SHORT COMMUNICATION

EFFECT OF INADEQUATE FREQUENCY RESPONSE OF DIRECT WRITING ELECTROCARDIOGRAPH ON RAT ELECTROCARDIOGRAM

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(Received on August 28, 1984)

Summary : Fairly good electrocardiograms of rats can be recorded by using a band width of 0.5 to 75 Hz. Change in low frequency did not alter the wave pattern or duration. Change in high frequency altered the durations and wave pattern grossly. 50 Hz filter is useful in avoiding AC interference but creates artificial notches in all the waves.

Key words : rat ECG frequency response

INTRODUCTION

Rat electrodocardiogram (ECG) is frequently employed as a tool to assess effects of various factors under experimental conditions (5,6,7,8,9). Rat heart rate is very high and S-T segment in its ECG is generally absent. Errors in amplitude and wave shape of ECG can occur with inadequate frequency response of the recording system (1,2).

At present, most of the direct writing electrocardiographs have high frequency response ranging from 75-100 Hz. Integrity of recorded output may be affected by low as well as high frequency characteristics of commonly used A.C. recording systems. With the instruments available for recording human ECG, inadequate frequency may fail to resolve fine details in rat ECG and may also introduce slurs and notches on the QRS complex.

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In this study, an attempt has been made to evaluate the effect of inadequate frequency response of the electrocardiograph on rat ECG.

MATERIAL AND METHODS

ECG records from twenty adult rats (150-200 g BW) were obtained under light ether anaesthesia using 26 gauge needle electrodes placed subcutaneously in the limbs, at a paper speed of 100 mm/sec and sensitivity of 20 mm/1 mV on a polygraph (Grass Model).

Control ECGs were recordcd with the band width of 0.5 Hz to 75 Hz of the recording and amplifier unit. ECGs were repeated with (a) 50 Hz filter, (CF), and recordings were continued at (b) 0.5 to 35 Hz band (HF 35), (c) 0.5 to 15 Hz band (HF 15), (d) 0.1 to 75 Hz band (LF 1) and (e) 0.C4 to 75 Hz band (LF 2).

Six tracings of ECG were obtained from each animal and each tracing was analysed for amplitudes and durations of various complexes and intervals. Total number of ECG tracings analysed were 120.

Intervals and duration were measured using a magnifying lens. In case of QRS complexes, the amplitudes and durations were estimated keeping in mind the variations in rat ECGs. With normal pattern of QRS, amplitude was estimated from lowest point of 'S' wave to the peak of 'R' wave, but only in the presence of ST elevation, this amplitude was measured either from lowest point of Q wave (if present) or from the isoelectric line.

In the evaluation of the error, measurements made on the control band were taken to be 'true' values. Measurements made on the identical ccmplex of the records taken at other frequency responses were compared with these 'tıue' values and any deviations were regarded as errors caused by the limited frequency response of ıhe recording system.

RESULTS

1. (a) With the amplifier frequency width of 0.5-35 Hz (HF 35) the amplitudes of P, QRS and T decreased drastically. The durations showed prolongation but this was not significant. The striking feature was the elevation of ST segment (Table I, Fig. 1).

(b) When the amplifier frequency was further reduced to 15 Hz (HF 15), decline in amplitudes and elevation of ST segment were more pronounced. Both QRS duration, and QT interval were found to be prolonged in some tracing (Table I, Fig. 1).

TABLE I : Effect of frequency alteration and 50 Hz filter on rat ECG.

