Original Article

Normal ultrasonographic dimensions of the gallbladder and common bile duct in neonates

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Abstract

Background: Ultrasound (US) is the first choice of imaging in neonates presenting with persistent jaundice to exclude surgically correctable causes and differentiate obstructive from nonobstructive causes. Previous studies on normal dimensions of gallbladder (GB) and common bile duct (CBD) recruited adults and children spread across a wide age group.

Aims: This study aimed to determine GB and CBD normal dimensions in a large homogeneous neonatal population as well as guide decision regarding pre-US fasting in neonates who require GB evaluation.

Materials and Methods: Five hundred and twenty-eight healthy newborns were recruited between May 2009 and May 2011. The widest intraluminal anterior-posterior diameters of GB and CBD were measured. Neonatal age in days, sex, birth weight, weight and height, gestational age at delivery, and time interval since last feed recorded.

Results: The mean age was 9.56 ± 7.66 days, and 50.6% were males. The mean CBD diameter was 1.16 ± 1.61 mm while the mean GB diameter was 4.42 ± 2.16 mm. GB and CBD were clearly seen and measurable in 297 (55.8%) neonates and 237 (44.38%) neonates, respectively. There was a significant correlation between CBD diameter and GB diameter ($P = 0.04$) but no correlation with any demographic parameter. GB visualization was not dependent on time interval from last feed.

Conclusion: Mean neonatal values for CBD and GB were established, but neonates have a wider range of GB diameters compared with older children, so GB diameter may not be a reliable parameter for neonatal GB pathologies. GB visualization was not dependent on time interval from last feed; hence, a recent feed should not delay emergency scans, especially in ill neonates

Keywords: Common bile duct, gallbladder, neonates

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INTRODUCTION

Ultrasound (US) is currently the first choice of imaging in children with symptoms referable to the abdomen as US is quick to perform, does not utilize ionizing radiation, and requires no elaborate preparation or sedation. In neonates presenting with jaundice, US is performed in order to exclude surgically correctable causes such as biliary atresia or choledochal cyst.[1,2] Gallbladder (GB) size is crucial as it may be small or absent in children with biliary atresia or after recent feeding. GB may also be dilated in children with sepsis. Previous authors have recommended fasting

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of about 4 h and 8 h before US of the GB for young and older patients, respectively.[3] Evaluation of the common bile duct (CBD) is also important in jaundiced patients as the size can help to differentiate obstructive from nonobstructive causes. The dimensions of both the GB and CBD show variations with prandial status.

Many previous studies have been done to record normal dimensions of the GB and CBD to serve as reference points for detecting pathologies. However, most of the studies were carried out in mixed populations of adults and children or in children with ages spread between the neonatal and teenage periods.[3-9] To our knowledge, no previous study has been done in only a large neonatal population.

It is hoped that this study of 528 neonates will give a more accurate spread of normal CBD dimensions for the neonatal population as well as guide the decision regarding pre-US fasting in neonates who require GB evaluation.

MATERIALS AND METHODS

Study site

The study sites were (i) the University College Hospital – a tertiary health institution which serves as a referral center in the Ibadan metropolis and in South-West Nigeria. The hospital has about 2000 deliveries in a year and has two wards dedicated to the care of newborns and infants, and (ii) Adeoyo Maternity Hospital – a state hospital with some tertiary services also for the Ibadan metropolis and its environs.

Subjects

All healthy newborns delivered at or who presented for immunization at any of the two hospitals between May 2009 and May 2011 were included in the study through purposeful sampling throughout the study period (2 years). If general and systemic examinations are normal, babies were classified as apparently healthy. Preterm and term neonates were recruited to allow for a large degree of generalizability as preterms may also need such investigations. A total of 528 neonates had abdominal US examinations.

Ethical approval for the study was obtained from the Oyo State Research Ethical Review Committee (OYSRERC, Reference number AD 13/262/183). Informed written consent was obtained from the parents/caregiver of the neonates. Translation of the consent form was done to the local language and applied when needed.

Exclusion criteria

1. Neonates with jaundice, birth asphyxia, neonatal sepsis, congenital heart diseases, and other systemic abnormalities
2. Neonates, whose mothers or caregivers refused participation in the study
3. Children older than 28 days.

Clinical evaluation

All the neonates were evaluated by the pediatrician (neonatologist) who performed a complete systemic examination, and the following parameters were recorded on the preprepared questionnaire: (i) age in days and sex, (ii) birth weight, (iii) weight and height at examination, (iv) gestational age at delivery, and (v) time interval since last feed in minutes.

Ultrasound examination

All the US studies were performed at the neonate's side by the consultant radiologist with over 10 years' experience in neonatal sonographic practice, using a portable Sonosite US machine with a 5–7.5 MHz convex transducer with Doppler facilities.

