Ecg Changes in Chronic Cor Pulmonale

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INTRODUCTION

Due to growing industrial hazards and increased smoking habits, chronic respiratory diseases and chronic cor pulmonale are few examples of deseases which today are in increasing incidence. Joule correctly observes "the air we breath, is as important as the water we drink, it must be uninfected and unpolluted". In the United States chronic obstructive pulmonary disease is the 4th main cause of death at present. More than half of the patients with chronic obstructive lung diseases have Cor-Pulmonable, and this conditions constitutes between 5-10 percent of all adult heart diseases in the United States.

In many respects the heart and lung comprise a functional unit with interrelations such that disease of one may often affect the other, e.g. in mitral stenosis, lesion is in mitral valve of the heart and it gives rise to pulmonary oedema, whereas in Cor pulmonale the lung pathology which gives rise to adverse effects on the heart.

The electrocardiogram bears a unique relationship to this situation, not only because it reflects certain aspects of cardiac function but also because much of the cardiac potentials must traverse lung tissue to reach the recording electrode.

Various definitions of cor pulmonale have been given by different authors.

Wood defines cor pulmonale as "Cardiovascular disorder, caused secondary to disease of lung parenchyma."

Fulton defines it as "heart in chronic lung disease". Wayne Marshall defines chronic cor-p as "right ventricular strain and hypertrophy secondary to chronic pulmonary disease". It is evident that all definitions are incomplete in one or the other way.

The W.H.O. Expert Committee on chronic cor pulmonale gives the following definition : chronic cor pulmonale is defined as the "Hypertrophy of the right ventricle resulting from diseases affecting the function and/or the structure of the lung, except, when these pulmonary alterations are the result of diseases that primarily affect the left side of heart, or of congenital heart disease." The definition of W.H.O. is in conformity with the current cardiological practice, and at present seems to be the most complete one.

Chronic obstructive lung diseases cause cor pulmonale through several interrelated mechanisms, including hypoventilation hypoxemia from ventilation/perfusion mismatch and destruction of perfused surface area when chronic bronchitis predominates, cough productive of sputum is common symptom, and the striking V/O inequality leads to hypoxemia, hypercarbia, erythrocytosis, and early onset of cor pulmonale ("Blue Bloalers") when emphysema predominates, dyspnoea on exertion is the most prominent symptom and these patients ("Pink Puffers") have less V/O inequality and therefore, develop cor pulmonale later.

In patients with chronic obstructive lung diseases increased cough and dyspnoea are hall marks of periodic worsening of the disease. Such exacerbations in patients with severe chronic obstructive lung diseases may be life threatening and may lead to acute respiratory failure as well right heart failure. The latter occurs secondary to pronounced increases in pulmonary artery pressure and pulmonary vascular resistance, which, in turn, are due primarily to hypoxic pulmonary vasoconstriction. i.e. as the FEVI drops below 1 liter, severe arterial hypoxemia, hypercapnia, and cor pulmonale are evident.

In the present circumstances for the diagnosis of cor pulmonale and to know the severity and progress of cor pulmonale following diagnostic tools are possible :

1) Pulmonary catheterization.
2) Radionuclida Ventriculography study
3) Echocardiography
4) Megnetic resonance imaging.
5) E.C.G. criteria
6) Radiology.

The clinical diagnosis of cor pulmonale is often equivocal. Many of the signs and symptoms associated with right ventricular failure overlap the signs and symptoms of primary lung disease itself. The radiological evidence of cor pulmonale (i.e. right ventricular hypertrophy or right ventricular dilatation) is inaccurate and even catheterization proved pulmonary hypertension does not establish the diagnosis of cor pulmonale.

Pulmonary catheterization is an invasive procedure, costly and cannot be repeated at short intervals. Radionuclide studies and M.R.I. are also costly and all these are done at specific specialized centres.

Radiology is most useful for early detection of emphysema but for cor-pulmonale it is less useful for diagnosis as well as for regular follow up.

Echocardiography is most sensitive and specific for early diagnosis of right ventricular involvement in COPD cases. At the same time 2D Echo is costly and is not available at small centres.

