

POSITION OF HEART IN RELATION TO STERNUM AND NIPPLE LINE AT VARIOUS AGES

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ABSTRACT

Frontal X-ray pictures of 210 healthy children from birth to twelve years of age with radio-opaque markers at sternal ends and both nipples were reviewed. The position of centre of cardiac silhouette was correlated with sternal areas and internipple line. The heart was found to descend with age, its centre lying beneath mid-sternum during first six months of life and beneath lower sternum after infancy ($p < 0.001$). The position did not vary with age in relation to internipple line ($p > 0.05$). In 77.6% of all children, it was below the internipple line and in 22.4% above or at the internipple line. Because of the erratic relationship of cardiac centre with internipple line, the latter should not be considered a landmark for cardiac position. External cardiac massage should be applied in relation to sternum and at different locations according to the age. Sites for optimal compression have been suggested. No sexual dimorphism was observed.

Key words: Cardiac compression, Cardiac silhouette, Sternal segments, Internipple line.

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The position of heart in relation to sternum is important in the cardiopulmonary resuscitation (CPR). Keeping in view the direct compression theory, more applicable in infants and young children, external cardiac compression should be applied directly over the location of heart. Conventionally, the heart is believed to descend with age, lying under the sternum at nipple line in infants, beneath the lower third of sternum in adolescents and between these two locations in children(1-5). The descent occurs from six months to six years of age as observed in cadaveric anatomic(1) or radiologic and compression studies(2,3). Hence, external cardiac compression has been advocated at different locations appropriate to the subject's age(6-8).

Following detailed roentgenologic and angiographic studies using markers, observations during open heart surgery and results of cardiopulmonary resuscitation(9,10), it is suggested that the heart lies under the lower third of sternum at all ages, and more effective resuscitation results from compressing the lower third of sternum at all ages(8-10).

In order to determine the exact location of the heart, we studied the chest roentgenograms in 210 children of various age groups.

Material and Methods

The study was carried out on healthy newborns, infants and children admitted to the pediatric wards or attending the children's Outpatient Department of the New Civil Hospital, Surat. Frontal (anteroposterior or posteroanterior) chest roentgenograms were taken on 105 girls and 105 boys from birth to 12 years of age; some preterm newborns were also included. Radioopaque lead markers were placed at

both nipples, sternal notch and the base of xiphoid process in each child (Figs. 1a & 1b). The age of each child was recorded from birth record or by detailed inquiry using a local calendar.

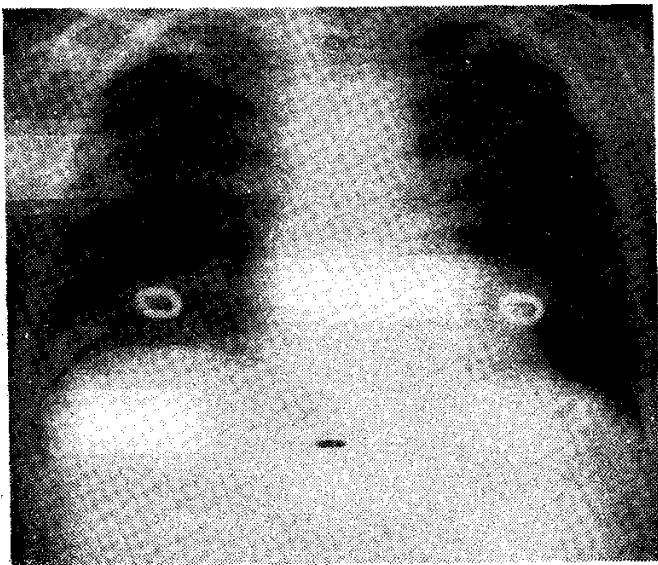


Fig. 1a. Chest roentgenogram with radiopaque markers at xiphoid (x), suprasternal notch (S) and nipples (N, N).

