Is Age Associated with Size of Adult Extrahepatic Bile Duct: Sonographic Study[1]

Mindy M. Horrow, MD
J. Charles Horrow, MD
Ali Niakosari, MD
Cheryl L. Kirby, MD
Henrietta Kotlus Rosenberg, MD

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Abbreviation:
AP = anteroposterior

[1] From the Department of Radiology, Albert Einstein Medical Center, 5501 Old York Rd, Philadelphia, PA 19141-3098 (M.M.H., A.N., C.L.K., H.K.R.); and Department of Anesthesiology, MCP-Hahnemann University, Philadelphia, Pa (J.C.H.). From the 2000 RSNA scientific assembly. Received October 24, 2000; revision requested December 6; revision received March 30, 2001; accepted May 9. **Address correspondence to** M.M.H. (e-mail: *horrowm@einstein.edu*).

Author contributions:
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PURPOSE: To determine if the size of the extrahepatic bile duct increases with age in adults.

MATERIALS AND METHODS: A total of 258 consecutive patients 18 years and older, without known biliary or pancreatic disease, who were fasting to undergo routine abdominal sonography were examined. The transverse and anteroposterior dimensions of the extrahepatic bile duct were measured proximally at the porta hepatis, at the middle above the head of the pancreas, and distally at the head of the pancreas. Simple linear regression of the average of these measurements against age tested the hypothesis of a slope of 1.0 mm per decade.

RESULTS: The sample included a wide variety of ages: 55 years ± 16 (mean ± SD), with a range of 20–92 years, including 151 men and 107 women. One-tenth of the cohort were younger than 35 years old and one-tenth were older than 77 years old. The six measurements were proximal-transverse 3.5 mm ± 1.0, proximal-anteroposterior 2.9 mm ± 1.1, middle-transverse 3.9 mm ± 1.2, middle-anteroposterior 3.4 mm ± 1.2, distal-transverse 4.1 mm ± 1.2, distal-anteroposterior 3.5 mm ± 1.2. Least squares regression slope differed significantly from 0.1 mm per year (95% CI; −0.000703, +0.00110) and in fact contained zero.

CONCLUSION: Findings were not able to help confirm an association between age and size of the extrahepatic bile duct in an asymptomatic adult population.

Ultrasonography (US) plays a crucial role in the initial imaging work-up of a patient with jaundice. Because a dilated extrahepatic duct distinguishes obstructive from nonobstructive causes of jaundice, accurate standards for normal measurements must be available. Most authors accept a diameter of 6 mm or less, with a range of 4–8 mm, for a normal extrahepatic bile duct at the level of the common hepatic duct at the porta hepatis. Based on a study by Wu et al (1), the size of the bile duct is considered to increase normally with age, with 10 mm considered normal in the elderly. A standard US text states, "A simple rule of thumb is to consider as normal a 4 mm mean duct diameter at age 40, a 5 mm mean duct diameter at age 50, a 6 mm mean duct diameter at age 60, and so on" (2). We have not observed such an increase in bile duct size in our population. The purpose of our study was to determine if the size of the extrahepatic bile duct increases with age in adults.

MATERIALS AND METHODS

We prospectively collected data on consecutive patients who were 18 years of age or older and who were to undergo abdominal US. All patients had fasted for longer than 6 hours, most for longer than 12 hours. No patient had undergone prior gallbladder, biliary, pancreatic, or liver surgery. Patients with cholelithiasis or any other gallbladder or pancreatic abnormality were not included. Only patients in whom the entire extrahepatic bile duct was depicted were included in the study. The institutional review board classified this study as exempt, and informed consent was not required.

Patients underwent scanning with a variety of machines (Acuson XP, Mountain View, Calif; ATL Mark 9 and ATL 3000, Advanced Technical Laboratories, Bothell, Wash) with transducers varying between 3 and 5 MHz. Images were obtained with the patient supine or in a left lateral decubitus position, by using an intercostal or subcostal approach, whichever provided more optimal images.

The extrahepatic bile duct was measured at three locations: in the porta hepatis just after where the left and right intrahepatic ducts join (proximal), in the most distal aspect of the head of the pancreas (distal), and midway between these measurements, just before the duct enters the pancreas (middle). For each location, anteroposterior (AP) measurements were obtained from the longitudinal images. The transducer was then carefully rotated 90° to obtain transverse images from which medial to lateral measurements were made. Measurements were made from inner to inner walls of the ducts by using electronic calipers. Studies were performed by one of three radiologists (M.M.H., C.L.K., H.K.R.) who subspecialized in US and one of six registered sonographers.

