (s) and 0.43±0.01 (s), respectively. There was no significant change in mean QTc in ECGs taken at 3 h (0.004 s, $p=0.137$). However, a significant correlation was found between PAS at the onset and change in QTc at 3 h ($r=0.564$, $p<0.05$). The QTc findings of our study were in contrast to a study done by Khalilian *et al*. who found that there was a statistically significant difference in QTc before and after three repeated salbutamol nebulizations administered at 20 min interval. In their study, mean increase in QTc in the group receiving three repeated nebulizations at a dose of 0.15 mg/kg/dose was 0.02±0.01 (s), and in the group receiving nebulizations at a dose of 0.1 mg/kg/dose, it was 0.01±0.01 (s); both of which were statistically significant ($p<0.05$) [14]. From our study, it appears that repeated salbutamol nebulizations cause no significant QTc changes. However, in children with higher severity scores at the onset, cardiac monitoring is warranted if they continue to receive repeated salbutamol nebulizations up to 3–4 h.

The strength of our study is that we have studied the effect of repeated salbutamol nebulizations (three or more) on serum potassium levels, unlike studies done in the past who have mostly studied this effect for maximum up to three repeated salbutamol nebulizations or after a single large dose of nebulized salbutamol. Furthermore, we excluded those children who were on any prior systemic medications that could affect serum potassium levels. The limitation of our study is that we did not include those children who also required other medications such as ipratropium, prednisolone, and aminophylline during the initial acute phase, which could further activate cAMP-dependent Na+/K+ ATPase, which in turn might accentuate symptomatic hypokalemia. Hence, the effect of repeated salbutamol nebulizations on serum potassium while the child is on multiple drugs could not be studied. However, practically, we often require a combination of these drugs during the management of acute severe asthma.

CONCLUSION

Repeated salbutamol nebulizations, in children aged 6 months to 12 years, are associated with an increase in heart rate and a decrease in respiratory rate. A statistically significant mean fall in serum potassium level was observed. The study also revealed that the fall in potassium levels was more in those children who received >3 repeated salbutamol nebulizations. However, there were no arrhythmias or QTc abnormalities seen. We conclude that serum potassium levels should be monitored in children receiving repeated salbutamol nebulizations for acute wheeze.

REFERENCES

1. Martinez FD, Wright AL, Taussig LM, Holberg CJ, Halonen M, Morgan WJ, *et al.* Asthma and wheezing in the first six years of life. The group health medical associates. N Engl J Med 1995;332:133-8.
2. Bisgaard H, Szefler S. Prevalence of asthma-like symptoms in young children. Pediatr Pulmonol 2007;42:723-8.
3. Stern DA, Morgan WJ, Halonen M, Wright AL, Martinez FD. Wheezing and bronchial hyper-responsiveness in early childhood as predictors of newly diagnosed asthma in early adulthood: A longitudinal birth-cohort study. Lancet 2008;372:1058-64.
4. Mallol J, Andrade R, Auger F, Rodríguez J, Alvarado R, Figueroa L, *et al.* Wheezing during the first year of life in infants from low-income population: A descriptive study. Allergol Immunopathol (Madr) 2005;33:257-63.
5. Tenero L, Piazza M, Piacentini G. Recurrent wheezing in children. Transl Pediatr 2016;5:31-6.
6. Papo MC, Frank J, Thompson AE. A prospective, randomized study of continuous versus intermittent nebulized albuterol for severe status asthmaticus in children. Crit Care Med 1993;21:1479-86.
7. Svedmyr N, Löfdahl CG. The use of beta 2-adrenoceptor agonists in the treatment of bronchial asthma. Pharmacol Toxicol 1996;78:3-11.
8. Udezue E, D'Souza L, Mahajan M. Hypokalemia after normal doses of nebulized albuterol (Salbutamol). Am J Emerg Med 1995;13:168-171.
9. Assadi FK. Therapy of acute bronchospasm complicated by lactic acidosis and hypokalemia. Clin Pediatr (Phila) 1989;28:258-60.
10. Epelbaum S, Benhamou PH, Pautard JC, Devoldere C, Kremp O, Piussan C. Respiratory arrest in an asthmatic girl treated with beta-2-mimetics and theophylline. Possible role of hypokalemia in sudden death in asthmatic patients. Ann Pediatr (Paris) 1989;36:473-5.
11. Singhi SC, Jayashree K, Sarkar B. Hypokalaemia following nebulized salbutamol in children with acute attack of bronchial asthma. J Paediatr Child Health 1996;32:495-7.
12. Hung CH, Chu DM, Wang CL, Yang KD. Hypokalemia and salbutamol therapy in asthma. Pediatr Pulmonol 1999;27:27-31.
13. Mohammad H, Abdulfttah M, Abdulazez A, Mahmoud A, Emam R. A study of electrolyte disturbances in patients with chronic stable asthma and with asthma attacks. Egyptian. J Chest Dis Tuberc 2014;63:529-4.
14. Khalilian MR, Fayezi A, Alisamir M, Khorasani MN. Effect of ventolin on QTc in children with respiratory distress. J Cardiovasc Thorac Res 2016;8:83-5.
15. Jartti T, Kaila T, Tahvanainen K, Kuusela T, Vanto T, Välimäki I, *et al.* The acute effects of inhaled salbutamol on the beat-to-beat variability of heart rate and blood pressure assessed by spectral analysis. Br J Clin Pharmacol 1997;43:421-8.
16. Milic M, Bao X, Rizos D, Liu F, Ziegler MG. Literature review and pilot studies of the effect of QT correction formulas on reported beta2-agonist-induced QTc prolongation. Clin Ther 2006;28:582-90.
17. Yap YG, Camm AJ. Drug induced QT prolongation and torsades de pointes. Heart 2003;89:1363-72.
18. Tisdale JE. Drug-induced QT interval prolongation and torsades de pointes:

Role of the pharmacist in risk assessment, prevention and management. Can Pharm J (Ott) 2016;149:139-52.
19. Ducharme FM, Chalut D, Plotnick L, Savdie C, Kudirka D, Zhang X, *et al.* The pediatric respiratory assessment measure: A valid clinical score for assessing acute asthma severity from toddlers to teenagers. J Pediatr 2008;152:476-80, 480.e1.
20. Phumeetham S, Bahk TJ, Abd-Allah S, Mathur M. Effect of high-dose continuous albuterol nebulization on clinical variables in children with status asthmaticus. Pediatr Crit Care Med 2015;16:e41-6.
21. Hartman S, Merkus P, Maseland M, Roovers L, van Setten P. Hypokalaemia in children with asthma treated with nebulised salbutamol. Arch Dis Child 2015;100:970-2.
22. Cunningham S, Logan C, Lockerbie L, Dunn MJ, McMurray A, Prescott RJ, *et al.* Effect of an integrated care pathway on acute asthma/wheeze in children attending hospital: Cluster randomized trial. J Pediatr 2008;152:315-20.

Funding: None; Conflict of Interest: None Stated.

How to cite this article: Jain G, Vasnik GK, Rawat A. A study on effects of repeated salbutamol nebulizations on serum potassium levels and QTc on electrocardiogram in children with acute wheeze. Indian J Child Health. 2018; 5(11):653-658.

Doi: 10.32677/IJCH.2018.v05.i11.001