Humeral Head Ossification Center in Congenital Heart Disease

SUKANYA LOHITKUL, M.D.*,
KRIANGSAK THONGCHAIPRASIT, M.D.**,
SUPHANEEWAN JAOVISIDHA, M.D.*,
PIMJAI SIRIWONGPAIRAT, M.D.*

Abstract

The objective of this study was to evaluate the ossification (visualization) of proximal humeral ossification center (PHOC) which may indicate bone growth in infants with acyanotic and cyanotic congenital heart disease (HD) compared to normal infants. The medical records and chest radiographs within 3 months after birth of infants who were diagnosed as congenital HD by echocardiography or cardiac catheterization from 1989 to 1999 were reviewed. The PHOC was recorded from chest radiograph as presence or absence in every one-month interval since birth. In all cases, the corrected age of 0 month was defined as 40 weeks post conception. We used a study of 260 normal Korean infants as the normal population in this study. We found that from 67 cases enrolled in this study; 10 cases were excluded because of lack of complete medical records and sequential chest radiographs. In the remaining 57 cases, the average gestational age of the infants was 38.1 $\pm$ 2.7 weeks and the average birth weight was 2860.5 $\pm$ 597.7 grams. Female to male ratio was 1.28: 1. The infants were classified by gestational age as term (75.4%) and pre-term (24.6%). Types of congenital HD were diagnosed from echocardiogram (96.5%) and cardiac catheterization (3.5%) of cases; and were divided as acyanotic HD (64.9%) and cyanotic HD (35.1%). The ossification of PHOC in acyanotic full-term infants at 0, 1, 2, and 3 months was 24.0 per cent, 32.0 per cent, 72.0 per cent and 88.0 per cent; in cyanotic full-term infants it was 27.8 per cent, 33.3 per cent, 77.8 per cent, and 94.4 per cent ; and in acyanotic pre-term infants was 8.3 per cent, 8.3 per cent, 25.0 per cent, and 41.7 per cent, respectively. There were 2 cyanotic pre-term infants who did not show ossification of PHOC until 3 months. In full-term infants with both types of HD; the appearance of PHOC was significantly later than normal at 1 month corrected age ($p = 0.000002$) but not significant at 0, 2, and 3 months ($p > 0.05$); whereas, in pre-term infants with acyanotic HD, the appearance was later than normal at 1, 2, and 3 months ($p = 0.02$, $p = 0.01$, and $p = 0.0002$, respectively). We concluded that the ossification of PHOC is significantly later than normal in pre-term infants with congenital HD, but not significant in full-term infants with congenital HD.

Key word : Congenital Heart Disease, Epiphysis, Humerus

**LOHITKUL S, JAOVISIDHA S,
THONGCHAIPRASIT K, SIRIWONGPAIRAT P
J Med Assoc Thai 2001; 84: 635-639**

* Department of Radiology, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok 10400,
** Section of Pediatrics, Cardiology Unit, Chon Buri Hospital, Chon Buri 20000, Thailand.

Appearance of ossification center has been widely used as an indication of bone maturation. Relationship between congenital heart disease (HD), particularly cyanotic type, and growth retardation (presents as abnormalities of ossification center)[1] has been documented in the literature[2-5]. The etiology may be abnormal hemodynamics, malnutrition from cardiac cachexia, electrolyte imbalance from diuretic therapy, or early congestive heart failure. However, some discrepancies still exist. It was reported[2,3] that the incidence of ossification center of hyoid bone, as well as of the proximal humeral head, in the newborn period was lower in fatal tetralogy of Fallot (TOF) and fatal interrupted aortic arch than normal and nonfatal cases. Contrary, the incidence is increased in transposition of the great vessels (TGA). PHOC will be visible in plain radiography by at least 38 weeks GA, or more in almost every case, and rarely found in infants 36-37 weeks GA (5-7). Girls have a greater tendency than boys to have a visible nuclei, but the difference is not statistically significant[4,8]. There was no difference in the pattern of ossification between black and white infants[9].

The purpose of this study was to evaluate the ossification (visualization) of the PHOC which may indicate bone maturation, in infants with acyanotic and cyanotic congenital HD compared to normal infants.

