



Relationship between age and location of the apex beat among apparently healthy children

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Abstract

Background: Unlike in the adult population apex beat position varies with advancing age and getting localized to a particular space at a certain age group in children. The standard way of quoting apex beat is in relation to the midclavicular line. However, there is a paucity of literature on the surrogate marker of the midclavicular line.

Objective: To localize the apex beat in various age groups of apparently healthy children in the form of intercostal space & to find a correlation between the Apex beat position from the midclavicular line to various anatomic landmarks. To find a surrogate landmark for the midclavicular line.

Materials and Methods: In a cross-sectional study carried out in the Department of Paediatrics, a total of 710 healthy Indian children including newborns to 14 years of age were enrolled. Apex beat location in the intercostal space was determined and the distance of the apex beat from the midsternal line, left sternal margin, mid-clavicular line and nipple line were measured. Anthropometric measurements were done.

Results: Correlation between Apex beat position from Midclavicular line to 3 different anatomic landmarks showed statistically significant value in all age groups was left sternal margin. In children up to the age of three years, the apex beat was in the 4th left intercostal space lateral to the midclavicular line. Above seven years, it was located in the 5th left intercostal space medial to the midclavicular line.

Conclusion: The findings in the present study have established the surrogate marker for the midclavicular line was the left sternal margin. All Children above 7 years of age have apex beat at the 5th intercostal space medial to the midclavicular line.

Keywords: Apex beat, Children, Mid-clavicular line, left sternal margin

Introduction:

The Levocardiac apex beat or apical impulse is the palpable cardiac impulse farthest away from the sternum and farthest down on the chest wall, usually caused by the left ventricle and located medial to the midclavicular line (MCL) in the fifth intercostal space in the adult population. In children, it has been described to be in the 4th intercostal space lateral to MCL from birth to two years and at the 5th intercostal space after 2 years of age.⁴ Apex beat can be palpated by placing the palm over the right & left side of the chest wall further localizing them with the ulnar border of the hand followed by finger for maximal pulsation. The location of the apex beat is an integral part of routine cardiovascular system examination in clinical practice.¹ It is notable that cardiac diseases are associated with changes in the normal position of the heart leading to displaced apex beat, usually due to cardiomegaly, and in respiratory diseases, knowingly pleural effusion and pneumothorax etc can displace apex beat, which can easily be detected during routine bedside clinical examination.⁵⁻⁷ Consequently, knowing a child's normal apex beat position will help with the early discovery of abnormal heart size which may indicate the presence of an underlying cardiorespiratory disorder. There is a paucity of literature on surrogate landmarks in the chest wall for the Midclavicular line in the localization of apex beat in children in India. The aim of the study is to measure the location of the apex beat in relation to various anatomical landmarks and intercostal space on the chest wall and correlate it with age.

Objectives of the study:

- To localize the apex beat in various age groups of apparently healthy children in the form of intercostal space.
- To find a correlation between apex beat position from Mid clavicular line to various anatomic landmarks such as the Midsternal line, Left sternal margin and nipple line.
- To find a surrogate landmark in the chest wall for Mid clavicular line in localization of apex beat.

Methodology :

This study is a cross-sectional study carried out on apparently healthy Indian children between January 2023 and March 2024. The study was conducted at Chettinad Hospital and Research Institute, Kelambakkam, India. Institutional ethical approval was obtained from the Institutional Human Ethical Committee (IHEC) and informed consent was obtained from parents and guardians of children participating in the study.

Children up to the age of 14 years of age of both genders visiting the outpatient Department of Paediatrics were enrolled. Newborn babies delivered by Normal vaginal delivery without any illness were included in the study. Children with congenital heart disease or another cardiovascular disease, Severe anaemia, cardiac murmurs, chest wall deformity, and Respiratory illnesses namely bronchial asthma, pneumothorax and pleural effusion were excluded.

