THE TIMING OF THE KOROTKOFF SOUNDS: A MEASURE OF HYPERTHYROIDISM

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SYNOPSIS

The interval between the onsets of the ORS complex and of the brachial Korotkoff sounds at the diastolic pressure in 23 cases of hyperthyroidism was distinctly shorter, 0.15 ± 0.002 sec (SE), than the interval of 0.21 ± 0.004 sec obtained in euthyroid subjects. Measurement of this interval offers a simple, safe, rapidly obtained index of thyroid function.

The timing of the Korotkoff sounds in the cardiac cycle is of value in the study of various cardiovascular abnormalities. (Rodbard *et al.* 1957 and 1965) In patients with hypothyroidism, the interval between the onsets of the electrical activity of the heart and of the arterial sounds of Korotkoff at the brachial artery is abnormally prolonged. (Rodbard *et al.* 1966) The time of onset of the Korotkoff sounds in the cardiac cycle was therefore examined in patients with hyperthyroidism.

MATERIALS

Studies were performed on 23 hyperthyroid subjects and 23 clinically euthyroid subjects, with ages ranging from 23 to 70 years. The measurements were performed at the Ito Hospital of Tokyo, or at the Department of Geriatrics, University of Tokyo.

METHODS

The patient was comfortably recumbent. Electrocardiographic leads of a phonocardi-

graphic machine were connected to the four limbs to provide a time reference. A sphygmomanometer cuff on the upper arm inflated to a pressure higher than the systolic pressure was allowed to deflate slowly to a level well below the diastolic pressure. A microphone placed lightly over the brachial artery transmitted the acoustic signal to the second channel of the recorder. Each 10 mm Hg fall in cuff pressure was marked by the introduction of standardization impulses into the electrocardiogram; a double standardization marked the 100 mm Hg level. The time from the onset of the QRS complex (Q) to the onset of the Korotkoff (K) was termed the QK interval. The interval at the systolic (s) pressure was designated as QKs; the interval at the diastolic (d) pressure was designated as QKd. The difference between QKs and QKd was listed as QKs-d and designated as the rise time (T) of the arterial pressure wave. Pulse pressure (P) was divided by T to give the mean rate of pressure rise, P/T.

RESULTS

Tables 1 and 2 demonstrate that patients

Table 1. Korotkoff sounds in hyperthyroidism

Initials	Age	Sex	Arterial Pressure mm Hg			Korotkoff Interval secs.			P/T mm Hg	BMR %	RAIU	PBI γ/ml	Resin Sponge Uptake %
			Systo- lic	Dia- stolic	Pulse (P)	QKs	QKd	QKs-d (T)	0.01 sec.				
MH	75	F	138	65	73	.34	.16	.18	4.0	+50			61
TH	57	M	120	85	35	.19	.13	.06	5.8	+88			59
MT	48	F	112	15	97	.22	.13	.09	10.8				
HT	46	F	124	15	109	.32	.15	.17	6.4	+56			
RS	42	F	165	90	75	.25	.15	.10	7.5	+73	72	5.5	
MW	41	F	165	55	110	.37	.15	.22	5.0	+61			
RS	38	F	130	40	90	.25	.15	.10	9.0	+96	76	8.4	
FA	33	F	155	25	130	.24	.14	.10	13.0	+58			39
HA	33	M	156	10	146	.27	.14	.13	11.2	+43			40
TI	31	F	120	58	62	.23	.16	.07	8.9	+110			56
MH	31	M	135	30	105	.28	.16	.12	8.8	+69		13.9	
MK	30	F	144	74	70	.23	.15	.08	8.8	+75			
MT	30	F	128	82	46	.35	.17	.18	2.6	+47			
TK	29	M	140	12	128	.25	.15	.10	12.8	+75	59	14.3	
KU	27	F	126	32	94	.28	.13	.15	6.3	+43			
HI	26	F	138	10	128	.30	.14	.16	8.0	+37	75		56
SM	25	F	132	20	112	.26	.15	.11	10.2	+34	51		
SO	25	F	120	60	60	.27	.15	.12	5.0	+72			58
AO	25	F	129	48	81	.29	.16	.13	6.2	+25			
KE	23	F	140	75	65	.31	.16	.15	4.3	+80		16.3	50
SH	23	M	155	30	125	.28	.15	.13	9.6	+105		20.0	53
KF	23	M	124	42	82	.30	.16	.14	5.8	+54			34
HS	22	M	143	25	118	.27	.16	.11	10.7	+75	59	14.3	
Average	34	7M 16F	136±3*	43±5*	96±6*	.28 ±.009	.15* ±.002	.13 ±.008	7.8* ±0.6				

*P<0.01 from Euthyroid Subjects.

with hyperthyroidism had higher systolic and pulse pressures, and lower diastolic pressures than were found in euthyroid subjects of the control group. QKd was shorter in hyperthyroid subjects than in euthyroid controls. QKs and QKs-d did not discriminate between euthyroid and hyperthyroid subjects. The mean rate of pressure rise, P/T, was greater in the hyperthyroid patients than in the euthyroid subjects. BMR and QKd in the hyperthyroid subjects were not correlated (Fig. 1).