From above discussion it is clear that ECG criteria for early diagnosis of right ventricular involvement is most readily

available investigation, cheaper and available at even small centres in rural areas and could be carried out at regular short intervals.

ECG changes in chronic cor pulmonale may show :
(a) Isoelectric "P" waves in lead I or right axis deviation of P vector.
(b) P-pulmonale pattern (as increase in p-wave amplitude in II, III, avF).
(c) Tendency for right axis deviation of the QRS.
(d) R/S amplitutde ratio in V6 < 1
(e) Low voltage QRS.
(f) S1, Q3, or S1, S2, S3 pattern.
(g) Incomplete (and rarely complete) RBBB.
(h) R/S amplitude ratio in VI > 1.
(i) Market clockwise rotation of the electrical axis.
(j) Occasional large Q wave or QS in the interior or mid precordial leads, suggesting healed myocardial infarction.
(The first seven criteria are suggestive but non specific, the last three are more characteristic of cor pulmonale in obstructive disease of the airway.)

The electrocardiogram in cor pulmonale is often affected and altered by extraneous and extracardiac factors, such as conductivity of the intrathoracic structures the cardiac position and rotation, the duration and degree of right ventricular overload, the presence of coexisting left ventricular hypertrophy and electrolyte imbalance.

ATM OF STUDY
Various workers have analysed the electrocardiogram in chronic cor pulmonale but many controversial points still exist in the diagnosis of right ventricular hypertrophy in the presence of extensive lung disease. The aim of this study is to formulate the criteria for detection of early right ventricular hypertrophy, particularly in the hearts which are not enlarged.

MATERIAL AND METHODS
In this study 100 cases of chronic cor pulmonale admitted in medical ward as well as emergency ward of our institution, were taken up for this study. The patients were of age between 40 and 70 years.

The lung pathology in these patients were mainly chronic bronchitis, emphysema and bronchiectasis. The criteria for the selection of the patients were :

(1) Presence of chronic pulmonary disease, e.g. chronic bronchitis, bronchiectasis and emphysema.
(2) Presence of right ventricular hypertrophy and absence of left ventricular hypertrophy.
(3) Absence of congenital, valvular, infective, hypertensive and ischemic heart disease.
(4) Added criteria taken into the consideration was the presence of C.C.F.
The diagnosis was based on clinical grounds and radiological aid was taken when required.

RESULTS AND OBSERVATIONS
Table Showing Electrocardiographic Abnormalities in 100 patients of chronic Cor Pulmonale

Sr.No.	ECG Abnormalities		Percentage

01.	P wave axis		
	- Right ward	76	
	- Left ward	0	
	- Normal	24	
02.	QRS Axis		
	- Right axis deviation		80
	- Left axis deviation		0
	- Normal		20
03	Position of heart		
	- Vertical		68
	- Semivertical		21
	- Intermediate		9
	- Semi Horizontal		2
	- Horizontal		0
	- Indeterminate		0
04.	Rotation of Hearton Longitudinal axis		
	- Clockwise rotation		75
	- Counter clock wise rotation		0
05.	Morphology of "P" Wave		
	- Normal		20
	- Peaked P with normal amplitude		35
	- Peaked P with increased amplitude		45

Sr.No.	ECG Abnormalities		Percentage
06.	P in lead aVL		
	- Inverted		76
	- Upright		24
	- Biphasic		0
	- Flat		-
07.	Dominant "R" in lead aVR		44
08.	RVH Pattern in lead V1 :		
	(a) qR		20
	(b) rSR		10
	(c) rSr		4
	(d) rsR		2
	(e) RS or rR		4
09.	Incomplete RBBB		4
10.	Low Voltage QRS in		
	- Lead V1		86
	- Lead V6		36
11.	QS Pattern in V1-V6		10
12.	Dominant S in lead V5-6		74
13.	Abnormal ST-T changes		
	- in Right chest leads	48	
	- in left chest leads	2	60
	- in all chest leads	6	
	- in std. lead II, III & aVF	60%	
14.	Associated Arrhythmias		10
15.	Left Ventricular Hypertrophy		0

100 Cases of Chronic cor pulmonale admitted in medical ward as well as emergency ward at our institution, were taken up for this study. The patients were of age between

40-70 years.

