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Original Article

Electrocardiographic characteristics in young male patients with left primary spontaneous pneumothorax estimated by the collins equation

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ABSTRACT

Objective: To investigate the 12-lead surface electrocardiographic (ECG) findings in young male patients with left primary spontaneous pneumothorax (PSP) estimated by the Collins equation.
Methods: From 2003 through 2008, 60 young male patients who had left PSP and 61 age-matched unaffected males were included for 12-lead ECG analyses. The PSP size was estimated by the Collins equation. Those with left PSP were divided into two groups: 1) large PSP ≥30% (n = 37), and 2) small PSP <30% (n = 23). The ECG in the unaffected was used as the normal control. Baseline demographic, anthropometric, and electrocardiographic findings including heart rate, P-QRS-T axes, wave intervals, and RS voltages were compared among three groups.
Results: As compared to the unaffected, patients with left PSP had faster heart rate, longer QTc interval, greater QRS and T axes. With regard to RS amplitudes, greater R in lead aVR and V1, and deeper S in lead II indicating predominant rightward forces, and smaller R in lead I and V3-V6 indicating inferior leftward forces were present in patients with left PSP. Of these ECG findings, heart rate, S voltage in lead II and R voltage in V1 in the large PSP but not in the small PSP had greater values than that in the unaffected group.
Conclusion: Among young male patients with left PSP estimated by the Collins method, the ECG showed faster heart beat and predominant rightward forces especially for those with large PSP.

1. Introduction

Primary spontaneous pneumothorax (PSP) occurs in persons who have no clinically apparent lung disease, and is not caused by trauma or any obvious precipitating factor. It is typically seen in tall, thin young males, and occurs rarely over the age of 40.[1,2] The management of PSP is usually dependent on the clinical situation despite the current management guidelines recommended by the British Thoracic Society and by the American College of Chest Physicians.[2–4] In general, experts suggest that patients who had pneumothorax size ≥30% or ≥3 cm apex-to-cupola distance or were symptomatic should receive air evacuation by simple manual aspiration or chest tube drainage.[2]

In clinical practice, 12-lead body surface electrocardiography (ECG) additionally to chest X radiography (CXR) provides essential information in patients with sudden onset chest pain such as ST-segment elevation myocardial infarction. Several typical ECG characteristics in left PSP have been described, including phasic R wave variations, right ward shift of the frontal QRS axis, diminution of the QRS complex, T-wave inversion, and loss of R waves in the precordial leads.[5–8] ECG findings may provide a clue to the presence of left PSP.

Moreover, our previous report found that S voltage in V2 and V3 in ECG might predict large pneumothorax size (>20%) by the Light index in young male patients with left PSP.[9] However, there are no published data on the ECG findings of left PSP estimated by the Collins method.[10,11] An understanding of ECG changes in pneumothorax is important for suspecting the condition and ordering CXR

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for these patients. In this study, we investigated the ECG characteristics in male patients with left PSP estimated by the Collins method.

2. Methods

This retrospective case-control study was conducted in an 1800-bed tertiary medical center in Taiwan. We took a thorough history and performed full physical examination of all patients who visited our emergency department with suspected pneumothorax. CXR was obtained and 12-lead surface ECG was performed as indicated. From January 2003 to February 2008, we reviewed only male patients with left PSP (n = 101) as the effect of breast in female patients may vitiate the ECG findings.[12] Sixty-six patients with available ECG (65.3%) were enrolled. After excluding those with hydro- pneumothorax, history of acquired cardiac and pulmonary diseases, isolated diaphragmatic elevation, chest wall deformity and previous lung volume reduction surgery, there was a final sample of 60 patients with left PSP for analysis. Echocardiography was not routinely performed for these patients since their young ages. The following data were reviewed and analyzed from the ED medical records and online picture; patients' demographic data including age, sex, height, weight, and body mass index, radiological appearance in pneumothorax size and 12-lead surface ECG characteristics. The Tri-Service General Hospital Institutional Review Board approved the study and waived the requirement for informed consent for this retrospective review of medical records (TSGHIRB09705103).

All patients had posteroanterior CXR in the upright position taken at the same time of admission in the ED, which were reviewed by two physicians. If discrepancy existed in the classification of PSP size by the Collins method, another radiologist blinded to the results further reviewed the CXR and determined the PSP size greater or less than 30%. The Collins method, a function of the interpleural distance (ID), was used for measuring the sizes of pneumothorax and the calculated formula was listed below.[10,11]

$$\%\text{Collins} = 4.2 + 4.7\ (A + B + C)$$

–A = maximal apical ID.

–B = ID at the midpoint of the upper half of the lung.