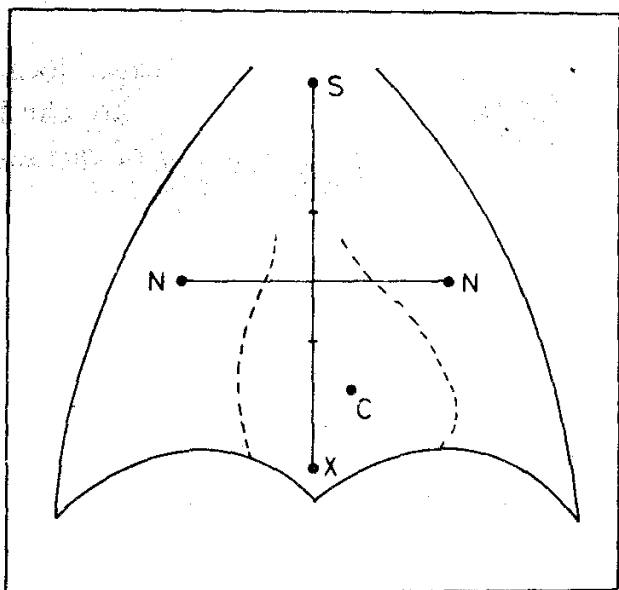


Fig. 1b. Representative drawing of X-ray showing the markers, centre of cardiac silhouette (C) and points dividing the sternal length (SX) into three.

For children under 2 years of age, supine anteroposterior projections at 40 inch tube distance were used with penetration 46 to 50 KVP and output 2 to 4 mAs. When necessary, binders were used to restrict the child and time was given for the child to settle in this position. For children over 2 years of age, erect posteroanterior projections at 40 inch tube distance were used with penetration 50 to 56 KVP and output 4 to 6 mAs. All efforts were made to prevent the rotation of child and to take films on quiet children during deep inspiration.

The distance between the two markers placed on the sternal ends was divided into three on the X-ray plates. A line was drawn between the two markers placed at the nipples (Fig. 1b). The cardiac boundaries were traced out and cut. The cutting was suspended freely from a plumb line at three random points, and the lines of suspension were marked. The point of intersection of these three lines was taken as the centre of cardiac silhouette(11) (Fig. 2), and its position in comparison with the sternal markers and the internipple line was noted.

Chi-square test was used for statistical analysis, and Chi-square for trend was used for analysis for trend in linear proportions for the age related location of heart in relation to sternum.

Results

A total of 105 girls and 105 boys distributed in age from birth to twelve years were studied. As is evident from Table I, the position of heart varied with age ($p < 0.001$). During the first six months of infancy, the centre of cardiac silhouette was beneath the midsternum in 85.4% of children. In the next six months, the centre was beneath the mid-and lower sternum in

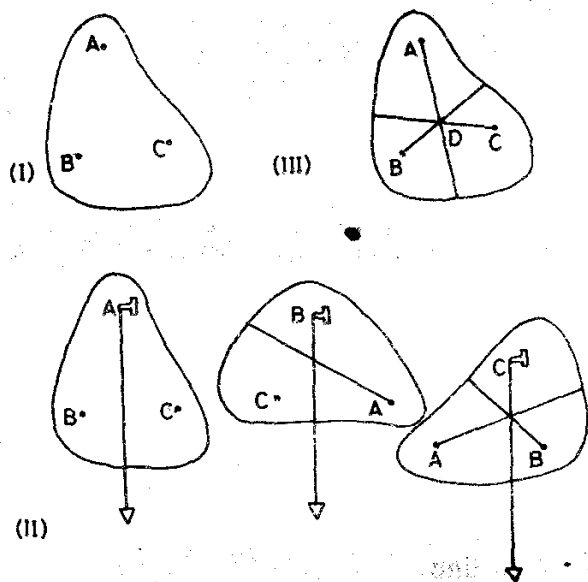


Fig. 2. Method of obtaining the centre of cardiac projection (D). (I) Paper cutting of cardiac silhouette; A, B, C are random points of suspension. (II) Cutting is suspended freely on a plumb line from the above three points and lines of suspension drawn. (III). Lines of suspension intersect at the centre of cardiac silhouette (D).

equal numbers of children. In the age groups 13-60 months and 61-144 months, the centre of cardiac silhouette was beneath the lower third of sternum in 93.9 and 98.3% of children, respectively. There was no significant sexual difference between boys and girls in the position of heart ($p > 0.1$).