All the cases were subjected to electrocardiogram and chest x-ray. The electrocardiographic changes were studied and following results and observations are made.

(a) "P" Wave Axis

Right Ward	76%
Left Ward	0
Normal	24%

76% of cases showed right ward deviation of P axis i.e. axis above +650, Remaining 24% of cases showed normal P weave axis i.e. in between +250 to 0450. There was no case showing left ward "P" axis deviation.

Comparison of right axis deviation of "P" wave in various studies.

Zuckermann et at	80%
Cold et al	79%
Spodick	73%
S. Padmavati	58.6%
Previous Study	78%
Present Study	76%

Thus our results are consistent with the results of above authors.

(b) QRS AXIS

Right axis deviation	80%
Left axis deviation	0
Normal axis	20%

Right axis deviation of QRS complex was seen in 80% of the cases 20% of the cases showed normal axis.

Comparison of right axis deviation of QRS in various studies.

Coel Ho.	46%
Mishra	62.75%
S. Padmavati	79%
Millard et al	85%
The Previous Study	72%
The Present Study	80%

In this present study, the left axis deviation of QRS axis is not observed in any of the cases. The incidence of same was 2.2% in S. Padmavati's series while Mishra et al reported it to be present in 5.5% of cases.

(c) POSITION OF THE HEART

Vertical	68%
Semivertical	21%
Intermediate	9%
Semi Horizontal	2%
Horizontal	0
Indeterminate	0

In the study of position of the heart, most of the cases showed vertical and semivertical position. 68% of cases showed vertical position and other 21% of cases showed semivertical position. 9% cases showed intermediate position. No case was found with Horizontal heart position. In S. Padmavati's series 82.3% of cases showed either vertical or semivertical position. The previous study showed 87% of cases with either vertical or semi vertical heart position.

(d) Rotation of Heart on Longitudinal Axis

Clockwise rotation	75%
Counterclockwise rotation	0

Clockwise rotation of heart was observed in 75% of cases in the present series. Counter clockwise rotation was not present in any of the cases. Mishra in his series noted clockwise rotation in 74.48% of the cases with not a single case of counterclockwise rotation was found in his series. In previous study. The incidence of clockwise rotation was 69%. Thus the observations of the present study. Correlate with previous studies.

(e) Morphology of "P" wave

	Present Series
Normal "P" Wave	20%
Peaked "P" with normal amplitude	35%
Peaked "P" with increased amplitude	45%

"P" wave changes were predominantly found in II, III and aVF. Out of 100 cases 80% of cases showed peaked "P" waves while 20% of cases showed normal "P" wave. In 45% cases peaked "P" with increased amplitude showed classical "P" pulmonale confirugration. While 35% of cases showed peaked "P" wave without increased amplitude.

The incidence of "P" pulmonale in other series is as follows :

Spodick et al	13.9%
Cairod and walkman	15.5%
Chappel	29.0%
Calatuyad et al	46.2%
Mishra	34.48%
The Previous Study	47.0%
The present Study	45.0%

The present stud has recorded the incidence of peaked "P" waves without increased amplitude as being 35%, the incidence of the same in Mishra's series was 30%.

The conclusion drawn from the above results is that "P" pulmonale in chronic cor pulmonale is variable and inconstant finding, which is of least importance.

Another interesting point observed in this series is that all the cases of "P" pulmonale showed right ward deviation of "P" axis while all the cases which showed rightward deviation of "P" axis did not show "P" pulmonale, suggesting that rightward deviation of P axis is an earlier event than to development of "P" pumonale, and so right ward deviation of "P" axis is more reliable, more useful and early criteria for diagnosis of chronic cor pulmonale.

(f) "P" CONFIGURATION IN LEAD aVL

Mishra's Series	100% inverted
Previous Study	71% inverted
The present series	76% inverted

In the present series 76 patients out of 100 cases showed inverted "P" wave in lead aVL. Normally "P" wave in lead aVL is upright.

(g) DOMINANT "R" IN LEAD aVR

S. Padmavati Series	44%
Previous Study	31%
Present Study	44%

In the present series "R" dominance in lead aVR was noticed in 44% of cases. It also showed correlation with classical right ventricular hypertrophy.

