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

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Abstract *Background:* Normal location of apex beat varies with age in children. Location of apex beat is an integral part of routine cardiovascular system examination in clinical practice. However, there is paucity of literature on apex beat location in Nigerian children.
Objective: The aim of this study was to locate apex beat position in apparently healthy Nigerian children from birth to ten years, and to relate the location with age.
Subjects and Methods: This was a cross sectional study carried out in Sagamu, Nigeria. A sample size of two hundred and thirty-seven was calculated from a previous study. Hence two hundred and thirty-seven apparently healthy Nigerian children who satisfied the inclusion criteria were enrolled for the study. Apex beat location in the intercostal space was determined and distance of apex beat from the midline, mid-clavicular line and nipple lines were measured. The measured distances were related to age using linear regression and Pearson correlation.
Results: The mean distance of apex beat from the midline from birth to 10 years ranged from 2.3cm to 6.4cm. The distance of apex beat from the midline increased progressively with age. In children up to the age of three years, the apex beat was in the 4th left intercostals space. In 91.7%, 51.3% and 14.3% of children aged four, five and six years respectively, the apex beat was present in the 4th left intercostal space. Above six years, it was located in the 5th left intercostals space.
Conclusion: The location of the apex beat from the midline was strongly related with age Thus, the distance of apex beat from the midline can be predicted from age in months.

Keywords: Apex beat, Children, Mid-clavicular line, Nigeria, Nipple line

Introduction

The apex beat is the lowermost and outermost point of maximal cardiac pulsation.[1-5] Generally, normal apex beat location in children has been described to be in the fourth left intercostal space about mid-clavicular line from birth to two years and in the fifth left intercostals space, about mid-clavicular line after two years of age.[6] The study by Antia *et al* [7], about three decades ago described normal apex beat position in childhood in some Jamaican children. That study found apex beat to be better described with distance of apical impulse from the midline than with the mid-clavicular line which hitherto had been the reference point. [7]

It is notable that cardiac diseases are associated with changes in the normal position of the heart (displaced apex beat), usually due to cardiomegally,[8-10] which can easily be detected during routine bedside clinical examination. Therefore, the knowledge of the normal apex beat positions in childhood will facilitate early detection of abnormal cardiac size which could be a pointer to an underlying cardiac disease. This will aid early referral of children in these categories for proper evaluation, especially from rural settings where most of these children are born. Thus, it is important to ascertain the relationship between age and another essential clinical landmark like the location of the apex beat. Therefore, the objective of this study is to measure apex beat location from anatomical landmarks on the anterior chest wall and relate it to age.

Methods

This was a cross sectional study carried out on apparently healthy Nigerian children between December 2009

and April 2010. The study was conducted in Sagamu, Ogun State; a town located within the Yoruba cultural region of the southwestern Nigeria. Institutional ethical approval was obtained from the Scientific and Ethical Review Committee of the Olabisi Onabanjo University Teaching Hospital, Sagamu and informed consent was also obtained from the parents and guardians of selected children.

The inclusion criterion was age from birth to 10 years. The newborn babies included were term, products of spontaneous vaginal delivery, appropriate for gestational age from 12 hours of age (when events of delivery had resolved), without asphyxia or other forms of critical illness. Subjects with history suggestive of acute or chronic ill health such as congenital heart disease or other cardiovascular diseases, sickle cell anaemia, chronic respiratory tract disease or chronic renal disease were excluded from the study. Subjects with cardiac murmurs, chest deformities or displaced trachea were also excluded.

Sample size: A previous study[7] reported the mean apex beat distances from the midline in different age groups of children from birth to ten years. Assuming a margin of error of 5% of the mean for each age group, the sample that would be necessary to study at 5% level of significance (95% confidence interval) was calculated from the formula:[11] $N = (\boldsymbol{\sigma}^2 [Z_{\alpha/2}]^2) / \varepsilon^2$ where $\boldsymbol{\sigma}$ is the assumed standard deviation, Zα/2 represents Type -1 Error while ε is the margin of error (5% for each age group). The total calculated sample size was 237. Table 1 shows the calculated sample size for each age group.