SUBJECTS AND METHOD

The medical records and chest radiographs within 3 months after birth of infants who were diagnosed as congenital HD by echocardiography or cardiac catheterization from 1989 to 1999 were reviewed. Patients having medical records of musculoskeletal and endocrine disorders affecting bone maturation[5] were excluded. The GA was determined by ultrasonography, last menstruation period, or Dubowitz score[10]. In all cases, the corrected age of 0 month was defined as 40 weeks post conception. The PHOC was recorded from chest radiographs as presence or absence in every one-month interval since birth (Fig. 1). The range of chest radiography records defined 41-44 weeks, 45-48 weeks, and 49-52 weeks corrected age as 1, 2, and 3 months, respectively. This study used 260 normal Korean infants[11] as the normal population for comparison (Table 1).

Definitions

Cyanotic heart disease is defined as congenital HD with right to left shunt lesion identified by echocardiogram or cardiac catheterization, and having hypoxia (deoxyhemoglobin > 5% or oxygen

Table 1. Incidence of proximal humeral ossification center in 260 normal infants[11].

	Corrected age (40 weeks = 0)			
	0	1	2	3
	%	%	%	%
Term (n=218)	24.3	66.7	83.3	90.3
Pre-term (n=42)	2.4	20.0	43.2	69.4

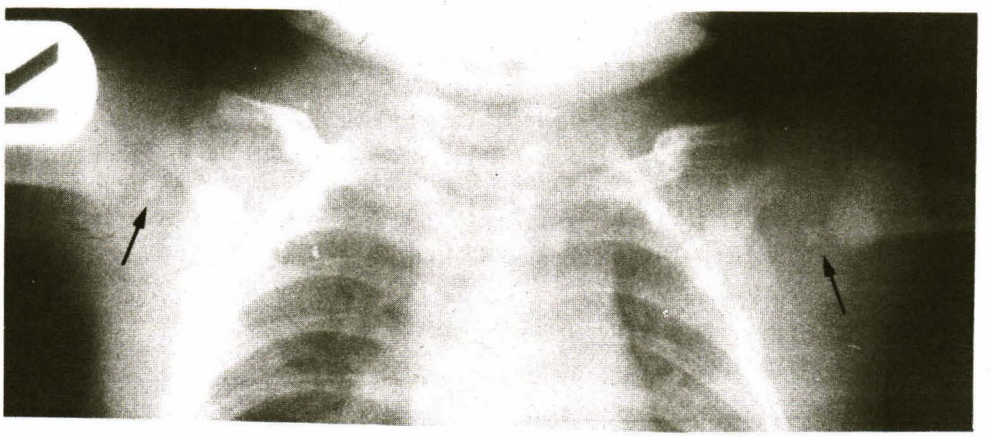
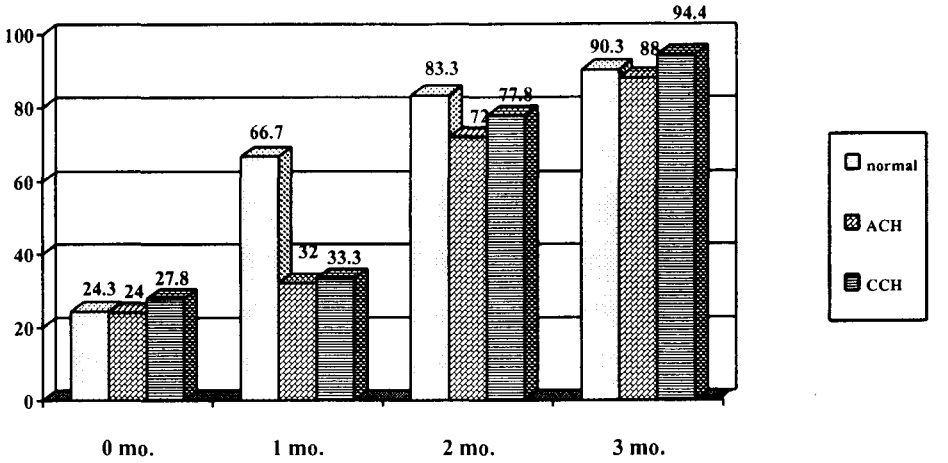


Fig. 1. Proximal humeral ossification center in chest radiography (arrows) recorded as "presence".