When the centre of cardiac silhouette was correlated with the internipple line it was observed that in 77.6% of children at all ages the centre of cardiac silhouette was below this line. There was no significant variation with age in the location of the centre of cardiac silhouette in relation to internipple line ($p > 0.05$). In 22.4% of children the centre of heart was above or at the internipple line. No significant differ-

ence was observed between the sexes in the position of heart in relation to the internipple line ($p > 0.1$).

Discussion

Finholt *et al.*(10) reported that on angiography, the centre of cardiac silhouette corresponds with that of the right ventricle. Since the right ventricle occupies much of the substernal cardiac surface, compression applied directly over this point is likely to be maximally effective in external cardiac compression during cardio pulmonary resuscitation (CPR).

There is controversy regarding the location of heart in relation to sternum at different ages. This study clearly depicts that the heart lies higher in thoracic cavity during the first six months of life, descends during the next six months and lies lower still, beneath the lower third of sternum after infancy. Hence, the site of external cardiac compression should be varied with age. This observation is in conformity with that of earlier workers(1-5) and the National Conferences for Standards for CPR and ECC(6-8). The observation is contrary to the findings of Orłowski(9) and Finholt *et al.*(10), that the centre of heart lies under the lower third of sternum at all ages. The objection that these authors had against the previous studies(1,2), that they were in cadaveric subjects, can not be applied to this study.

There is a controversy regarding the landmark for external cardiac compression also, some reference to internipple line being made traditionally for infants(6-8). This study depicts that there is no age related difference in location of heart in relation to internipple line. Centre of heart lies at or above this line in as many as one fourth children. So, even if the external

TABLE I—Location of Centre of Heart in Relation to Sternum

Age group (months)	No. of cases (n = 210)	Mid-sternum (n = 65)		Lower sternum (n = 145)	
		No.	%	No.	%
0-6	48	41	85.4	7	14.6
7-12	36	19	52.8	17	47.2
13-60	66	4	6.1	62	93.9
61-144	60	1	1.7	59	98.3

$\chi^2 = 177.7$; df, (degree of freedom) = 3, $p < 0.001$.

TABLE II—Location of Centre of Heart in Relation to Internipple Line

Age group (months)	No. of cases (n = 210)	Above nipple line (n = 26)		At nipple line (n = 21)		Below nipple line (n = 163)	
		No.	%	No.	%	No.	%
0-6	48	3	6.2	2	4.2	43	89.6
7-12	36	4	11.1	2	5.6	30	83.3
13-60	66	8	12.1	9	13.6	49	74.3
61-144	60	11	18.3	8	13.3	41	68.4

$\chi^2 = 10.4$, df (degree of freedom) = 6, $p > 0.05$.

cardiac compression is applied below the nipple line, as is suggested in recent literature(8), in a significant number of patients it would be expected to result in inadequate compression and possibly suboptimal resuscitation. We agree with Orłowski(9) and Finholt *et al.*(10), that because of the wide variation in the location of heart in relation to internipple line, it should not be considered a landmark for cardiac compression.

From this study it is clear that sternum is a better reference point for cardiac position at different ages than internipple line. We suggest that it should be used as a landmark for external cardiac compression. As a corollary to our findings, the optimal site of compression may be midsternum in infants 0-6 months of age,

junction between mid and lower sternum in infants 7-12 months of age and lower sternum beyond infancy.

As no difference in heart position was observed between boys and girls, the site of cardiac compression need not be varied between sexes.

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NOTES AND NEWS

HONOURS AND AWARDS

Dr. K. Indirabai, Professor of Pediatrics, Rajah Muthiah Medical College and Hospital, Annamalai University and Past President of Indian Academy of Pediatrics is selected for the prestigious Dr. B.C. Roy National Award.