–C = ID at the midpoint of the lower half of the lung.

To compare the estimate of left PSP size between the Light index and the Collins method, we plotted the scatter diagram of pneumothorax sizes by two methods in our patients. Large PSP was defined as ≥30% by the Collins method (group 3, n = 37); and the small PSP was defined as <30% (group 2, n = 23).[13] The ECGs from 61 age-matched healthy males were as the normal control (group 1). ECG in all patients was taken in supine position. The R wave was measured from the initial positive deflection of ventricular despoliation. The S wave was measured from the first negative deflection of ventricular depolarization that follows the first R wave. The ECGs were performed by experienced technicians in our ED during the study period. Two cardiologists reviewed the results of the 12-lead ECG. If discrepancy (the measurement difference over 10%) existed, another cardiologist blinded to the results would review it again and an average of the two closest results was used as the final value.

2.1. Statistical analysis

Data were demonstrated either as percentage of the group (categorical variables) or as mean ± standard deviation (continuous variables). P-values were derived from Tukey's pairwise multiple comparison procedure. The statistical package SAS (SAS Institute Inc., Cary, NC, USA), was used for all analyses. All *p*-values were 2-sided; $p < 0.05$ was considered significant.

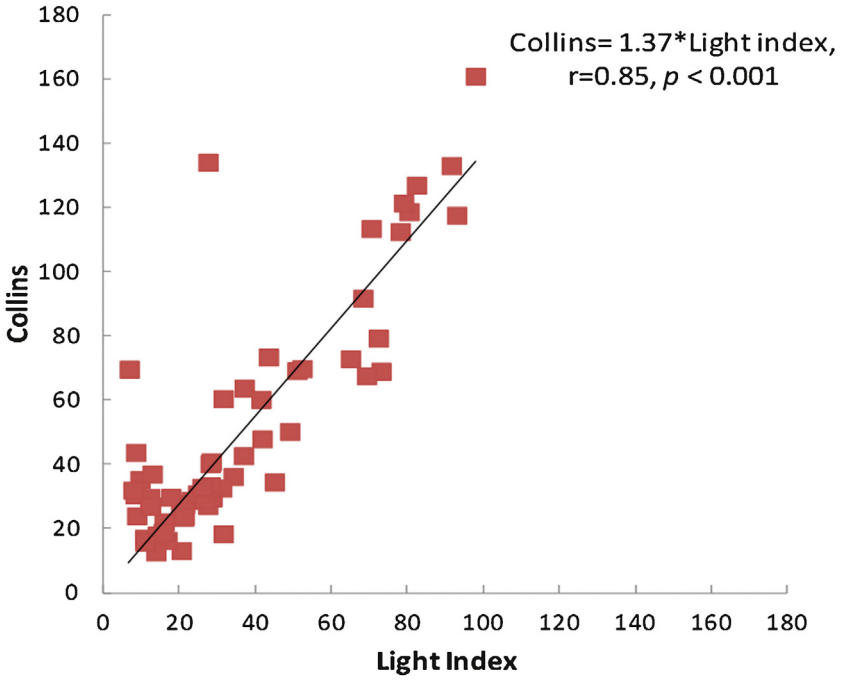

Fig. 1. The scatter diagram of pneumothorax sizes estimated by the Light index and the Collins' Method.

3. Results

The regression line in Fig. 1 shows positive relation with correlation coefficient of 1.37 in the present study. Accordingly, the cut-off point of 20% for left PSP size by the Light index in our previous study reset to 30% (20% x 1.37) by the Collins method here was compatible. Baseline characteristics of the unaffected and patients with left PSP were shown in Table 1. As compared to the unaffected (group 1), patients with left PSP (groups 2 and 3) had lower body mass index, faster heart rate, longer corrected QT interval, greater QRS and T axes. With regard to RS amplitudes, greater R in lead aVR and V1, and deeper S in lead II indicating predominant rightward forces, and smaller R in lead I and V3-V6 indicating inferior leftward forces were present in patients with left PSP. As compared the demographics in patients with small left PSP with that in large left PSP, there was no difference in body mass index. The ECG characteristics also show that heart rate, S voltage in lead II, and R voltage in V1 in the large PSP but not in the small PSP had significantly greater values than that in the unaffected group. There were no statistically significant differences in other ECG findings between the small and the large left PSP group. Table 2 illustrates the comparison of RS amplitudes in all leads among 3 groups. Fig. 2 shows the typical ECG changes before (A) and after (B) chest tube placement in a patient with left PSP which size estimated 20% by the Collins method.