*** P value = 0.000002 at 1 mo. of corrected age in acyanotic congenital heart disease (ACH) and cyanotic congenital heart disease (CCH).**

Fig. 2. Incidence of PHOC from chest radiography in term infant with congenital heart disease (43 cases) compared to normal.

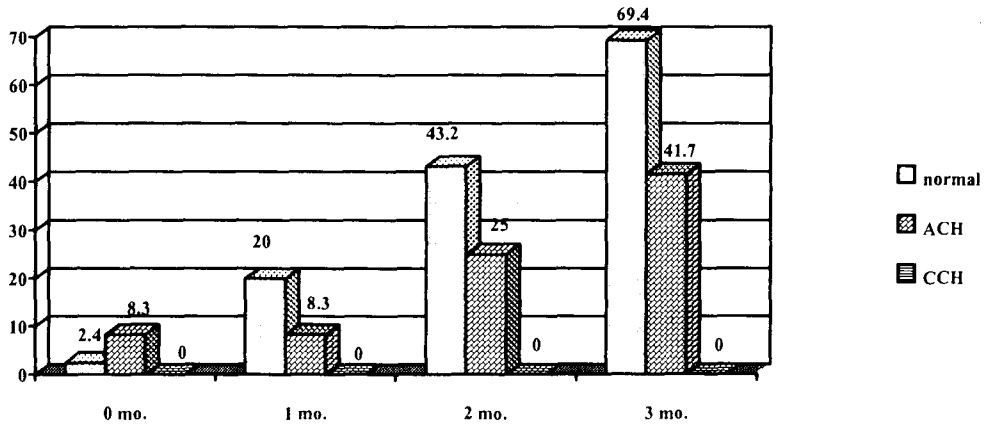
saturation < 90%) i.e., d-TGA, truncus arteriosus, TOF, total anomalous of pulmonary venous return (TA-PVR) etc. *Acyanotic heart disease:* Congenital HD with shunt lesion or obstructive lesion can be identified by echocardiogram or cardiac catheterization i.e., atrial septal defect, ventricular septal defect, patent ductus arteriosus, pulmonary stenosis, co-arctation of aorta, etc.

RESULT

From 67 cases enrolled in this study; 10 cases were excluded because of lack of complete medical records and sequential chest radiographs. In the remaining 57 cases, the average gestational age of infants was 38.1 $\pm$ 2.7 weeks and the average birth weight was 2860.5 $\pm$ 597.7 grams. Female to male ratio was 1.28 : 1. The infants were classified by gestational age as term (75.4%) and pre-term (24.6%). None of them had musculoskeletal syndrome or endocrine disease that would affect bone growth. Types of congenital HD were diagnosed from echocardiogram (96.5%) and cardiac catheterization (3.5%) of cases; and were divided as acyanotic HD (64.9%) and cyanotic HD (35.1%). The ossification of PHOC in acyanotic full-term infants at 0, 1, 2, and 3 months was 24.0 per cent, 32.0 per cent, 72.0 per cent and 88.0 per cent ; in cyanotic full-term infants was 27.8 per cent, 33.3 per cent, 77.8 per cent, and 94.4 per cent ; and in acyanotic pre-term infants was 8.3 per cent, 8.3 per cent, 25.0 per cent, and 41.7 per cent, respectively. We had 2 cyanotic pre-term infants in our study (one had d-TGA and another had double outlets of the right ventricle); they did not show ossification of PHOC until 3 month corrected age. In full-term infants with HD, the appearance of PHOC is significantly later than normal at 1 month corrected age ($p = 0.000002$), but not significant at 0, 2, and 3 months ($p > 0.05$) (Fig. 2); whereas, in pre-term infants with acyanotic HD, the appearance was later than normal at 1, 2, and 3 months ($p = 0.02$, $p = 0.01$, and $p = 0.0002$, respectively) (Fig. 3).

