The Electrocardiogram in Thyrotoxicosis

(Prolongation of P-R Interval is Characteristic of Hyperthyroidism)

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According to the textbooks the electrocardiogram in hyperthyroidism discloses no distinct feature except the usual nonspecific sinus tachycardia (100%), the characteristic atrial fibrillation (10%), and occasional arrhythmia. Recently the author encountered 135 cases of thyrotoxicosis, which were examined electrocardiographically, finding sinus tachycardia, left ventricular hypertrophy, prolongation of P-R, low voltage in limb leads, atrial flutter-fibrillation, sinus arrhythmia, ventricular premature contraction, and normal one in them. Among them the prolongation of P-R interval is so characteristic of hyperthyroidism that the author wants to proclaim it should be considered as a manifestation of hyperthyroidism.

This paper is intended to testify to it.

Material and Criteria

The 135 cases of thyrotoxicosis visited my clinic in the year of 1958 (Jan. 1st through Nov. 29), consisting of 8 cases of toxic goiter, with exophthalmos, 16 cases of toxic nodular goiter, 94 cases of toxic diffuse goiter, and 17 cases of hyperthyroidism without goiter.

The 135 cases of thyrotoxicosis visited my clinic in the year of 1958, consisting of		RELATION OF SEX AND AGE TO TOXIC GOITER SEX DISTRIBUTION	
1. Toxic diffuse goiter	94 cases (70%)	Male	38 cases (28%)
2. Toxic nodular goiter	16 cases (12%)	Female	97 cases (72%)
3. Toxic goiter with Exophthalmos	8 cases (6%)	Total	135 cases (100%)
4. Hyperthyroidism without goiter	17 cases (12%)	AGE DISTRIBUTION	
Total	135 cases (100%)	First decade (0-10)	0 case (0%)
		Second decade (10-20)	21 cases (15%)
		Third and fourth decades	88 cases (65%)
		Fifth decade (40-50)	17 cases (13%)
		Sixth decade (50-)	9 cases (7%)
		Total	135 cases (100%)

The criteria for diagnosis are symptoms of nervousness, hyperhidrosis, hypersensitivity to heat, fatigue, and weight loss, and signs of tachycardia, tremor, goiter and greater pulse pressure. As we have no facilities of measurements of PBI, or I^{131} uptake studies, we use BMR measurements only. Lastly the diagnosis of all cases was confirmed by

therapeutic tests. Administration of propylthiouracil 300-400 mg daily for 4-8 weeks followed by improvements in the clinical status and a clearly related decrease in BMR is the indication of thyrotoxicosis.

Of the 135 cases, 38 were males, and 97 were females: 21 were under the age of 20, 88 were between the age of 20-40, 17 were 40-50 years of age, and 9 were above the age of 50.

THE ELECTROCARDIOGRAMS IN THYROTOXICOSIS			70/m	90/m	110/m
Sinus tachycardia	120 cases (90%)	Adult	0.20sec.	0.18sec.	0.16sec.
Left ventricular hypertrophy	31 cases (23%)	Children			
Prolongation of P-R interval	12 cases (9%)	0-1½	0.16	0.145	0.135
Low voltage in limb leads	9 cases (7%)	1½-6	0.17	0.155	0.145
Atrial flutter-fibrillation	4 cases (3%)	7-13	0.18	0.16	0.15
Sinus arrhythmia	3 cases (2%)	14-17	0.19	0.17	0.16
Ventricular premature contraction	2 cases (1.5%)				
Normal	10 cases (8%)				

Fig. 1.

The electrocardiograms showed: sinus tachycardia in 120 cases (90%), suggestive of left ventricular hypertrophy in 31 cases (23%), prolongation of P-R interval in 12 cases (9%), low voltage in limb leads in 9 cases (7%), atrial flutter-fibrillation in 4 cases (3%), sinus arrhythmia in 3 cases (2%), ventricular premature contraction in 3 cases (1.5%), and normal one in 10 cases (8%). The criterion for the prolongation of P-R interval: The P-R interval is the period of time from the beginning of auricular depolarization (onset of P wave) to the beginning of ventricular depolarization (onset of QRS), which represents the amount of time necessary for the impulse to pass over the auricles, the A-V node, and the bundle of His. This period of time should not be more than 0.20 second. The more rapid the heart rate, the more quickly the A-V conduction must occur. Therefore the P-R interval varies with the heart rate and with the age as well.