Sampling method: The neonates in this study were recruited from term normal delivery cases from Olabisi Onabanjo University Teaching Hospital, Sagamu while infants were recruited from immunization and Child Survival Clinics of the same institution. Recruitment was done consecutively until the desired sample size for each age group was met.

Recruitment of children aged between one and five years was made from daycare and nursery schools in Sagamu. There were 106 daycare and nursery schools in Sagamu from which five were randomly selected. Children between six to ten years were recruited from primary schools. There were 150 primary schools in Sagamu town out of which five were also randomly selected. The selected schools were visited and subjects were made to queue up for physical examination. Those who satisfied the inclusion criteria were recruited consecutively from age-group to age-group until the desired sample size for each age group was met.

Measurements: Before the commencement of the study, two research assistants who were junior resident doctors in the same department with the researcher were trained in the art of physical examination and apex beat location and for every ten children the researcher examined, the research assistants examined one child to minimize observer error. For each subject, the location of the apex beat was determined according to standard clinical methods.[12] The apex beat was determined in the supine position in the newborn babies and infants, in erect position in children aged between one and three years, and in both erect and supine positions in the others.[7] The location of the apex beat was measured from the midline, nipple line and the mid-clavicular line. The midline was established by joining the central point in the suprasternal fossa to the xiphisternal angle, and the horizontal distance of the apex beat and the nipple were measured from the midline using an inelastic tape. The extreme medial and lateral ends of the clavicle were identified and the corresponding points on the skin marked with ink. The length of the clavicle represented by these points marked on the skin was similarly measured. Half of the clavicular length was taken as corresponding to the mid clavicular line. Horizontal distance of the mid clavicular line was measured from the midline. During measurements in the erect and supine positions, the upper arms were lightly pressed against the chest wall so as not to stretch the skin. The trachea position was also checked with the index and ring fingers on each of the manubrioclavicular joint and the middle finger locating the trachea via the suprasternal notch. Any deviation automatically disqualified the child from participating in the study.

The data were analysed with SPSS version 15.0 software using the Students test, linear regression analysis and the Pearson Correlation (r). P values less than 0.05 were accepted as significant.

Results

A total of 237 children with ages ranging from 12 hours to 10 years were studied (Table 1). These consisted of 131 (55.3%) males and 106 (44.7%) females (M: F = 1: 0.8).

Table 2 shows the mean distance of the apex beat from the midline in both erect and supine positions. The mean distance ranged between 2.3cm (median=2.3cm) in the neonates and 6.39cm (median=6.35cm) in children who were 10 years old. No significant difference was found in comparison of apex beat distance in the supine and erect positions.

Location of apex beat from the midline in relation to mid-clavicular line and nipple line

The location of apex beat in relation to mid-clavicular line, nipple line and midline is presented in Table 3. The mean distance of apex beat measured from the midline progressively increased with age till age nine years. The mean distance of the apex beat from the midline was consistently less than the distance of the mid-clavicular line and nipple line from the midline up to age seven years while in children older than seven years, the mean

Table1: Sample size calculation for each age group using meandistance of apex beat from the midline in a previous study

Age(months)	*Mean*	σ	$Z_{\alpha/2}$	ε	*Sample size*
NEONATES	2.8	0.4	1.96	0.19	17
2-12	3.8	0.4	1.96	0.14	31
13-24	4.1	0.7	1.96	0.21	43
25-36	4.7	0.3	1.96	0.24	06
37-48	4.6	0.4	1.96	0.23	12
49-60	5.0	0.8	1.96	0.25	39
61-72	5.1	0.5	1.96	0.26	14
73-84	5.2	0.7	1.96	0.26	28
85-96	5.4	0.6	1.96	0.27	19
97-108	5.5	0.5	1.96	0.28	12
109-120	5.7	0.6	1.96	0.29	16
TOTAL					237

distance of the apex beat from the midline was greater than the mid-clavicular line and nipple line from the midline. The apex beat was consistently medial in location in relation to the mid-clavicular line and the nipple line till seven years of age. Thereafter, it was located lateral to the mid-clavicular and nipple lines.