DISCUSSION

In congenital HD, chest radiography is an important and frequently performed investigation which also renders visualization of PHOC. This detection represents bone maturation. Kim et al[11] reported that a normal pre-term infant has delayed bone maturation compared to a term infant in the same corrected age. In our study, the pre-term infant with congenital HD also had delayed bone maturation compared to normal. PHOC can be an early detection of delayed bone maturation in



*** P value = 0.02, 0.01, 0.0002 at 1, 2 and 3 months corrected age, respectively, in pre-term acyanotic congenital heart disease (ACH).**

Fig. 3. Incidence of PHOC from chest radiography in pre-term infant with acyanotic congenital heart disease (14 cases) compared to normal.

infants with congenital HD, and results in early therapeutic decision to decrease severity of growth retardation in this group of patients. In addition, evaluation of PHOC in chest radiography can obviate the cost of investigation for standard bone age radiography and can decrease radiation exposure to the infants.

The limitation of this study was due to a small number of pre-term infants with cyanotic HD (2 in 57 cases), resulting in this subgroup not being well evaluated. Another limitation was this being a retrospective study, we did not have the chest film of exact timing i.e., 1 month or 2 month corrected age. We had to evaluate the film in the range of time (i.e., 41-44 weeks = 1 month, etc.).

We concluded that the ossification of PHOC is significantly later than normal in pre-term infants with acyanotic congenital HD, but not significant in full-term infants with both cyanotic and acyanotic congenital HD.

(Received for publication on July 7, 2000)

REFERENCES

1. Sinden AA, Sutphen J. Growth and nutrition. In: Emmanourtdies GC, Rimenscneider TA, Allen HD, Gutgesell HP eds. Moss and Adums Heart Disease in Infants, Children and Adolescents. 5thed, Baltimore: Williams and Wilkins 1995: 366-74.
2. Well TR, Landing BH, Senac MO Jr, et al. Ossification center of the hyoid bone in complete transposition of great vessels, Ivemark asplenia syndrome, and Down's syndrome with congenital heart disease: correlation with humeral capital epiphysis. Br J Radiol 1986; 59: 1069-72.
3. Well TR, Gilsanz V, Senac MO Jr, et al. Ossification center of the hyoid bone in DiGeorge syndrome and tetralogy of Fallot. Br J Radiol 1986; 59: 1065-8.
4. Kuhns LR, Sherman MP, Paznanski AK, et al. Humeral head and coracoid ossification in the new born. Pediatr Radiol 1973; 107: 145-9.
5. Kuhns LR, Finnstrom O. New standard of ossification of the newborn. Pediatr Radiol 1976; 110: 655-60.

6. Needlman RD. Growth and development. In : Nelson HE, Behrman RE, Kliegman RM, Arvin AM eds. Nelson Textbook of Pediatrics. 15thed, Philadelphia: WB Saunders 1996: 38-44.
7. Tachdjian MO. Introduction; radiology and other diagnostic tools. In : Tachdjian Pediatric Orthopedics. 2nded, Philadelphia: WB Saunders 1990: 59-67.
8. Lemperg R, Liliequist B. Appearance of the ossification center in the proximal humeral epiphysis of newborn children. Acta Radiol (Diag) 1972; 12: 76-80.
9. Christie A. Prevalence and distribution of ossification centers in the newborn infant. Am J Dis Child 1941; 61: 471-82.
10. Dubowitz LM, Dubowitz V. Clinical assessment of gestational age in the newborn infant. J Pediatr 1970; 77: 1-10.
11. Kim SC, Lee Y, Kim I. The difference of the appearance of proximal humeral epiphysis ossification center in the preterm and full-term infants. Radiology 1997; 205: 386.

การเกิดขึ้นของ ossification center ที่ส่วนบนของกระดูกต้นแขนในผู้ป่วยเด็กที่มีโรคหัวใจแต่กำเนิดเทียบกับเด็กปกติ

สุกัญญา โลหิตกุล, พ.บ., สุภนีวรรณ เชาว์วิศิษฐ, พ.บ.*, เกรียงศักดิ์ ทองชัยประสิทธิ์, พ.บ.**, พิมใจ ศิริวงศ์ไพรัช, พ.บ.**