According to Dr. E. Grey Diamond the upper limits of P-R interval are outlined in the accompanying chart. (Fig. 1.)

The most common causes of the prolongation of P-R interval are acute rheumatic carditis, digitalis intoxication and arteriosclerotic heart disease. That hyperthyroidism is also a cause of it, has not been mentioned in any literature as much as I know.

The electrocardiograms taken at my office from April 1957 through Nov. 29, 1958 were 1153 in number. Among them the prolongation of P-R interval was found in 90 cases. In the 90 cases of the prolongation of P-R interval there were 12 cases, which were considered to be due to hyperthyroidism.

The cases regarded as due to hyperthyroidism were examined for ESR to eliminate acute rheumatic carditis as the latter has a rapid ESR in most cases (98%). To exclude the one due to digitalis intoxication a careful history was taken. Also to exclude the one

due to arteriosclerotic heart disease ophthalmoscopic examination of the eye grounds was done.

Report of Cases

Case 1. A 20 years old woman was seen at my office, complaining of nervousness,

CASE No. 1

Fig. 2. Electrocardiogram in Toxic Goiter, female, age 20. Sinus Rythm, Rate regular 120/m, P-R 0.20, QRS 0.08, QT 0.32, Vector QRS +60°, Vector T +60°, S1+R4=16+30=46. Impression: Sinus Tachycardia, Prolongation of P-R interval, and Suggestive of Left Ventricular Hypertrophy.

hyperhidrosis, hypersensitivity to heart, palpitation of heart, and weight loss of 6 kg. with goiter of two years' duration. Tapazole or methylthiouracil caused skin rashes. On physical examination: her skin was moist. Pulse rate regular 120/m, B.P. 130/60

CASE No. 2

Fig. 3. Electrocardiogram in Toxic Goiter, female, age 30, Sinus Rhythm, Rate regular 122/m, PR 0.22, QRS 0.08, QT 0.23, Vector QRS $+60^\circ$, Vector T $+60^\circ$, $S_2 + R_5 = 30 + 30 = 60$. Impression: Sinus Tachycardia, Prolonged PR, and Suggestive of Left Ventricular Hypertrophy.

mmHg. HEENT: goiter diffusely enlarged without tenderness. Eye grounds: negative. Otherwise essentially negative except for fine rhythmical tremor of hands appreciated. Laboratory findings: BMR +76%, ESR 3 mm/hr, RBC 3900,000/c.D.C., WBC 5,600/c.D.C.: Neutrophils 68%, Lymphocytes 32%, Urine: Albumin (-), Sugar (-), Ecg.: sinus rhythm rate regular 120/m, P-R 0.20", QRS 0.07", QT 0.32", S1+R4=42. Sinus tachycardia, prolongation of P-R interval, and suggestive of left ventricular hypertrophy.

Course and Treatment: She was given propylthioracil 400 mg daily for eight weeks with improvement in symptoms (gaining weight about 2 kg.), and in signs (pulse rate 80/m, B.P. 120/80mmHg. goiter has become smaller than before, BMR+9%. Ecg: rate regular 78/m, P-R 0.18", QRS 0.08", QT 0.36").

Case 2. A 30 years old woman has developed goiter of 4 years' duration with toxic symptoms such as excessive perspiration, nervousness, palpitation of heart with exertional breathlessness, and loss of weight of about 6 kg. meanwhile. On physical examination: pulse rate regular 120/m, B.P.160/80 mmHg. HEENT: goiter of moderate, diffuse enlargement without tenderness. Otherwise, negative except for tremor of hands and feet and positive leg test and decreased knee jerks. Laboratory finding: BMR+62%, ESR 2 mm/hr, Hct 46% with normal differential count. Urine: negative in albumin and sugar. Ecg.: sinus rhythm, rate regular 122/m, P-R 0.22", QRS 0.08", QT 0.28", S2+R5=60, Impression of Ecg.: sinus tachycardia, prolonged P-R and suggestive of left ventricular hypertrophy.