4. Discussion

Our study confirmed that male patients with left PSP are younger and have lower body wight in comparison with age-matched healthy males. In addition, young male patients with left PSP had increased heart rate than the unaffected subjects which is probably due to pain, hypoxia, elevated catecholamine levels and activation of sympathetic tone while lung rupture and air leakage to the pleural space.[1]

Previously, we have found that the ECG findings in young male patients with left PSP include greater R voltage in aVR and V1 indicating predominant rightward forces and smaller R voltage in lead I and V3-6 and smaller S in lead aVR indicating inferior leftward forces. In addition, there were significant differences in S voltages of V2 and V3 between patients with left PSP size <20% and those with left PSP size ≥20% estimated by the Light index. These changes were explained by extra-pulmonary air redistribution to the anterior-cardiac area which makes more cardiac clockwise rotation and inferior deviation in large PSP. The air redistribution would lead to increased resistance on the lateral leads V3-5 when the air leak volume expands. In V2 and V3, the electrodes would be closer to the heart and receive the greatest cardiac electrical potential.[9]

When pneumothorax size was estimated by the Collins method, the ECG findings were not totally in line with the previous study. We found deeper S voltage in lead II indicating greater rightward force as PSP size was measured by the Collins method rather than smaller S voltage in lead aVR indicating inferior leftward force as PSP size was evaluated by the Light index. In addition, smaller S

Table 1
Baseline Characteristics and Electrocardiography of Unaffected Individuals and Those With Left Primary Spontaneous Pneumothorax Estimated by the Collin's Method.

Variables	Group 1 Unaffected (n = 61)	Group 2 PSP size <30% (n = 23)	Group 3 PSP size ≥30% (n = 37)	P-value[a]
Characteristics				
Age (yr)	22.49 ± 1.13	19.22 ± 2.81**	23.46 ± 6.29	<0.001
Height (cm)	171.66 ± 5.69	174.52 ± 6.27	173.03 ± 7.57	0.659
Weight (kg)	70.78 ± 10.99	60.43 ± 7.76***	58.47 ± 7.09***	0.714
BMI (kg/m^2)	23.95 ± 3.39	19.86 ± 2.56***	19.57 ± 2.50***	0.931
Baseline ECG				
HR (per min)	62.69 ± 8.46	69.35 ± 12.47	80.86 ± 17.09***	0.002
PR (ms)	153.72 ± 21.13	153.26 ± 28.26	157.86 ± 25.67	0.666
QRS (ms)	90.90 ± 13.55	92.04 ± 9.13	93.24 ± 11.74	0.928
QT (ms)	367.46 ± 49.67	373.13 ± 37.02	348.08 ± 34.25	0.078
QTc (ms)	378.30 ± 30.54	395.91 ± 29.14*	398.38 ± 28.51**	0.948
P-axis	50.78 ± 54.57	54.87 ± 19.89	67.65 ± 18.20	0.468
QRS-axis	57.88 ± 30.93	86.57 ± 43.85**	80.97 ± 31.43**	0.809
T-axis	43.68 ± 16.63	57.04 ± 14.39**	61.54 ± 14.84***	0.528
P-QRS	13.05 ± 36.85	31.70 ± 51.25	13.41 ± 33.74	0.188
QRS-T	16.98 ± 30.08	29.52 ± 44.60	19.51 ± 34.91	0.526

Data are presented as mean ± SD; cm: centimeter; BW: body weight; kg: kilogram; BMI: body mass index; ECG: electrocardiography; HR: heart rate; ms: millisecond; PR: PR interval; PSP: primary spontaneous pneumothorax; QRS: QRS interval; QT: QT interval; QTc: corrected QT interval; P-QRS: angle between P and QRS axis; QRS-T: angle between QRS and T axis.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$ were used for comparison between the unaffected group and the two pneumothorax groups; i.e. pneumothorax size <30% vs. unaffected, and pneumothorax size ≥30% vs. unaffected.

[a] Exact p-values are shown for comparison between pneumothorax size <30% and pneumothorax size ≥30% groups.

Table 2
Analyses of RS Amplitudes from Electrocardiography in the Unaffected and Those With Left Primary Spontaneous Pneumothorax Estimated by the Collin's Method.