(h) DOMINANT "S" IN LEAD V5-V6 i.e. R/S in V6 < 1

79% of cases of cor pulmonale showed dominant "S" wave in lead V5-V6. In the previous study of 1977 the incidence of the same was reported to be 65%. So it seems that "S" wave in V5-V6 is an important finding to RVH.

(i) RIGHT VENTRICULAR HYPERTROPHY PATTERN IN V1 i.e. R/S RATIO IN V1 > 1

40% of cases showed right ventricular hypertrophy pattern. But different patterns were analysed like qR the most common and rSR', rSr, rsR', RS or rR' less.

S.No.	Pattern	Present Study	Previous Study	Mishra's Study
01.	qR	20%	16%	19.3%
02.	rSR	10%	10%	5.5%
03.	rSr'	4%	4%	4.8%
04.	rSR'	2%	4%	7.58%
05.	RS or rR'	4%	8%	6.2%

In other study of such changes e.g. in Padmavati's series also qR pattern was dominant and thus from these studies it becomes evident that qR pattern is the commonest of all other patterns of right ventricular hypertrophy. This pattern is thought to be due to diastolic overload.

(j) QS PATTERN FROM V1-V6

This study showed QS pattern in about 10% of cases. In the previous study 1977 the incidence of the same was reported to be 7%. Padmavati 17%.

(k) LOW VOLTAGE QRS IN ALL LEADS

16% showed low voltage QRS in all leads in lead V1, Voltage of QRS <7 mm was noticed in 86% of cases, whereas in lead V6 only 36% of patients, showed low voltage.

(l) INCOMPLETE RBBB

4 patients out of 100 cases showed incomplete right bundle branch block in their ECG.

(m) ABNORMAL ST-T CHANGES

Abnormal ST-T changes in this present study were found in about 60% cases. More commonly it was found in standard loads II, III and aVF.

Right chest leads	48%
Left chest leads	2%
All chest leads	6%

(n) ARRHYTHMIAS ASSOCIATED WITH COR PULMONALE

10% of cases showed associated arrhythmia. In all cases there were supraventricular arrhythmias in the form of aterial extrasystoles.

(o) LEFT VENTRICULAR HYPERTROPHY

In this study there was no case of left ventricular hypertrophy. Also in previous study and in Mishra's study there was no case of LVH, whereas in Padmavati's series, only 1.4% showed left ventricular hypertrophy.

SUMMARY AND CONCLUSION

In this study 100 cases of chronic cor pulmonale due to bronchitis, bronchial asthma, emphysema and bronchiectasis were analysed with a view to determineelectrocardiographic changes. The electrocardiographic changes of chronic cor pulmonale are mainly due to vertical position of heart or right ventricular hypertrophy or both.

The most frequent observations was right axis deviation of QRS complexes (80%) followed by verticalisation of "P" axis in frontal reference system (76%) and inverted "P" in lead aVL (76%). This was followed by Clockwise rotation of heart (75%) in longitudinal axis, and low voltage of QRS in lead V1. Classical peaked "P" pulmonale with increased amplitude was found in only 45% of cases. It is also worth noting that heart assumes a vertical or semivertical position in chronic cor pulmonale.

Classical right ventricular hypertrophy is less commonly observed than expected. But amongst its different patterns, qR pattern is commonest. When classical right ventricular hypertrophy is absent, the features suggesting right ventricular hypertrophy were the combination of rS pattern in lead V5-V6, right axis deviation, clockwise rotation, dominant R in lead aVR and "P" pulmonale. The "P" pulmonale was perhaps the least associated feature from above all.

So it is seen that patients with COPD who are going for the involvement of right ventricle would have following ECG changes at the earliest-Right axis deviation, rightward axis of "P" wave, clockwise rotation and change of position of heart towards vertical.

In comparison with ECG, 2D Echo Echocardiography can detect RV measurements, interventricular septum thickness but cannot measure accurately RV ejection fractions. 2D Echo is also many a times inaccurate to detect pulmonary hypertension in COPD patients. Chest x-ray can detect cor-pulmonale in COPD patients but at an advanced stage. Hence for the early detection of RV involvement ECG. Criteria are better.

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