การเกิดขึ้นของ ossification center (OC) เป็นข้อบ่งชี้ภาวะการเติบโตของระบบโครงกระดูกซึ่งโดยทั่วไปแล้วจะดูจากภาพถ่ายรังสีของมือ ในขณะเดียวกันเด็กที่มีโรคหัวใจแต่กำเนิดจะได้รับการถ่ายภาพรังสีปอดอยู่แล้วบ่อย ๆ และ OC ที่ส่วนบนของกระดูกต้นแขนเป็นสิ่งที่สามารถเห็นได้ จึงได้ศึกษาการเกิดขึ้นของ OC นี้ในเด็กที่มีโรคหัวใจแต่กำเนิดเปรียบเทียบกับเด็กปกติ เพื่อจะได้ใช้ติดตามภาวะการเติบโตของระบบโครงกระดูกโดยไม่ต้องถ่ายภาพรังสีของมือ ซึ่งจะทำให้เด็กต้องได้รับรังสีและมีค่าใช้จ่ายเพิ่มขึ้น ได้ทำการศึกษาแบบย้อนหลังโดยการวิเคราะห์ภาพรังสีของปอดและทบทวนเวชระเบียนของผู้ป่วยเด็กที่มีโรคหัวใจแต่กำเนิดทั้งแบบที่มีและไม่มีอาการตัวเขียว และบันทึกการเกิดขึ้นของ OC นี้ว่ามีหรือไม่จากภาพถ่ายรังสีปอด โดยแบ่งภาพรังสีปอดที่มีอยู่ออกเป็น 4 ช่วงอายุคือ 0, 1, 2 และ 3 เดือน โดยกำหนดว่าอายุครรภ์ 40 สัปดาห์เท่ากับ 0 เดือน ผลการศึกษาพบว่าในจำนวนผู้ป่วย 57 รายที่มีภาพรังสีครบตามช่วงนั้น การเกิดขึ้นของ OC ในเด็กครบกำหนดที่มีโรคหัวใจแบบไม่เขียวที่อายุ 0, 1, 2, และ 3 เดือนเท่ากับ 24%, 32%, 72% และ 88%; ในเด็กครบกำหนดที่มีโรคหัวใจแบบตัวเขียวเท่ากับ 28%, 33%, 78% และ 94%; ในเด็กไม่ครบกำหนดที่มีโรคหัวใจแบบไม่เขียวเท่ากับ 8%, 8%, 25% และ 42% ส่วนเด็กไม่ครบกำหนดที่มีโรคหัวใจแบบตัวเขียวนั้นมีเพียง 2 รายซึ่งไม่พบการเกิดขึ้นของ OC นี้จนถึงอายุ 3 เดือน เมื่อนำผลการศึกษามาเปรียบเทียบกับข้อมูลของเด็กเอเชียปกติที่ตีพิมพ์ก่อนหน้าด้วยวิธีการเก็บข้อมูลในลักษณะเดียวกันพบว่า ในเด็กครบกำหนดที่มีโรคหัวใจทั้งแบบที่มีและไม่มีอาการตัวเขียว การเกิดขึ้นของ OC นี้พบน้อยกว่าเด็กปกติที่อายุ 1 เดือน ($p = 0.000002$) แต่ไม่มีความแตกต่างกันที่อายุ 0, 2 และ 3 เดือน ในเด็กไม่ครบกำหนดที่มีโรคหัวใจแบบไม่เขียว การเกิดขึ้นของ OC นี้พบน้อยกว่าเด็กปกติที่อายุ 1, 2 และ 3 เดือน ($p = 0.02$, $p = 0.01$, $p = 0.0002$ ตามลำดับ) ส่วนข้อมูลของเด็กไม่ครบกำหนดที่มีโรคหัวใจแบบตัวเขียวนั้นเนื่องจากมีเป็นจำนวนน้อยจึงไม่ได้นำไปศึกษาเปรียบเทียบกับข้อมูลของเด็กปกติ

คำสำคัญ : โรคหัวใจแต่กำเนิด, กระดูกต้นแขน, Ossification Center

สุกัญญา โลหิตกุล, สุภนีวรรณ เชาว์วิศิษฐ, เกรียงศักดิ์ ทองชัยประสิทธิ์, พิมใจ ศิริวงศ์ไพรัช จดหมายเหตุทางแพทย์ ฯ 2544; 84: 635-639

* ภาควิชารังสีวิทยา, คณะแพทยศาสตร์ โรงพยาบาลรามาธิบดี, มหาวิทยาลัยมหิดล, กรุงเทพ ฯ 10400
** กลุ่มงานกุมารเวชกรรม, หน่วยโรคหัวใจ, โรงพยาบาลศูนย์ชลบุรี, ชลบุรี 20000