Variables	Group 1 Unaffected (n = 61)	Group 2 PSP size <30% (n = 23)	Group 3 PSP size ≥30% (n = 37)	P-value[a]
Frontal leads (mm = 0.1 mV)				
IR	4.48 ± 2.25	2.80 ± 1.43**	2.82 ± 2.39***	0.993
IIR	10.97 ± 4.14	10.80 ± 4.10	10.49 ± 4.45	0.957
IIIR	7.26 ± 4.66	8.50 ± 3.96	8.26 ± 4.06	0.976
aVFR	9.04 ± 4.23	9.46 ± 4.28	9.23 ± 4.24	0.978
aVLR	0.94 ± 1.08	0.96 ± 1.53	0.77 ± 1.08	0.823
aVRR	0.16 ± 0.27	0.98 ± 1.11***	0.85 ± 1.15***	0.830
IS	1.10 ± 1.13	1.52 ± 1.39	1.11 ± 1.04	0.373
IIS	1.02 ± 1.19	1.63 ± 1.96	1.82 ± 1.64*	0.878
IIIS	0.90 ± 1.25	1.09 ± 1.23	1.27 ± 1.41	0.856
aVFS	0.84 ± 1.59	1.13 ± 1.29	1.49 ± 1.30	0.627
aVLS	2.56 ± 1.99	3.63 ± 1.55	3.26 ± 2.19	0.758
aVRS	7.34 ± 2.17	6.17 ± 2.53	6.12 ± 2.92	0.997
Precordial leads (mm = 0.1 mV)				
V1R	2.52 ± 1.47	2.72 ± 2.20	3.54 ± 2.68*	0.289
V2R	6.03 ± 3.04	6.09 ± 3.70	5.34 ± 3.90	0.693
V3R	10.25 ± 5.20	5.98 ± 3.81***	5.69 ± 4.10***	0.970
V4R	17.68 ± 4.87	6.98 ± 5.62***	6.61 ± 4.57***	0.958
V5R	16.89 ± 4.94	7.67 ± 4.66***	7.17 ± 5.08***	0.922
V6R	12.73 ± 4.34	7.67 ± 4.03***	6.68 ± 4.32***	0.654
V1S	9.06 ± 4.17	9.28 ± 5.98	9.49 ± 7.58	0.991
V2S	13.58 ± 5.02	17.41 ± 6.46	14.95 ± 8.88	0.349
V3S	8.84 ± 5.09	11.43 ± 6.01	9.64 ± 5.34	0.417
V4S	4.02 ± 3.37	5.87 ± 4.42	4.90 ± 4.06	0.608
V5S	2.08 ± 2.14	2.76 ± 2.20	2.33 ± 2.04	0.993
V6S	0.97 ± 1.04	1.61 ± 1.54	1.27 ± 1.32	0.559

Data are presented as mean ± SD; mm: millimeter; mV: millivolt; PSP: primary spontaneous pneumothorax.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$ were used for comparison between the unaffected group and the two pneumothorax groups; i.e. pneumothorax size <30% vs. unaffected, and pneumothorax size ≥30% vs. unaffected.

[a] Exact *p*-values are shown for comparison between pneumothorax size <30% and pneumothorax size ≥30% groups.