Course and Treatment: Administration of propylthiouracil 400 mg daily for seven weeks with much improvement in symptoms and signs (pulse rate 75/m, B.P. 120/80mmHg,

Table 1. Chief Symptoms, Signs and Laboratory Tests.

Case No.	Age Yr.	Sex	Duration of Symptoms (months)	Loss of wt. (Kg.)	Nervousness	Exophthalmos	Goiter	Pulse Rate	B. P. (mmHg)	Ecg.	ESR (mm/hr.)	BMR
1	20	F	24	6	###	—	D3	120/m	130/60	ST PPR LVH	3	+76%
2	30	F	48	6	###	—	D2	120/m	160/80	ST PPR	2	+62%
3	18	M	3	1	++	—	—	115/m	150/80	ST PPR	0	+38%
4	32	F	72	5	##	+	D2	115/m	150/80	ST PPR	4	+48%
5	31	F	8	2	##	—	D2	108/m	150/90	ST PPR LVH	0	+32%
6	35	F	36	0	##	—	N2	94/m	130/90	ST PPR LVH	2	+25%
7	32	F	12	0	++	—	D2	100/m	130/80	ST PPR	3	+32%
8	18	M	48	4	##	—	D1	120/m	140/80	ST PPR	0	+28%
9	38	F	24	2	##	—	N3	100/m	130/80	ST PPR LVH	8	+24%
10	16	M	6	0	###	—	—	100/m	150/90	ST PPR LVH	2	+30%
11	24	M	36	6	##	—	—	120/m	124/80	ST PPR	3	+20%
12	33	M	15	10	##	—	D3	108/m	170/80	ST PPR LVH	0	+60%

* D-diffuse; N-nodular; 1-barely palpable; 2-palpable and visible; 3-grossly visible; ST-sinus tachycardia; PPR-prolonged P-R interval; LVH-left ventricular hypertrophy; ESR (Wintrobe and Landsberg) normal 0-10 mm/hr.; BMR normal -10%—+15%.

Ecg.: pulse rate 75/m, P-R 0.20") BMR 3%, goiter became smaller.

Later on this patient was given I^{131} 5 mc orally with complete remission in three months.

Case 9. A 36 years old woman has been complaining of goiter of two years' duration

CASE No. 9

Fig. 4. Electrocardiogram in Toxic Goiter, female, age 39, Sinus Rhythm, Rate regular 100/m, PR 0.24, QRS 0.06, QT 0.32, Vector QRS +30°, Vector T-not clear, $S1 + R4 = 7 + 30 = 37$. Impression: Sinus Tachycardia, Prolongation of PR interval, and Suggestive of Left Ventricular Hypertrophy with strain.

accompanied by palpitation of hearts, tremor of hands, hyperhidrosis, frequent nocturia, and preference of cold weather to warm one, and loss of weight 2 kg. in the meantime. On physical examination: A nervous woman in no acute distress, pulse rate 100/m, B.P. 130/80 mmHg. HEENT: goiter of nodular enlargement, about 40 grams in size,

CASE No. 12

Fig. 5. Electrocardiogram in Toxic Goiter, male, age 33. Sinus Tachycardia, Prolonged PR, & Suggestive of LVH. Sinus Rhythm, Rate regular 94/m, PR 0.22, QRS 0.10, QT 0.44, Vector QRS+60°, Vector T+60, S2+R5=25+36=61.

with neck circumference of 32.5 cm. but without tenderness. Eye grounds: negative. Heart and lungs were normal on percussion and auscultation. Otherwise essentially negative. Laboratory finding: BMR +24%, ESR 8 mm/hr, Hct 38%, RBC 4020,000/c.D.C. WBC 7,100/c.D.C. Hgb 68%, Ecg.: sinus tachycardia, prolonged P-R interval (0.24"), and suggestive of left ventricular hypertrophy. Impression; Toxic, nodular goiter.

Course and Treatment:

Patient was given methylthiouracil 400 mg daily in four doses, and after four weeks' administration, she felt much improved in symptoms and signs with neck circumference of 30.5 cm, pulse rate regular 94/m, B.P. 120/80 mmHg, P-R 0.20". Finally she was given I 131 5 mc with complete recovery in two months.

