EFFECT OF CHANGE IN LIMB POSITION ON MEAN ELECTRICAL AXIS AND AMPLITUDES OF QRS COMPLEX OF RAT ELECTROCARDIOGRAM

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Summary : The effect of altered fore limb alignment to trunk on mean electrical axis (MEA) and on amplitude of the QRS complex of frontal plane leads was studied in both prone and supine postures in 32 albino rats. It was found that in both postures bilateral extension of fore limbs caused a significant change in MEA to right. Unilateral change in the fore limb alignment caused a shift in MEA to right only in supine position, but was ineffective in prone position. The amplitudes of QRS complexes also changed with change in MEA. The changes in MEA with change in limb alignment and subsequent alteration in amplitude of QRS complexes can be attributed to the alteration in anatomical orientation of the heart in the chest cavity.

Key words : electrocardiogram in rat mean electrical axis posture

INTRODUCTION

Features of normal electrocardiogram (ECG) in rat have been described by various investigators (4,5,6,7,8,9). These descriptions vary on one or more points. Many of these differences appear to be due to the details of recording techniques employed in these studies. Position of the animal is also considered by these workers as one of the important factors affecting ECG pattern in small animals. Some (2, 8, 10) have preferred supine position while others (1, 9) have considered prone position suitable for such work.

The mean electrical axes (MEA) obtained from the ECGs in these studies show wide variations. MEA in prone position has varied from –22 to +120 in rat ECGs recorded by Beinfield and Lehr (1) whereas the range was narrow in the same position used by Normann *et al.* (9). Such wide differences in the MEA are also noticed in supine position of rats (11, 12, 13).

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In all these investigations, limb alignments in relation to the trunk has not received due attention. Hanging of limbs in supine position (2) have been described. In small animals like rats, anatomical orientation of heart is most liekly to alter to a significant extent, when limbs especially the fore limbs are kept at different positions in relation to the trunk.

In interpreting the ECG, in studies using rats as experimental animals, the position of the animal should also be taken into account. In this work, an attempt has, therefore, been made to study the effect of alteration in fore limb alignments on the MEA and ventricular complexes of ECG in supine and prone positions of the rat.

MATERIAL AND METHOD

Thirtytwo healthy albino rats of ether sex weighing 120-180 *gm* were used in this study. ECGs were recorded under light either anaesthesia in various fore limb positions of the rat.

Electrodes constructed from 26 gauge needles were placed subcutaneously and ECGs were recorded by employing frontal plane leads (I, II, III/aVR, aVL and aVF) on Grass Polygraph model 7 with a paper speed of 100 mm/sec. Sensitivity was adjusted to provide a deflection of 20 mm/mV.

In each limb position, care was taken to keep the needle electrodes at a fixed distance (50 mm and 130 mm in case of fore and hind limbs respectively) from a chosen point located at the level of second rib on the intersternal line to minimise the positions in tissue impedance while varying the limb positions.

The position of one or both fore limbs was altered as described below in supine (dorsal) as well as prone (ventral) position of each animal before recording ECG.

1. Both fore limbs kept at right angles to the trunk (A).
2. Both fore limbs extended upwards at an angle of 135° to the trunk (B).
3. Both fore limbs approximated towards the body at an angle of 45° to the trunk (C).

4 & 5. One of the fore limbs extended upwards at an angle of 135°, while keeping the other at right angle (D & E).

6. All the four limbs were kept hanging (in prone position only) (F).

Hind limbs were kept in slightly extended position throughout the experiment.

In all 352 tracings were analysed. Maximum amplitudes in mm of ventricular complexes (QRS) in all ECG leads were measured. Amplitudes of QRS complexes from Lead I and III were employed to dertemine the MEA in each position (4).

All values were analysed statistically and were compared with the controls using student's 't' test.

RESULTS

Heart rate and respiratory rate observed in this study were not affected by the change in position (Table I).

TABLE I : MEA, heart rate and respiratory rate in different limb alignments (A to E as in text).