Table 2: Comparison of mean distance of apex beat from the midline in the supine and erect positions

Age(months)	*N*	*Supine Mean (SD)*	*Erect Mean (SD)*	*t-test p-value*
Neonates	17	2.3 (0.6)	ND	NC
2-12	31	2.7(0.4)	ND	NC
13-24	43	ND	3.4(0.6)	NC
25-36	06	ND	4.8(1.1)	NC
37-48	12	5.0 (1.3)	5.0 (1.3)	0.9
49-60	39	4.9 (1.1)	4.9(1.1)	0.9
61-72	14	5.5 (0.7)	5.5 (0.8)	1.0
73-84	28	6.0(0.6)	6.0(0.6)	0.9
85-96	19	6.3 (0.6)	6.3 (0.7)	0.9
97-108	12	6.7(0.5)	6.7(0.5)	0.9
109-120	16	6.4(0.9)	6.4 (0.8)	0.9

NC - Not computed; ND – Not done

Table 3: Location of apex beat from the midline in relation to mid-clavicular line and nipple line from the midline

Age(months)	*Mean apex beat from Midline(cm)*	*Mid-clavicular line (cm)*	*Nipple line (cm)*	*Location of apex in relation to MCL*	*Location of apex in relation to NL*
Neonates	2.3 ± 0.6	3.5 ± 0.6	4.1 ± 0.5	Medial	Medial
2-12	2.7 ± 0.4	4.0 ± 0.6	4.5 ± 0.5	Medial	Medial
13-24	3.4 ± 0.6	4.5 ± 0.7	5.2 ± 0.8	Medial	Medial
25-36	4.8 ± 1.1	5.6 ± 0.8	5.2 ± 1.2	Medial	Medial
37-48	5.0 ± 1.3	5.1 ± 0.6	5.4 ± 0.6	Medial	Medial
49-60	5.0 ± 1.1	5.6 ± 0.8	5.8 ± 0.6	Medial	Medial
61-72	5.5 ± 0.8	6.1 ± 0.6	5.8 ± 0.7	Medial	Medial
73-84	6.0 ± 0.6	6.2 ± 0.5	6.4 ± 0.6	Medial	Medial
85-96	6.3 ± 0.7	6.0 ± 0.7	6.2 ± 0.7	Lateral	Lateral
97-108	6.7 ± 0.5	6.0 ± 0.7	6.7 ± 0.7	Lateral	Lateral
109-120	6.4 ± 0.9	5.9 ± 1.2	6.0 ± 1.0	Lateral	Lateral

Relationship between distance of apex beat measured from the midline and age

The distance of apex beat from the midline strongly and positively correlated with age (r = 0.869; p = 0.000). The relationship between age (in months) and distance of apex beat from the midline was described with a linear regression equation as follows:
Distance of apex beat from midline = 2.741 + (0.035 x age in months) where 2.741 and 0.035 were constant values generated from the linear regression analysis.

Using the above stated equation, the distance of apex beat from the midline was predicted for all the age groups as shown in Table 4. This table also shows a comparison between the actual mean distance of apex beat from the midline and predicted mean distance of the apex beat from the midline. There was no significant difference between actual mean distance of apex beat from the midline and the predicted mean distance of apex beat from the midline in all the age groups except in infancy and in the 9 to 10 years age- group.

Table 4: Comparison between mean apex beat from the midline and predicted apex beat from the midline

Age Group	Mean apex beat from Midline (cm)	Predicted Apex beat (x = k +by) (cm)	P- values
Neonates	2.3 ± 0.6	2.8	0.02∗
2-12	2.7 ± 0.4	3.2	0.00∗
13-24	3.4 ± 0.6	3.4	0.575
25-36	4.8 ± 1.1	3.7	0.052
37-48	5.0 ± 1.3	4.6	0.268
49-60	5.0 ± 1.1	5.1	0.282
61-72	5.5 ± 0.8	5.5	0.868
73-84	6.0 ± 0.6	6.0	0.926
85-96	6.3 ± 0.7	6.4	0.310
97-108	6.7 ± 0.5	6.9	0.155
109-120	6.4 ± 0.9	7.4	0.000∗

∗ Statistically significant differences

Relationship between age and the apex beat location in the intercostals spaces

Table 5 shows the comparison of proportions of children in the different age groups with apex beat in specific intercostal spaces in the erect or supine position. The apex beat was in the left 4th intercostal space in all subjects from birth to three years. Between three and four years, the apex beat was in the left 4th intercostal space in 91.7% of the subjects and in the 5th left intercostal space in 8.3% of the subjects. In those between four and five years, the apex beat was in the 4th left intercostal space in 51.3% of the subjects and in the 5th left intercostal space in 48.7%. Thereafter, with increasing age, the apex beat gradually moved into the 5th left intercostal space so that above six years of age, the apex beat was consistently located in the 5th left intercostal space in all the children studied.