Measurements:

Before enrolling participants in the study, the primary investigator was trained in measuring apex beat location from various anatomical landmarks, to maintain uniformity examination findings were reconfirmed by the research assistant in order to reduce observer error. In each participant, the location of the apex beat was determined according to standard clinical methods.⁸ In newborns and infants apex beat was measured in the supine position and in children > 1yr of age measured in an erect posture.² After localizing the apex beat its relation to the midclavicular line, sternal line, left sternal margin and nipple line was measured using transparent non-stretchable inch tape. The midpoint between the two extreme ends of the left clavicle is taken from which the line is drawn perpendicular towards the chest wall is Mid clavicular line(MCL). The mid-sternal line (MSL)is drawn from the midpoint of the suprasternal fossa to the xiphisternum. The left sternal margin is a vertical line drawn parallel to the junction of the manubrium sternum to the ribs. A nipple line is a vertical line drawn at the level of the nipple. The distance between the apex beat from the corresponding lines was measured in centimetres (cm). Anthropometric measurements such as weight using standardized weighing machine approximate to 20gm (Phoenix Series NBY-30 baby weighing scale for infants &AccuSure digital weighing machine for children), height/ length children < 2yrs infantometer (Dr Care height measurement scale infantometer) and > 2yrs stadiometer(Dr.Care height measurement scale stadiometer) approximated to nearest 0.1cm was used, chest circumference and Mid-arm circumference were measured in centimetre (cm) using the same non-stretchable inch tape.

Statistical analysis :

Descriptive statistics such as mean, median and standard deviation were calculated. Inferential statistics and correlation of the relationship between the variables and chi-square for the association between the variables were calculated. MS excel and SPSS 16 versions were used for carrying out the analysis. P values less than 0.05 were taken as significant.

Results:**Table 1: Basic demographic details**

Variable	(n =710)
Gender	n (%)
● Male	383 (53.9)
● Female	327 (46)
● Neonate – 5 years	Median (IQR) Height in cm 80 (67 , 96)
● 6-10 years	124 (119 , 130)
● 11- 14 years	137 (132 , 144)
● Neonate – 5 years	Median (IQR) Weight in Kg 9 (6.2 , 11.5)
● 6-10 years	21 (18 , 26)
● 11- 14 years	30 (27 , 34)
● Neonate – 5 years	Median (IQR) Midarm circumference in cm 13.5 (12 , 15)
● 6-10 years	17 (16 , 18.5)
● 11- 14 years	17.5 (16.5 , 19)

<ul style="list-style-type: none"> ● Neonate – 5 years ● 6-10 years ● 11- 14 years 	Median (IQR) Chest circumference in cm 47 (41 , 50) 58 (54 , 61) 62 (60 , 64)
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Table 1 outlines the demographic characteristics of the study group had a 53.9% male and 46% female population. The median (IQR) of Height, weight, midarm circumference and chest circumference of different groups of children were expressed in the table.

Table 2 :Proportion of children with apex beat location in Specific intercostal space

Age in months	Total number	Apex beat in 4 th Intercosta space n(%)	Apex beat in 5 th Intercosta space n(%)
Neonates	50	50 (100.0)	0 (0.0)
2 - 12	52	52 (100.0)	0 (0.0)
13-24	46	46 (100.0)	0 (0.0)
25-36	58	58 (100.0)	0 (0.0)
37-48	40	36 (90)	4 (10)
49-60	46	22 (47.8)	24 (52.1)
61-72	78	7 (8.9)	71 (91.0)
73 – 84	61	2(3.2)	59 (96.7)
85-96	40	0 (0.0)	40 (100.0)
97- 108	32	0 (0.0)	32 (100.0)
109 - 156	101	0 (0.0)	101 (100.0)
157 - 168	106	0(0.0)	106 (100.0)

Table 2 shows the comparison of proportions of children in the different age groups with apex beats in specific intercostal spaces. The apex beat was in the left 4th intercostal space lateral to MCL in all subjects from birth to three years. Between three and four years, the apex beat was in the left 4th intercostal space lateral to MCL in 90% of the subjects and in the 5th left intercostal space lateral to MCL in 10% of the subjects. In those between four and five years, the apex beat was in the 4th left intercostal space at the level of MCL in 47.8% of the subjects and in the 5th left intercostal space in 52.1% at the level of MCL. Thereafter, with increasing age, the apex beat gradually moved into the 5th left intercostal space so that above seven years of age, the apex beat was consistently located in the 5th left intercostal space medial to MCL in all the children.

Table 3: Correlation between Apex beat position from Midclavicular line to 3 different anatomic landmark.