PRONE POSITION					*SUPINE POSITION*				
Limb alignment	*Frontal plane axes*		*Heart Rate*	*Respiratory rate*	*Limb alignment*	*Frontal Plane axes*		*Heart rate*	*Respiratory rate*
	Mean ±SE	*Range of axes*	*Mean ±SE*	*Mean ±SE*		*Mean ±SE*	*Range of axes*	*Mean ±SE*	*Mean ±SE*
C	54.5± 1.87°	41.–64°	395.0± 11.0	72.0± 3.7	C	52.88± 2.09°	42°–61°	402.5± 9.9	69.8± 4.0
A	74.0*± 2.347°	60.–90°	401.8± 9.0	65.5± 3.1	A	67.13*± 1.84°	55°–80°	387.2± 10.6	75.2± 8.8
B	71.85*± 1.17°	64°–78°	382.6± 7.5	70.0± 2.9	B	71.12*± 1.63°	62°–83°	394.0± 7.9	64.9± 2.9
D	59.50± 2.24°	55°–69°	405.5± 10.0	64.8± 3.6	E	79.75*± 2.15°	72°–100°	421.9± 9.2	63.0± 3.2
E	56.25± 1.17°	48°–62°	372.0± 8.5	79.0± 2.5	D	82.2*± 1.61°	73°–96°	411.0± 10.2	77.0± 3.0

The values are mean±SE. *$P<0.001$

Determination of frontal axes in various alignments revealed that MEA was almost identical when fore limbs were approximated to the body in either prone or supine position (Prone: 52.82.±09°., Supine 54.5±1.87·).

MEA in other alignments were therefore, compared with this common MEA.

Electrical axis in prone position : As shown in Table I, maximum displacement of MEA to the right in prone position is brought about by extension of fore limbs ($P < 0.001$). This displacement is well beyond the range of MEA found in fore limb approximation. Assymetrical (unilateral) extensions are not effective in bringing about such significant change to the right (Fig 3A).

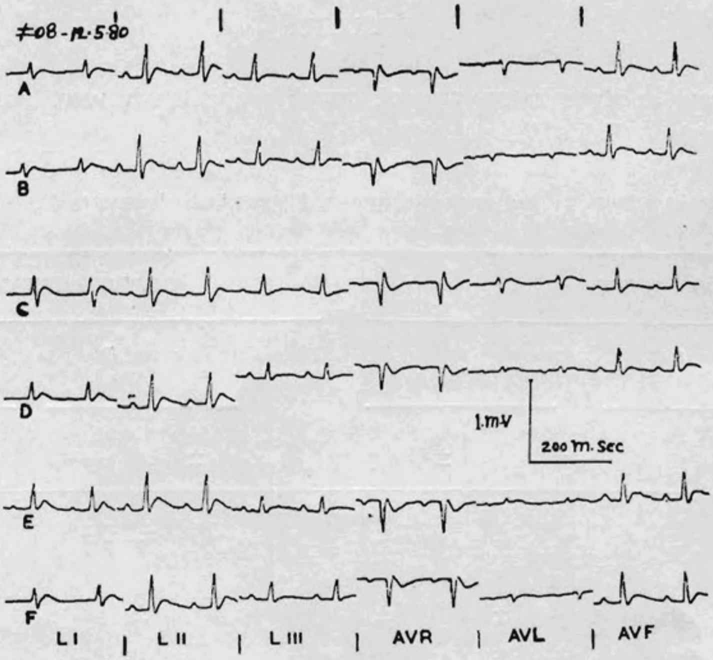

Fig. 1 : ECG tracings of a rat (frontal plane leads) recorded with different fore limb alignments in Prone Position (A to F as in the text).

Electrical axis in supine position : In supine posture of the animal the extension of fore limbs results in highly significant shift in MEA to right (Fig. 3B and Table I). Unilateral extension however is more effective and maximum displacements in this position is more than $+90°$ ($P < 0.001$), (D & E, Table I).

Configuration of ventricular (QRS) complexes : Consistent with the shift in MEA, there was also alteration in amplitude and configuration of QRS (Table II and III) waves with different limb positions. Such changes were most marked in Lead I and aVL (Fig. 1 and 2).