Table 5: Proportion of children with apex beat location in specific Intercostal spaces in the erect or supine Position

Age (months)	Total No	Apex beat in 4th Intercostal Space	Apex beat in 5th Intercostal Space
Neonates	17	17 (100.0)	0 (0.0)
2-12	31	31 (100.0)	0 (0.0)
13-24	43	43 (100.0)	0 (0.0)
25-36	6	6 (100.0)	0 (0.0)
37-48	12	11 (91.7)	1 (8.3)
49-60	39	20 (51.3)	19 (48.7)
61-72	14	2 (14.3)	12 (85.7)
73-84	28	0 (0.0)	28 (100.0)
85-96	19	0 (0.0)	19 (100.0)
97-108	12	0 (0.0)	12 (100.0)
1109-120	16	0 (0.0)	16 (100.0)

Figures in parentheses are percentages

Discussion

Earlier report[13] had shown that the apex beat location in childhood varies with age as well as with various physiological factors which cause a shift of the apical portion of the left ventricle towards the chest wall. Since the thickness of the left ventriclar wall increases with age,[14] the position of the apex beat in childhood in relation to mid-clavicular line, nipple line and intercostal space would be expected to change with age as well as the chest circumference.

With respect to the position of the apex beat in the intercostal spaces, this study did not support some of the earlier reports that the apex beat is in the 4th left intercostal space in all children from birth to the age of two years and thereafter in the 5th left intercostal space, [6] or that it is in the 4th left intercostal space in children of all ages[15-16] or that irrespective of age, it is usually in the 5th left intercostal space.[17]

The findings in the present study agrees with an earlier report in a similar study of position of apex beat in childhood done in Jamaica over three decades ago.[7] The present study showed that in all children up to the age of three years, the apex beat was in the 4th left intercostal space whereas in children aged four, five and six years, the apex beat was in the 4th left intercostal space in some proportions while in the 5th left intercostal space in others. This was similarly reported in the Jamaican study. However, in this study, all children above six years had their apex beat located in the 5th left intercostal space whereas in the Jamaican study, some proportions of children above six years had their apex beat located in the 4th left intercostal space.

With respect to the distance of apex beat from the midline in relation to age, the Jamaican study [7] reported that from the first birthday onwards, using linear regression equation, the apex beat is about 3.8 plus 0.2cm for every year of age while this study showed that the apex beat is about 2.7 plus 0.04cm for every month of age. These two linear regression equations are both useful, the former was computed in years of age while the latter was computed in months of age, to accommodate neonates and infants. The lack of statistically significant differences between actual mean of apex beat from the midline and predicted mean for most of the age groups (using this latter linear regression equation) implies the usefulness of this linear regression equation in predicting apex beat distance from the midline in the age group studied. The significant differences noticed in infancy and nine to ten years age-group may be due to the small

sample size studied in those age groups.

With regard to the relationship between apex beat distance from the midline, nipple line and mid-clavicular line, earlier report[7] stated that these landmarks were not accurate indices of normal apex beat location and that while the mid-clavicular was a relatively better reference point compared with the nipple line, the nipple line was of no value in assessing normal cardiac position and should not be used in clinical practice.[7] Furthermore, it was reported that the position of the nipple line in relation to the apex beat was well outside the apex beat in children of all ages, the mean distance of the nipple line being consistently greater than that of the apex beat. However, in this study, findings showed that the apex beat was consistently medial to the mid-clavicular line and nipple line up to the age of seven years after which the apex beat was lateral to mid-clavicular line and nipple line.