Age group	No. of subjects	MSL P- Value	r value	LSM P- Value	r value	NL P- Value	r value
neonates – 5 years	292	0.139	0.087	0.002*	0.185	0.876	0.009
6-10 years	215	0.001*	0.222	0.009*	0.177	0.000*	0.317

11-14 years	203	0.000*	0.351	0.000*	0.306	0.054*	0.135
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*p <0.05 is significant

MSL- mid sternal line , LSM – Left sternal margin , NL – nipple line

LSM showed a highly significant positive correlation in all 3 age groups in relation to the midclavicular line on comparison with 3 different anatomical landmarks namely the Midsternal line, Left sternal margin and nipple line.

Table 4 : Distance of Apex beat from Midclavicular and Left sternal margin

Age(in years)	Apex beat from midclavicular line (cm) Mean (SD)	Apex beat from Left sternal margin (cm) Mean (SD)
Neonates – 5 years	1.39 (± 0.38)	4.88 (± 0.63)
6-10 years	1.29 (± 0.46)	5.04 (± 0.46)
11-14 years	1.80 (± 0.52)	5.35 (± 0.59)

Table 4 outlines the mean (SD) of apex beat distance from the midclavicular line and surrogate marker Left sternal margin showing a progressive increase in distance as the age progresses with varying position of apex beat position in relation to MCL given below.

Table 5: Position of the apex beat in relation to mid clavicular line

Age(in years)	Lateral to MCL n(%)	At the level MCL n(%)	Medial to MCL n(%)
Neonates – 5 years	255 (87.3)	37 (12.6)	0 (0)
6-10 years	0 (0)	62 (28.8)	153 (71.1)
11-14 years	0 (0)	0 (0)	203 (100)

MCL- Mid clavicular line

Table 5 outlines the position of the apex beat in relation to the mid clavicular line showing 87.3% of neonates in 5 years age group had lateral to MCL, and 28.8% of children aged 6-10 years showed apex beat at the level of MCL. In the age group of 11-14 years, 100% of children had apex beat at medial to MCL.

Discussion

As per this report, there were more males than females —53.9% were male. Earlier reports⁹ demonstrated that the location of the children's apex beat varies with age and with different physiological conditions that result in displacement of the left ventricle's apical section towards the chest wall. The position of the apex beat in children with respect to the midclavicular line (MCL), nipple line and intercostal space should be predicted to vary with age along with the chest size because the left ventricular wall thickens with age.³

Participants in the study group of neonates to 5 years, 6-10 years and 11- 14 years had median weight of 9, 21 & 30, median height of 80, 124 & 137, median mid-arm circumferences of 13.5,17 &17.5, and mean chest circumferences of 47, 58 & 62 respectively.

The findings in the present study agree with an earlier report in a similar study of position of apex beat in childhood done in Jamaica over four decades ago.²The present study showed that in all children up to the age of three years, the apex beat was in the 4th left intercostals space lateral to MCL whereas in children aged four, five and six years, the apex beat was in the 4th left intercostal space in some proportions of population in the 5th left intercostal space. This was similarly reported in the Jamaican study and Nigerian study. However, in this study, all

children above seven years had their apex beat located in the 5th left intercostal space medial to MCL whereas in the Jamaican study, some proportions of children above six years had their apex beat located in the 4th left intercostal space and Nigerian study showed all children above 6 years had their apex beat at 5th intercostal space.

With respect to the mean distance of the apex beat from the midclavicular line and left sternal margin line in relation to age showed an increasing trend with an increase in the age group due to increased ventricular size and chest wall. On overlooking the position of the apex in relation to the midclavicular line showed scattered proportion in children in lateral, at the line and medial to the midclavicular line, of which 100% of children aged 7 years and more had apex beat medial to MCL. MCL is taken as the universal standard for the location of the apex beat, but the variation in the location of the apex beat medial or lateral may create confusion, hence we compared various anatomical landmarks and found out that the Left sternal margin is a surrogate marker showing statistically significant correlation to MCL.

Therefore, the left sternal margin line found to be a surrogate marker for apex beat position in comparison to standard landmark showed a statistically significant correlation. Three countries showed variation in the location of the apex beat. Therefore as there are individualized growth charts according to race due to different growth patterns of the population, we want to add an estimated nomogram for apex beat. The limitation was the unavailability of echocardiogram findings to exclude structural cardiac diseases.

Conclusion

The findings in the present study have established the surrogate marker for the midclavicular line was the left sternal line. All children above 7 years of age have apex beat at the 5th intercostal space medial to the midclavicular line. A multicenter study on apex beat location in normal children is highly desirable to validate the findings in this present study.

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