Ultrasound technique

- The longitudinal view of the GB was obtained by frontal scan of the abdomen with the neonate in the supine or slightly oblique position. The widest intraluminal anterior-posterior (AP) diameter of the GB in millimeters (mm) was then measured using the electronic cursors [Figure 1]
- The CBD was next identified at its anatomical location at the porta hepatis anterior to the portal vein. To avoid measuring a vessel, the absence of flow in the CBD was confirmed by Doppler interrogation. The widest intraluminal AP diameter in millimeters (mm) was measured with electronic calipers on a longitudinal image [Figures 2 and 3].

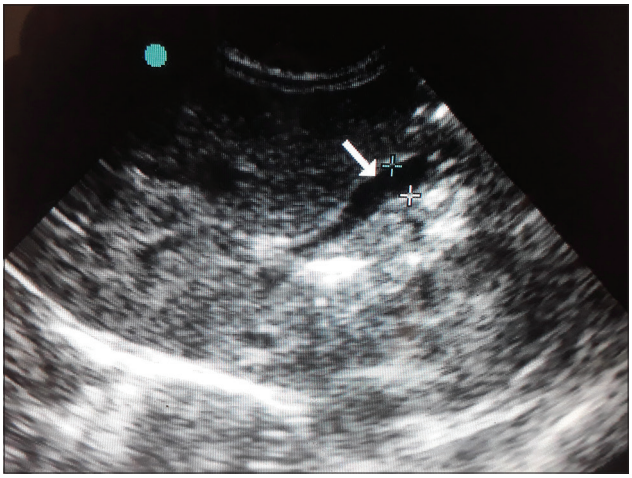

Figure 1: B mode ultrasound of the right upper quadrant showing longitudinal view of the gallbladder (white arrow) and measurement (calipers) of the widest intraluminal anterior-posterior diameter of the gallbladder

To minimize intra-observer error, measurements were taken thrice for each neonate and the mean value in millimeter (mm) was recorded to two decimal points. The same radiologist performed all scans to eliminate inter-observer error.

Data management and statistical analysis

Clinical and US findings were documented in structured questionnaires which were immediately cross-checked for completeness and consistency by a research assistant. They were then double entered and cleaned using EpiData version 3.1 by the EpiData Association, Odense, Denmark. The cleaned and edited data were transferred to Stata version 16 by StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX, USA: StataCorp LLC for analysis.

Descriptive statistics were run for the baseline characteristics which included age, sex, weight, and length of the neonates as well as GB and CBD diameters, body surface area (BSA), and time interval from last feed to scan and visualization of GB.

Mean and standard deviation (SD) as well as range of all continuous variables were calculated, and correlation coefficients of age, weight, length and BSA with CBD, GB diameter, and time interval from last feed to scan/GB visualization were estimated. Furthermore, mean difference analysis of GB diameter, CBD, and time interval from last feed to scan/GB visualization was carried out by gender of neonates. All analyses were performed at 5% level of significance.

RESULTS

There were 528 neonates, of which 50.6% were males. The ages of the neonates ranged from 1 to 28 days with a mean and SD of 9.56 ± 7.66 days and their BSA ranging from 0.13 to 0.31 m^2 with mean and SD of 0.22 ± 0.02 m^2. The mean CBD diameter was 1.16 ± 1.61 mm (range = 0.05-20.0) while the mean GB diameter was 4.42 ± 2.16 mm (range = 0.63-20.0). Other characteristics of the studied neonates such as weight, length, CBD diameter, GB diameter, and time interval from last feed to scan are shown in Table 1.

The mean time interval from last feed to scan was 30.86 min, but 53.7% of the neonates were scanned within 15 min of last feed. On US, 297 (55.8%) of the neonates had their GB clearly visualized and measurable while the CBD was clearly seen and measurable in only 237 (44.38%) of neonates.

Table 2 shows the correlation of age, weight, length, BSA, CBD diameter, and GB diameter. Age was found to

Table 1: Background characteristics of 528 neonates

Variable	Mean±SD	Range
Age (days)	9.55±7.66	1-28
Weight (kg)	3.18±0.58	1.5-5.19
Length (cm)	53.85±5.76	39-68
CBD diameter (mm)	1.16±1.61	0.05-20.0
Gallbladder diameter (mm)	4.42±2.16	0.63-20.0
BSA (m^2)	0.22±0.02	0.13-0.31
Time interval from last feed to scan (min)	30.86±38.96	2.00-270.00
Sex, *n* (%)		
Male	267 (50.57)	
Female	261 (49.43)	
CBD measured, *n* (%)		
Yes	237 (44.38)	
No	291 (55.62)	
Gallbladder measured, *n* (%)		
Yes	297 (55.75)	
No	231 (44.25)	