A limitation of the study was the inability to measure all the parameters in the same phase of respiration in all the subjects hence it was difficult to harmonize mid-clavicular line, nipple line and apex beat measurements with respiratory cycle. However, this, does not seem to have altered the measurements significantly. Measurements were done only in erect position for subjects aged one to three years because these subjects were rather restless and uncooperative in the supine position thereby making accurate measurements difficult. Another limitation was the unavailability of echocardiograms to exclude structural cardiac diseases and cardio version.

Conclusion

The findings in the present study have established local peculiarities in the location of apex beat in relation to age. The mean distance of apex beat from the midline from birth to nine years progressively increased with age. A multicentre study on apex beat location in normal children is highly desirable to validate the findings in this present study.

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References

1. Falase AO, Akinkugbe OO. The Cardiovascular System. In: Ndimele L, Egbunike N, eds. A Compendium of Clinical Medicine. Spectrum Books Limited, Ibadan. 2007; 10-118.
2. Bates B. The Cardiovascular System. In: A Guide to Physical Examination and History Taking. Fifth Edition. J.B. Lippincott Company, Philadelphia. 1991; 263-320.
3. Ernest C. Inspection and Palpation of the Precordium. In: Hurst JW, Louge RB, Rackley CE, Schlant RC, Sonnenblick EH, Wallance AG, eds. The Heart, 6th Edition. Graw Hill MC, New York. 1986; 152-6.
4. Timmis AD. Symptoms and Signs of Heart Disease. In: Essentials of Cardiology. Blackwell Scientific Publications, Oxford, London. 1988; 1-21.
5. Okoroma EO. Assesment and Investigation of the Cardiovascular system. In: Azubuike JC, Nkanginieme KEO, eds. Paediatrics and Child Health in a Tropical Region, 2nd Edition. African Educational Services, Owerri, Nigeria. 309.
6. Kaplan S. The Heart and Circulation in Health and Disease. In: Vaughan VC, Mckay RJ, eds. Nelson Textbook of Paediatrics. 10th Edition. Saunders, Philadelphia. 1975; 1000-17.
7. Antia AU, Maxwell SR, Gough A, Ayeni O. Position of the apex beat in Childhood. *Arch Dis Child 1978; 53: 585-9.*
8. Smith TW. Approach to the patient with Cardiovascular disease. In: Wyngaarden JB, Smith LH, eds. Cecil Textbook of Medicine. WB Saunders company, 1988: 175-9.
9. Hoffman JIE. The Circulatory System. In: Rudolph CD, Rudolph AM, Hostetter MK, Lister G, Siegel NJ, eds. Rudolph's Paediatrics, 21st edition. Mc Graw-Hill, New York. 2002: 1754-5.
10. Antia AU, Wilkinson JL, Jaiyesimi F. The Cardiovascular System. In: Hedrickse RG, Barr DGD, Mathews TS, eds. Paediatrics in the Tropics. Oxford Scientific Publications, London, 1991: 235.
11. Lemeshow S, Hosmer Jr DW, Klar J, Lwanga SK. Sample size for case control studies. In: Adequacy of sample size in health studies. New York: John Wiley & Sons (on behalf of World Health Organisation), 1990: 16-20.
12. Swash M. The Cardiovascular System. In: Hutchison's Clinical Methods. 20th Edition.1996; 166-73.
13. Delahaye J. The physical examination of the Cardiovascular system. In: Volta SD, De Luna AB, Brochier ML, Diensti F, Jezek V, Mortensen SA, eds. Cardiology. MC Grawhill internatonal, U.K, London. 1999; 89-96.
14. Cruz MV, de la Auseimi G, Romero A, Monroy G. A qualitative and quantitative study of the ventricles and great vessels of normal children. *Am Heart J. 1960; 60: 675-90.*
15. White PD. Physical Examination of the Heart itself. In: Heart Disease. 4th Edition. Macmillian, New York. 1951; 66-8
16. Dammann JF. Clinical aspects of Congenital Heart Disease. In: Luisada AA, ed. Cardiology volume 3. McGraw-Hill, New York.1959; 6:36-80
17. Julian DG, Turner RND. Examination of The Heart. In: Macleod J, ed. Davidson's Principle and Practice of Internal Medicine. 11th Edition. Churchill Livingstone, Edinburg. 1974; 210-4.