Statistical analysis was used to test the hypothesis that duct diameter increases 1 mm per decade of life (slope = 0.1 mm per year) against the hypothesis that the increase was less than 1 mm per decade (one-sided test) by using least squares linear regression, with a type I error of α = .05. Regression employed the mean of the six measured diameters as the response variable. An identical separate regression used the proximal AP measurement as a response variable.

RESULTS

The study population consisted of 258 patients; 151 men and 107 women; age, 55 years ± 16 (mean ± SD); range, 20–92 years; median, 51 years; and interquartile range, 25 years. One-tenth of the cohort were younger than 35 years and one-tenth were older than 77 years of age (Fig 1). The overall mean for all measurements of duct diameter was 3.5 mm ± 1.2 (n = 1,540) (Fig. 2). Table 1 lists the means and SDs of the six duct dimensions (three locations each measured AP and transverse). The least squares regression slope of 0.000578 mm ± 0.000334 (mean ± SE) per year differs significantly from 0.1 mm per year ($P < .001$). Moreover, a 95% CI (−0.000703, +0.00110) for this slope contains zero, indicating failure to provide evidence of an association of duct diameter with age. Analysis of regression residuals does not suggest an alternative model.

Results of the separate regression by using proximal AP as the response variable yielded regression slope of 0.0007679 mm ± 0.0003913 per year, a value also significantly different from 0.1 mm per year ($P < .001$), with a 95% CI (−0.0000274, +0.00153) that also contains zero.

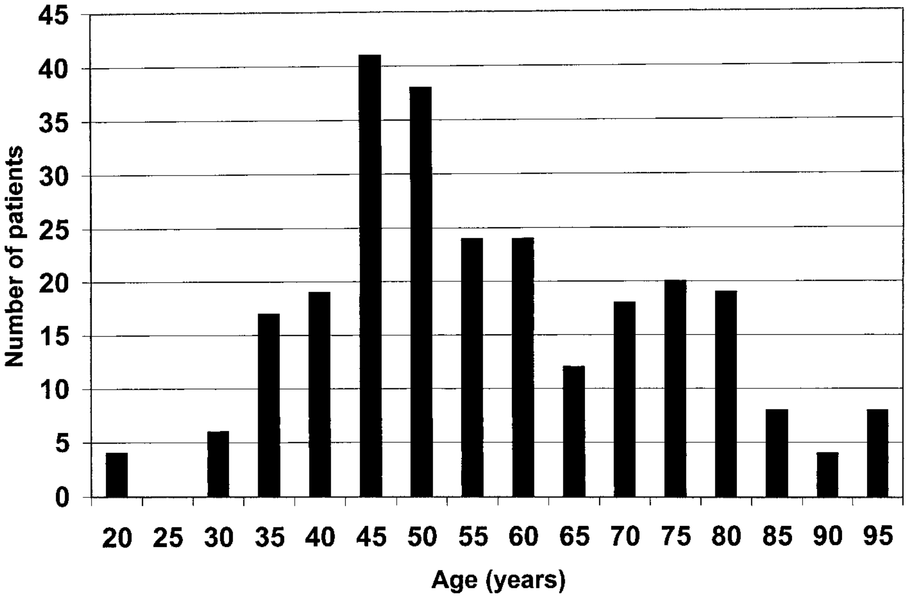

Figure 1. Graph depicts number of patients per 5-year age interval.