BSA – Body surface area; CBD – Common bile duct; SD – Standard deviation

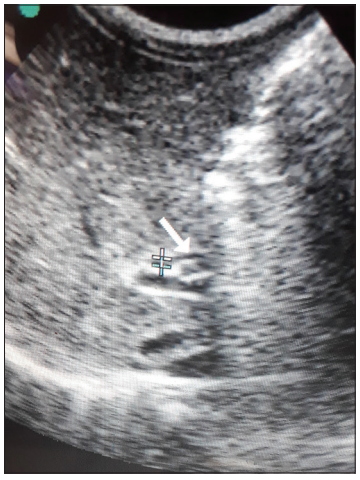

Figure 2: B mode ultrasound of the right upper quadrant showing longitudinal view of the common bile duct (white arrow) showing measurement (calipers) of the widest intraluminal anterior-posterior diameter

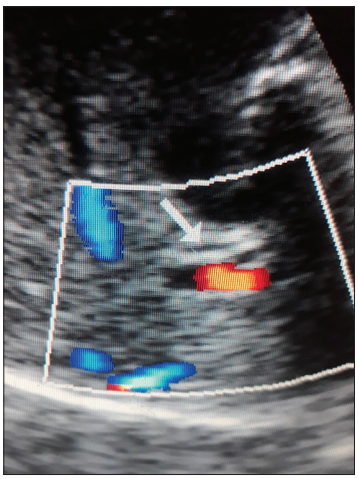

Figure 3: Color Doppler ultrasound of the right upper quadrant showing longitudinal view of the common bile duct devoid of color (white arrow) at the porta hepatis anterior to the portal vein (red color)

Table 2: Correlation of age, weight, length, and body surface area with common bile duct and gallbladder diameter

Variables	Age (days)	Weight (kg)	Length (cm)	BSA (m^2)	CBD diameter (mm)	Gallbladder diameter (mm)
Age (days)	1.0000					
Weight (kg)	0.3704* (<0.005)	1.0000				
Length (cm)	0.3540* (<0.005)	0.3801* (<0.005)	1.0000			
BSA (m^2)	0.4265* (<0.005)	0.9144* (<0.005)	0.7196* (<0.005)	1.0000		
CBD diameter (mm)	−0.0008 (0.9898)	0.0568 (0.3839)	−0.0449 (−0.4914)	0.0244 (0.7084)	1.0000	
Gallbladder diameter (mm)	−0.0817 (0.1603)	0.0047 (0.9354)	0.0042 (0.9423)	0.0071 (0.9030)	0.1454* (0.0420)	1.0000

P value in bracket ( ) *Significant at 5% level of significance. BSA – Body surface area, CBD – Common bile duct

be significantly correlated with weight, length, and BSA. Furthermore, weight, length, and BSA were significantly correlated. Furthermore, there was a significant correlation between CBD diameter and GB diameter ($P = 0.04$). However, since there was no significant correlation between CBD diameter in relation to age, weight, and BSA, we could not develop the normogram for CBD diameter.

The mean difference analysis in Table 3 also reveals that there is no significant difference in the mean diameters of CBD and GB with the gender of the studied neonates. Furthermore, the mean time interval from neonate's last feed to scan time was not significantly different between neonates who had their GBs visualized and those whose GBs were not visualized.

Table 3: Mean difference Analysis of variables

Variables	Mean±SD	95% C I	*P*-value
CBD diameter (mm)/Sex			
Male	1.14±1.89	0.81-1.47	0.8724
Female	1.17±1.21	0.94-1.40	
Gallbladder diameter (mm)/ Sex			
Male	4.42±2.01	4.11-4.74	0.9674
Female	4.41±2.33	4.02-4.81	
Time interval from last feed to scan/Gallbladder seen			
Yes	32.10±41.98	27.05-37.15	0.903
No	32.78±33.38	24.51-41.06	

DISCUSSION

This study evaluated the GB and CBD of a homogeneous population of 528 neonates. It was possible to clearly visualize the GB for measurement in 297 (55.8%) of the neonates while the CBD was clearly seen and measurable in only 237 (44.38%) of neonates. The small neonatal CBD was frequently undetectable with older US machines, but the detection rate has improved with advances in US equipment technology. The error of mistaking the hepatic artery for the CBD can be eliminated by ensuring the absence of flow in the CBD using Doppler interrogation, as was done in this study. GB visualization in previous studies on adults has reported up to 98% visualization rate after fasting,[10,11] however, one of the aims of this study was to assist decision regarding pre-US fasting in neonates who require GB evaluation; hence, fasting was not enforced in the neonates.