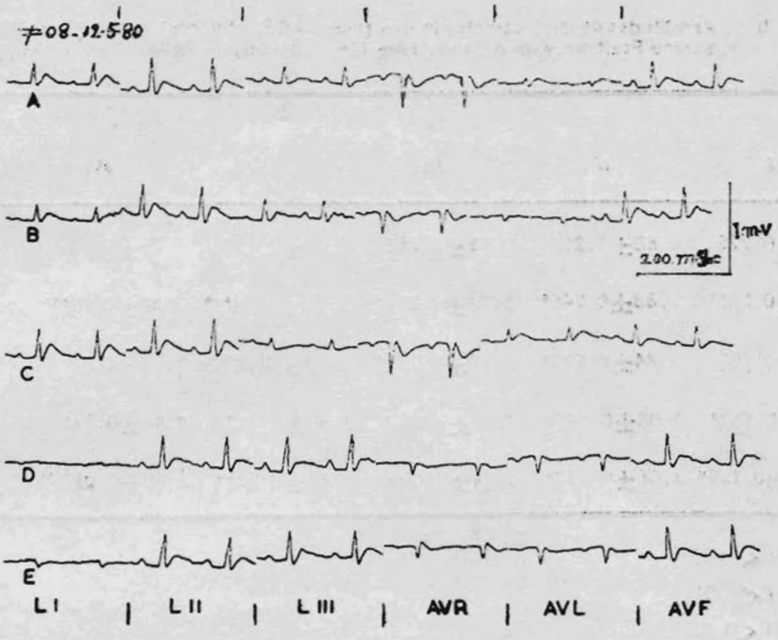

Fig. 2 : ECG tracings of a rat (frontal plane leads) recorded with different fore limb alignments in Supine Position (A to E as in the text).

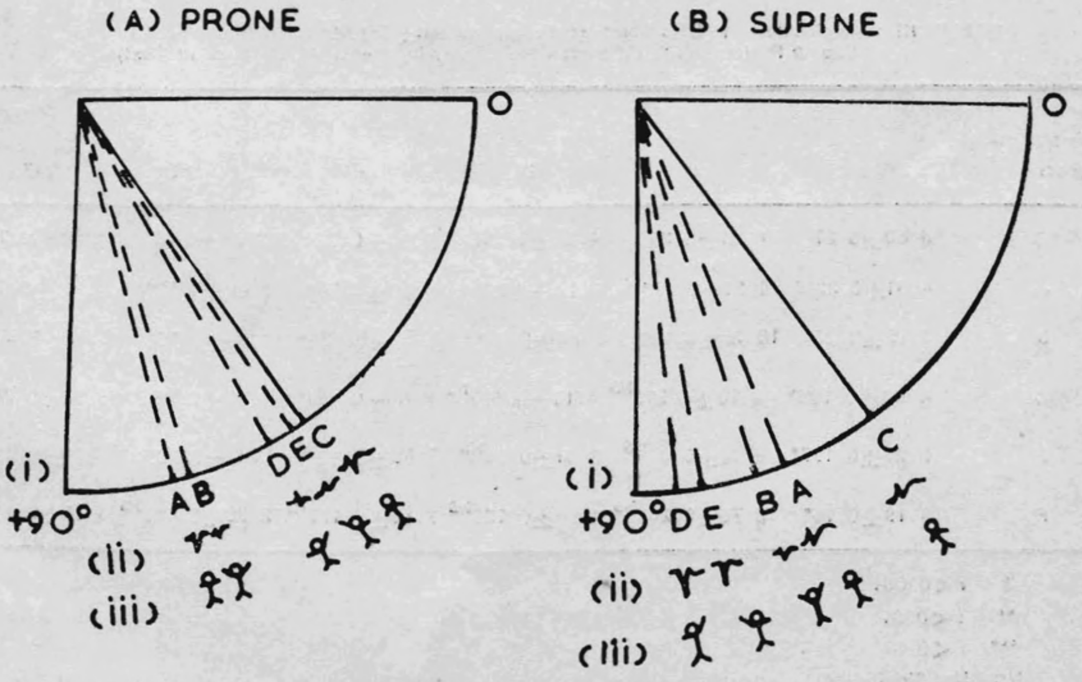

Fig. 3 : Shift in MEA (i) with change in fore limb alignments (iii) in Prone (A) and Supine position (B). Representative QRS tracing (ii) from Lead aVL are given below the respective mean MEAs, as given in Table I. MEA in Prone position (F) is excluded as it is similar to that in "C".