Frequency response	Complexes and Intervals	Duration: Increase, Less than 25%	Duration: Increase, More than 25%	Duration: No change	Duration: Decrease, Less than 25%	Amplitude: Increase	Amplitude: No change	Amplitude: Decrease, Less than 25%	Amplitude: Decrease, More than 25%
0.5-35 Hz	P	25	—	65	10	—	—	20	80
	P-R	10	—	90	—	—	—	—	—
	QRS	70	20	10	—	—	—	10	90
	Q-T	20	—	70	10	—	—	—	—
	T	25	5	20	50	—	—	15	85
0.5-15 Hz	P	35	—	65	—	—	—	10	90
	P-R	25	—	75	—	—	—	—	—
	QRS	85	5	10	—	—	—	10	90
	Q-T	80	15	5	—	—	—	—	—
	T	80	15	5	—	—	—	85	15
0.5-75 Hz with 50 Hz Filter	P	15	85	—	—	—	—	10	90
	P-R	5	—	90	5	—	—	—	—
	QRS	10	90	—	—	—	—	85	15
	Q-T	40	10	35	15	—	—	—	—
	T	5	5	70	20	5	5	80	10

The numbers indicate percentage of records that showed significant variation in the parameter from the control values recorded with the band width of 0.5-75 Hz.

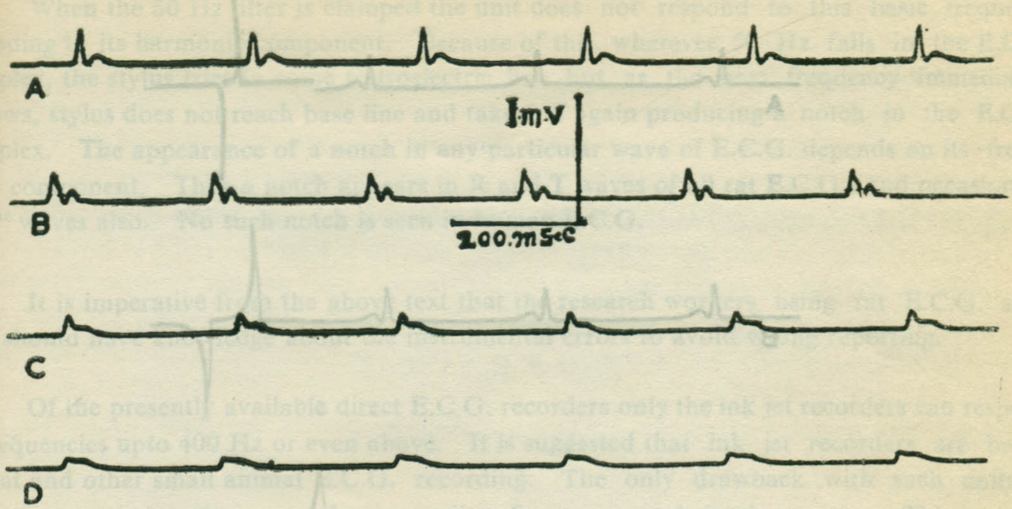

Fig. 1 : Rat ECG (Lead II) tracings recorded with 0.5 Hz-75 Hz band width (A), 50 Hz filter (B) and at frequencies of 0.5 to 35 Hz (C) and 0.5 to 15 Hz (D).

2. Reduction in low frequency response of the amplifier (LF 1 & LF 2) produced change in calibration voltage. But the ECG of rat failed to register any change under this influence (Fig. 2).

3. The amplitude of P, QRS and T showed a decline significantly by 50 Hz filter. The QRS duration was also affected to a significant degree. But PR and QT interval were not affected to a significant extent (Tables I and II).

TABLE II : QRS duration and Q-T interval after alteration in frequency response and use of 50 Hz filter.

	Control	*50 Hz Filter*	*0.5−35 Hz*	*0.5−15 Hz*
QRS duration (sec)	0.02315 ±0.00076	0.0305 ±0.0011**	0.0268 ±0.00081*	0.02635 ±0.00092*
Q-T interval (sec)	0.0702 ±0.00085	0 07305 ±0.00188	0.07194 ±0.00099	0.08155 ±0.0010**

Values are mean±SE. Statistically significant (*=p<0.01 and **=p<0.001) as compared to control values recorded withthe band width 0.5 −75 Hz.