Case 12. A thin but well nourished laborer has developed a diffuse goiter of 15 months' duration, with excessive perspiration, nervousness, frequent nocturia and weight loss of 10 kg.. Past history: negative. Familiar history: noncontributory. On physical examination: A thin man in no acute distress, pulse rate regular, 108/m, B.P. 170/80

Electrocardiogram after medication

Fig. 6. Electrocardiogram of Case 9 after four weeks' medication of Methylthiouracil 400 mg daily. Pulse rate regular 94/m P-R 0.20 (cf. PR 0.24 before medication).

Fig. 7. Electrocardiogram of Case 2 after seven weeks' medication of Propylthiouracil 400mg daily. Pulse rate 75/m, PR 0.20. (cf. Pulse rate 122/m, PR 0.22" before medication in Fig. 3.)

Table 2. Chief Symptoms, Signs and Laboratory Tests after medication.

Case	Medication	Duration	Gain of wt.	Goiter	Pulse rate	B. P. (mmHg)	Ecg.	BMR
1	PPL 400mg	8 wks.	2 kg	D2	80/m	120/60	LVH	+ 9%
2	PPL 400mg	7 wks.	1 kg	D2	75/m	120/80	n.	+ 3%
3	PPL 400mg	7 wks.	0 kg	—	72/m	130/90	n.	+ 8%
4	PPL 400mg	6 wks.	3 kg	D2	75/m	130/80	n.	+ 6%
5	PPL 400mg	7 wks.	3 kg	D1	78/m	120/80	LVH	+10%
6	PPL 400mg	4 wks.	0 kg	N2	84/m	110/80	LVH	+ 5%
7	PPL 400mg	8 wks.	0 kg	D1	82/m	120/80	n.	- 2%
8	PPL 400mg	8 wks.	1 kg	D1	78/m	130/90	n.	+ 5%
9	MTL400mg	4 wks.	0 kg	N2	94/m	120/80	LVH	+12%
10	PPL 400mg	8 wks.	0 kg	—	78/m	130/90	LVH	+ 8%
11	PPL 400mg	4 wks.	3 kg	—	84/m	116/80	n.	+ 2%
12	MTL400mg (daily)	8 wks.	2 kg	D2	84/m	140/80	LVH	+14%

PPL—propylthiouracil MTL—methylthiouracil n.—normal

mmHg. HEENT: goiter of diffuse enlargement without tenderness, about 50 grams in size. No exophthalmos. Cardiovascular: heart was enlarged to left side without murmur or thrill. Lungs are clear on percussion and auscultation. Otherwise ess. negative except for tremor of hands and feet and decreased knee jerks. Laboratory finding: BMR +60%, ESR 0 mm/hr, Hct 36%, RBC 3550,000/c.D.C., WBC 6,500/c.D.C. Hgb 55%.: Neutrophils 49%, Lymphocytes 46%, Monocytes 3%, Eosinophils 2%, Ecg.: prolonged P-R interval, sinus tachycardia, and suggestive of left ventricular hypertrophy. Impression: Toxic goiter. Treatment: The patient was placed on medication of methylthiouracil 400 mg a day. After eight weeks' medication the goiter became smaller and prolongation of P-R interval disappeared in Ecg.

Conclusion

In 135 cases of thyrotoxicosis, 12 cases of prolonged P-R interval were found (approximately 10%). This is much more than the cases of auricular fibrillation in thyrotoxicosis, which are only 4 cases in my series, though it is said to be 10% of all thyrotoxicosis. The prolongation of P-R interval which appears in thyrotoxicosis, disappears with the improvement of the disease after administration of antithyroid drugs for 4-8 weeks. This strongly suggests that the prolongation of P-R interval is characteristic of hyperthyroidism. In every case digitalis intoxication, arteriosclerotic heart disease or rheumatic carditis is excluded. The excessive thyroid hormone may exert some effect in the heart muscle cell, which causes delay or disturbance in the conduction, manifesting itself as auricular flutter-fibrillation or prolongation of P-R interval.

Summary

135 cases of hyperthyroidism were examined electrocardiographically. Among them, 12 cases showed prolongation of P-R interval, which is characteristic of thyrotoxicosis, the author found.

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