DISCUSSION

The QKd time is the sum of a chain of physiological intervals including the time

required for ventricular depolarization, mobilization of myocardial tension, and elevation of pressure sufficient to equal the systemic arterial diastolic pressure and to open the aortic valve, and the interval required for transmission of the pressure wave from the aortic valve to the recording site. The interval from the onset of electrical activity in the ventricle until the aortic valves open is normally about 0.07 sec. The time required for the arterial pressure wave to pass from the aortic valve to the cuff and to generate a sound may be considered to account for the remainder of the QKd interval.

It has long been known that the heart is very sensitive to circulating thyroid hormones.

Table 2. Korotkoff sound in euthyroid subjects

Initials	Age	Sex	Arterial Pressure mm Hg		Pulse(P)	Korotkoff Interval (sec.)			P/T mm Hg 0.01 sec.
			Systolic	Diastolic		QKs	QKd	QKs-d (T)	
TA	65	M	160	110	50	.36	.21	.15	3.3
TO	58	M	110	85	25	.36	.24	.12	2.1
HN	48	M	146	85	61	.33	.21	.12	5.1
SI	46	M	110	72	38	.30	.20	.10	3.8
MI	44	M	95	76	19	.28	.22	.06	3.2
SK	42	F	75	50	25	.28	.21	.07	3.6
TM	39	M	130	60	70	.31	.20	.11	6.4
TS	38	M	124	72	52	.30	.20	.10	5.2
YI	38	M	95	53	42	.27	.20	.07	6.0
TF	36	M	108	78	30	.34	.24	.10	3.0
YE	35	M	95	50	45	.30	.20	.10	4.5
TS	35	M	127	72	55	.32	.18	.14	3.9
TO	33	F	98	68	30	.32	.23	.09	3.3
MI	33	F	120	78	42	.30	.22	.08	5.2
MI	33	M	124	72	52	.30	.20	.10	5.2
KT	32	M	112	60	52	.32	.20	.12	4.3
KH	32	M	142	78	64	.30	.18	.12	5.3
SH	31	M	118	75	43	.32	.22	.10	4.3
MS	29	F	140	115	25	.28	.22	.06	4.2
KI	26	F	114	25	89	.34	.22	.12	7.4
YK	26	F	108	72	36	.37	.22	.15	2.4
SM	24	F	115	55	60	.32	.20	.12	5.0
NT	23	F	97	55	42	.32	.22	.10	4.2
Average	37	15M	116±4	70±4	46±3	.31	.21	.10	4.4
		8F				±.006	±.004	±.005	±0.3

Fig. 1. BMR and QKd in Hyperthyroidism

Recently it has been found that the sinus node takes up thyroid hormone selectively (Tommaselli *et al.*, 1965). Thyroid hormones can increase the heart rate and probably increase the rate of mobilization of myocardial tension, (Brewster *et al.*, 1958) accelerating the rise in ventricular pressure. It is possible that when the rate of mobilization of ventricular tension is increased, the velocity of the pulse wave is accelerated. This conclusion is suggested by the shortening of the QKd interval by as much as 0.07 sec in hyperthyroidism. Some of the shortening of the QKd interval must therefore be due to a reduction in the time required for transmission of the pressure wave from the aortic valve to the cuff.

Complete separation of QKd values in the two groups of subjects in the present

experiment suggests that this measure may be useful in evaluating the state of excessive thyroid activity. Thus, all hyperthyroid subjects showed QKd values less than 0.17 sec while all euthyroid subjects showed QKd values of 0.18 sec or longer. Evidence has been presented previously that hypothyroid states are associated with prolongation of the QKd (Rodbard *et al.*, 1966). In view of the QKd values of 0.16 ± 0.01 in another group of 10 patients with milder hyperthyroidism with BMR of 30 ± 4 %, occurrence of borderline QKd values is quite conceivable.

The mean rate of rise of the arterial pressure, P/T, was also significantly higher in hyperthyroidism than in euthyroidism, although there was considerable overlap of values obtained on hyper- and euthyroid subjects.

The absence of a readily recognizable correlation between QKd and basal metabolic rate, BMR, suggests that these two estimates of thyroid hyperactivity may represent somewhat different manifestations of the disease.

The measurement of QKd appears to offer a useful estimate of thyroid function. Thus, preparation of the patient by fasting or sedation is not necessary, previous intake of iodine need not be considered, venipuncture

is unnecessary, and the use of *in vivo* or *in vitro* radioiodine is not required. This safe, rapid test may offer some clinical advantages for the estimation of thyroid function, although conditions with high cardiac output such as anemia, fever, and post-exercise state could give false positive results.

ACKNOWLEDGEMENT

The cooperation of Drs. Hajime Orimo and Masahiro Ohata of the Department of Geriatrics, University of Tokyo Faculty of Medicine is appreciated.

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