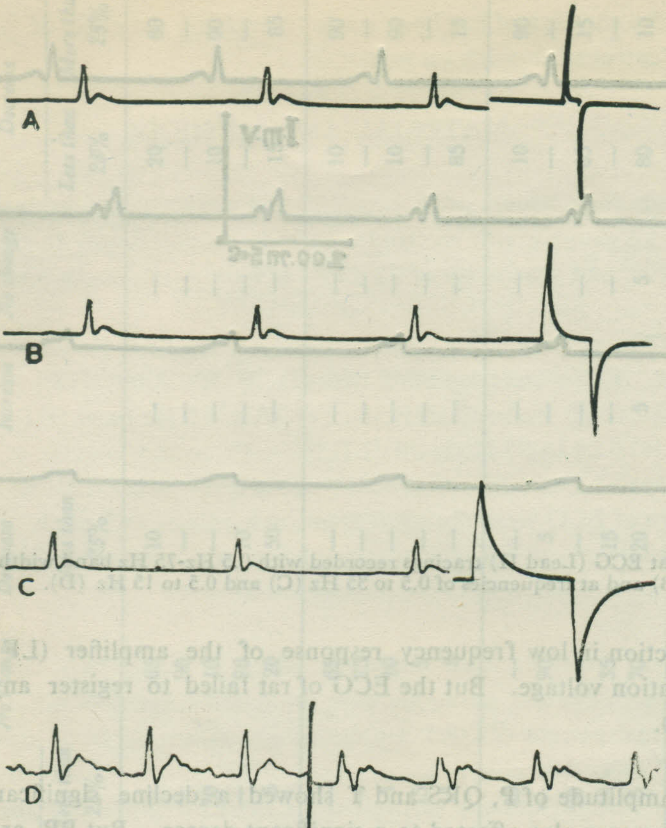

Fig. 2 : Rat ECG (Lead II) tracings recorded at frequencies of 0.04 to 75 Hz (A) 0 1 to 75 Hz (B) and 0.5 to 75 Hz (C). Lowermost tracing (D) on the left shows 50 Hz AC interferference when 50 Hz fiilter was not used. With the filter (right) AC interference is cleared but notches in QRS and T waves are clearly seen.

DISCUSSION

The present study shows that inadequate frequency response of the instrument produces distortions in the ECG of rats.

Any primary wave has its harmonics spread on either side of it. When the frequency response of the instrument in adequate to cover the primary as well as its harmonics then the wave can be inscribed in microdetail without distortion.

When the instrumental frequency response is inadequate it results in smooth rounded ends instead of normal sharp edges. This makes it difficult to demarcate the end of a wave exactly. Even the movement of the stylus becomes sluggish. Because of these two reasons the intervals and durations get prolonged, amplitude attenuation occurs and ST elevation also appears All the distortions that appeared in rat E.C.G. can be explained on this basis.

When the 50 Hz filter is clamped the unit does not respond to this basic frequency including to its harmonic component. Because of this, wherever 50 Hz falls in the E.C.G. complex, the stylus tries to come to isoelectric line but as the next frequency immediately follows, stylus does not reach base line and takes off again producing a notch in the E.C.G. complex. The appearance of a notch in any particular wave of E.C.G. depends on its frequency component. Thus a notch appears in R and T waves of all rat E.C.G.s and occasionally in 'P' waves also. No such notch is seen in human E.C.G.

It is imperative from the above text that the research workers using rat E.C.G. as a tool should have knowledge about the instrumental errors to avoid wrong reporting.

Of the presently available direct E.C.G. recorders only the ink jet recorders can respond to frequencies upto 400 Hz or even above. It is suggested that ink jet recorders are better for rat and other small animal E.C.G. recording. The only drawback with such units is electro magnetic interference at the power line frequency and its harmonics. This can be avoided with proper shielding and earthing.

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