Previous studies of children between 0 and 1 years have put normal values of the widest AP dimension of the GB at 5–12 mm, with a mean of 9 mm.[3,12,13] In this study, the AP diameter of the studied neonatal GBs is 0.63–20.0 mm, with a mean of 4.42 ± 2.16 mm. This neonatal mean is understandably smaller than that recorded for the heterogeneous pediatric population in previous studies which included older children in the United States and India.[3,6] This might imply that the GB diameter increases with age in older children and adults,[3,12] but no association between age and GB diameter was demonstrated in this neonatal cohort. Nevertheless, the neonatal range in this study shows lower and higher values than the lowest and highest of range values from previously cited studies. This suggests that neonates have a wider range of GB diameter values within the 1st month of life. The GB diameter may, therefore, not be a reliable parameter when considering neonatal GB pathologies.

In children aged 0–13 years in Canada, the normal AP diameter of the CBD has been put at <3.3 mm by previous authors while it should not be over 1.2 mm in children below 3 months of age.[4] This study recorded a mean CBD diameter of 1.16 ± 1.61 mm, with a range of 0.05–20.0. The recorded mean of 1.16 mm is in agreement with previous studies.[3,4,7,8] The high CBD values at the upper range are probably outliers or errors as the mean with SD values are still less than the 3.3 mm recommended for children below 3 months of age. Nevertheless, in a study of 59 asymptomatic children aged 1 day to 17 years with no definite cause of bile duct dilatation, Son *et al*. noted that 40.7% had spontaneous resolution.[13]

Normal adult CBD values are said to be between 4–8 mm and may be up to 10 mm.[14-16] Even though many studies on CBD dimensions have been done in the adult population, there are still conflicting reports on the association between age and size of the CBD in the asymptomatic population.[7,16-18] It is, however, agreed that the pediatric

CBD is significantly smaller than in adults, and the CBD diameter increases in children from birth to the teen years.[4] In this study, limited to the neonatal period, there was no significant correlation between neonatal CBD diameter in relation to age, weight, and BSA; hence, a normogram for CBD diameter could not be developed with these parameters. The lack of association between CBD diameter and neonatal age may be due to the narrow age range in the studied neonatal population.

The AP diameter of the CBD is easier to obtain and is said to be more precise due to better resolution, hence its use for this study. Even though only AP diameters of the GB and CBD were used for this study, normal US dimensions of the width, length, and volume of the GB have also been studied by previous authors.[6,12] The widest AP diameter was also used for evaluation of GB size because it is easy to measure in routine practice. Computed tomographic scan, scintigraphy, and magnetic resonance cholangiopancreatography (MRCP) can also be used to evaluate the GB and CBD in jaundiced neonates, however, the former two utilize ionizing radiation while the latter is not easily accessible nor affordable. MRCP had a 100% accuracy in excluding biliary atresia as the cause of neonatal cholestasis in a study of 16 jaundiced neonates and infants aged 3 days to 5 months.[2]

In adults, the prandial status is known to influence the GB and CBD dimensions because the CBD consists of fibroelastic tissue and hardly has any muscular support making it amenable to changes in size in response to intraductal bile flow volume.[4,14] Previous authors have also noted a significant difference in CBD diameters of children with distended GBs and those in whom the GB is contracted ($P = 0.02$).[4] Since the GB was not clearly visualized for measurement in about 44% of the neonates, if possible, scans should be delayed till about 60 min post feed before US. However, since the mean time interval from neonate's last feed to scan time was not significantly different between neonates whose GBs were visualized and those whose GBs were not visualized in this study, a recent feed should not delay emergency scans for GB evaluation, especially in ill neonates who may not be able to withstand prolonged fasting.

The strength of this study is in its large homogeneous neonatal population compared with previous studies of mixed age groups. Its weakness is the low percentage of GB and CBD visualization. Nevertheless, the study revealed that the mean time interval from neonate's last feed to scan time did not significantly influence GB visualization which was able to fulfill one of the study objectives.

CONCLUSION

The mean neonatal values for CBD and GB have been established in this study, but neonates have a wider range of GB diameters compared with older children, so GB diameter may not be a reliable parameter for neonatal GB pathologies. There was also no association between GB and CBD diameters with neonatal age in this study which precluded the development of a normogram for both parameters. Hence, it is suggested that the existing maximum values for the pediatric population of 3.3 mm for CBD and 12 mm for GB also be applied for clinical use in neonates. GB visualization was not dependent on time interval from last feed; hence, a recent feed should not delay emergency scans for GB evaluation, especially in ill neonates who may not be able to withstand prolonged fasting. However, if tolerated, scans should be delayed till about 60 min post feed before US to improve GB visualization.

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Conflicts of interest

There are no conflicts of interest.

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