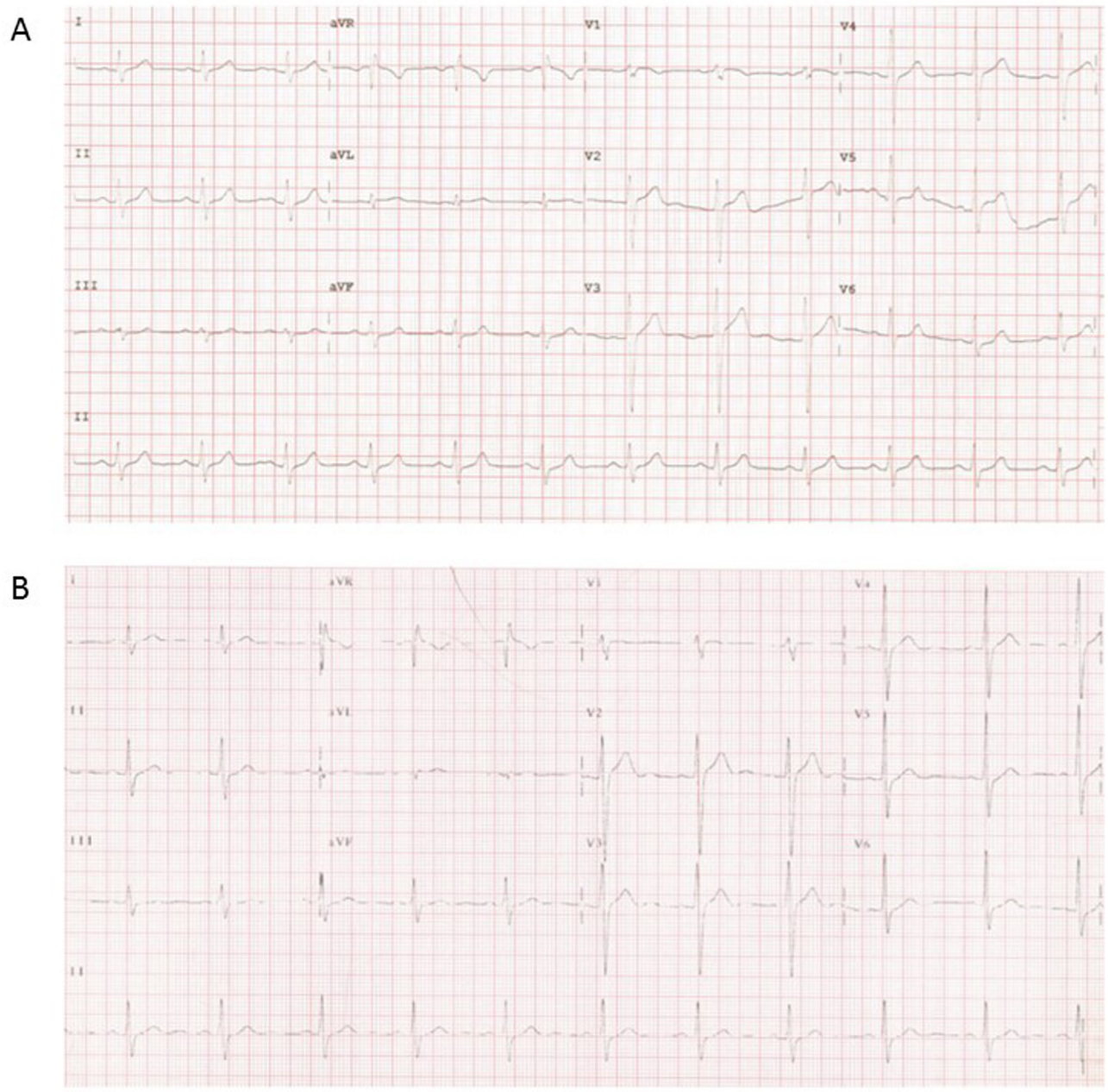

Fig. 2. The upper ECG (A) shows smaller R amplitudes in V3-V6 in a 24 year-old men with left PSP which size was estimated 20% by the Collins method before chest tube placement. The lower ECG (B) shows greater R amplitudes in V3-V6 in the same patient after chest tube placement.

voltages in V2 and V3 in the large PSP compared with that in the small PSP by the Light index may stand for a diminished leftward force, but there were no S voltage differences in V2 and V3 between the small and the large PSP groups using the Collins method. The inconsistence results may be related to the formula difference between the Light index and the Collins equation for estimating left PSP size. Notably, the ECG changes in V3-V6 are strong indicators of left ventricular mass displacement and diminished leftward force which might occur secondary to an increased rightward force by left PSP. As is known, the Light index amplifies the effect by cubic distance ratio between diameter of the collapsed lung and diameter of the left hemithorax, which corresponds to the pre-cordial leads V2 and V3 whereas Collins method dose not.[9–11]

This was the second case-control study to compare the ECG findings among the unaffected young male individuals, those with small left PSP, and those with large PSP. However there were also some limitations. First, the baseline profiles and the severity of pneumothorax of patients without ECG were not known. Second, there were about one third of male patients without available ECG which may result in a selection bias. Third, these ECG changes could be due to the asthenic habitus of patients who are more prone for pneumothorax. Finally since the retrospective study in nature, there was no available echocardiography data for all of the participants and we could not completely exclude the possibility of congenital heart diseases at baseline.

In conclusion, the ECG characteristics including faster heart rate and deeper S voltage in lead II and greater R voltage in V1

indicating predominant rightward forces were noted in larger left PSP when estimated by the Collins equation in young male patients. In general, the left PSP size by the Collins method was 1.37 times greater than that by the Light index. Although the ECG changes in S voltages in V2 and V3 have been found for differentiating left PSP size estimated by the Light index, the finding could not be re-produced by the Collins method. Therefore we have to interpret the ECG data carefully based on which method we use to measure the left PSP size in the young male population.

Conflict of interest

None

What is already known?

- Several electrocardiographic (ECG) changes in young male patients with left spontaneous pneumothorax have been reported using the Light index for the estimation of the size of pneumothorax.

What this study adds?

- As compared to the unaffected, patients with left PSP estimated by the Collins method had faster heart rate, greater right electrical forces (frontal aVRR, IIS, and precordial V1R), and smaller left electrical forces (frontal IR and precordial V3-6). Of these, heart rate, IIS and V1R voltages in the PSP $\geq$30% but not in the PSP $<$30% had greater values than that in the unaffected group.

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None.

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