TABLE II : Amplitudes of QRS complex in mm (mean±SE) of frontal plane leads in Supine Position with different Fore Limb Alignments (A to E as in Text),

Limb alignments	*I*	*II*	*III*	*aVR*	*aVL*	*aVF*
C	5.69±0.225	8.88±0.22	3.62±0.252	7.31±0.197	3.75±0.16	5.19±0.20
A	3.88±0.205*	7.88±0.245**	5.13±0.287*	6.56±0.24***	2.38±0.17***	6.07±0.252**
B	3.00±0.25*	7.44±0.225*	6.06±0.275*	5.38±0.205*	1.69±0.13*	7.25±0.205*
D	1.73±0.197*	7.06±0.227*	7.31±0.187*	3.88±0.25*	8.44±0.17*	7.69±0.178*
E	2.375±0.155*	7.06±0.197*	6.94±0.095*	4.25±0.207*	3.75±0.25 NS	7.87±0.24*

* P<0.001
** P<0.01
*** P<0.05
NS Not Significant

TABLE III : Amplitudes of QRS complex in mm (mean±SE) of frontal plane leads in Supine Position with different Fore Limb Alignments (A to E as in Text)

Limb alignments	I	II	III	*aVR*	*aVL*	*aVF*
C	6.50±0.21	8.31±0.275	4.25±0.155	7.50±0.20	3.06±0.027	6.06±0.20
A	4.31±0.225*	9.31±0.27***	6.13±0.205*	6.19±0.23*	3.69±0.20**	6.81±0.197*
B	3.13±0.20*	10.25±0.19*	5.63±0.13*	6.13±0.125*	2.00±0.10*	7.44±0.075*
D	4.00±0.195*	8.13±0.275 NS	4.19±0.177 NS	6.06±0.197*	1.82±0.885*	5.56±0.25 NS
E	5.25±0.177*	8.69±0.35 NS	3.81±0.20 NS	7.50±0.20 NS	1.81±0.10	6.69±0.147***
F	5.19±0.16*	8.75±0.247 NS	4.56±0.127 NS	7.56±0.177 NS	2.75±0.155 NS	6.81±0.13**

* P<0.001
** P<0.01
*** P<0.05
NS Not Significant

MEA with hanging limbs in prone position : The MEA in prone position with four limbs hanging was found to be within the range of common MEA in prone position (41° – 64°)

DISCUSSION

The MEA in prone position shifted from 41° to 90° in this study as the limbs were displaced away from the body. Beinfield and Lehr (1) have reported a wide range of MEA in prone posture ranging from –22 to +120°. Eventhough the limbs in their studies were kept hanging these fluctuations seem to be the result of the recording techniques used by these workers. On the other hand in rat ECGs recorded by Normann *et al.* (9) the fontal axis was reported to shift within a narrow range. These findings are comparable to the MEAs determined from one of the positions in our study in which fore limbs were approximated. Normann *et al.* (9) have not clarified the position of the limbs. but it is possible that the limb alignments were similar to those used in our study.

In the present series, bilateral limb displacements have produced maximum shifts in MEA in both supine and prone positions. Any assymetrical disposition of fore limbs is maximally effective in displacing the MEA to the right. in supine position. but is not effective in prone position.

Our results are similar to those of Sambhi and White (10) and Fraser *et al.* (2) since MEA in their studies also exhibited wide fluctuations in supine positions. Sambhi and White (10) have kept the limbs in restrained position and Fraser *et al.* (2) have extended the limbs gently. In this respect our results demonstrate that if the limb alignments are not kept constant during recording procedures there is more likelihood of the MEA shifting within a wide range. Moreover, it is also obvious that assymetrical disposition of the limbs in supine position can lead to large shifts in MEA.

When the findings in prone position are compared with those in the supine, it is clear that changes in limb position in supine posture bring about greater displacement of the MEA than those in prone posture.

The displacement of MEAs can be attributed to the alteration in anatomical orientation of the heart in the chest cavity when the limbs are displaced bilaterally or unilaterally. This shifting is always in vertical direction when the flexed limbs are moved towards position of extension.

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