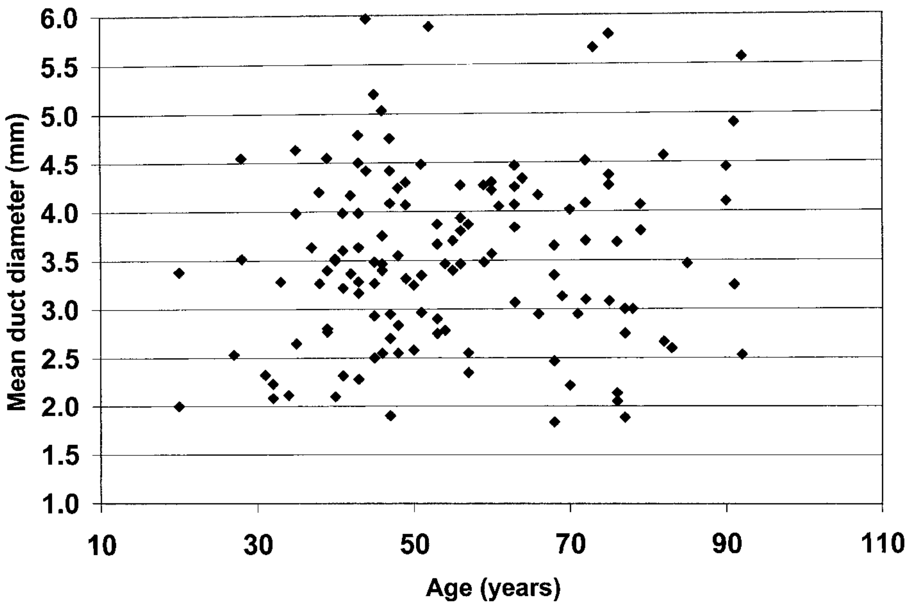

Figure 2. Graph depicts average duct diameter versus age.

DISCUSSION

The study of Wu et al (1) established an effect of age on size of the extrahepatic bile duct. In their study, the maximum AP inner diameter of the extrahepatic bile duct was measured. This dimension varied from 1 to 10 mm and was age dependent ($r = 0.60$, $P < .001$). The study was based on 256 subjects, a cohort of similar size. However, the group included 18 subjects less than 21 years old, of whom half were less than 10 years old. There were eight subjects aged in their 70s, two in their 80s, and none 90 or older. Our study included many more older patients and no pediatric patients. It is well established that the size of the extrahepatic bile duct is smaller in children and increases gradually from birth

Extrahepatic Bile Duct Measurements

Location	AP (mm)	Transverse (mm)
Proximal	2.9 ± 1.1	3.4 ± 1.0
Middle	3.5 ± 1.2	3.9 ± 1.2
Distal	3.5 ± 1.2	4.1 ± 1.2

Note.—Data are the mean ± SD.

through the teenage years. Hernanz-Schulman et al (3) found an average diameter of 1.27 mm ± 0.67 in 173 children aged 1 day to 13 years (mean, 6.0 years). Average diameter of the extrahepatic bile duct was less than 3.3 mm in all patients and less than 1.2 mm in children aged 3 months or younger. Including a pediatric population will clearly accentuate age differences in duct measurements. Moreover, data points for values of the independent variable (age) farthest from the centroid exert greater influence on the regression results. The results of Wu et al (1) reflect the flaws in their statistical methods.

Two studies present data that conflict with our findings. Kaude (4) found a small gradual increase in the size of the extrahepatic bile duct from 2.8 mm in a group aged 20 years or younger to 4.1 mm in patients aged 71 years and older, with a cohort of 350 healthy patients. The study does not specify the ages of patients older than 71 years and is heavily weighted toward younger patients with 35% less than 30 years old and 5% greater than 71 years old. Including pediatric patients forces the regression to show an age effect. In addition, the specific location of duct measurements is not mentioned.

Kaim et al (5) looked specifically at the elderly, with a cohort of 45 patients over 75 years old (mean, 85 years; range, 75–96 years), without cholelithiasis or cholecystectomy. The width of the common bile duct was 6.5 mm ± 2.5 (range, 2.1–15.0 mm), considerably higher than the overall mean for our study. The location of duct measurements was not specific but was described as "commonly measured at its mid-portion (suprapancreatic)." We have not observed normal ducts as large as 15 mm and wonder whether the proximal or distal measurements of these ducts would fall into the more normally accepted range. Since some of these elderly adults had 2-mm ducts, we question the authors' recommendation of considering 10 mm as the upper limit of normal. For some elderly adults, 10 mm would definitely represent dilatation.

Wachsberg et al (6) found that the bile duct tended to be oval in shape when dilated, which accounted for the discrepancy between sonographic and endoscopic measurements of the dilated duct. The standard sonographic measurement is AP, and endoscopic measurements on an AP view are necessarily transverse. Our findings corroborate these findings in nondilated ducts in that transverse measurements numerically exceed AP measurements. Thus, consistency of measurement in one plane is mandatory. The AP measurement is usually easier to obtain and theoretically more precise because of better transverse than side to side resolution.

Location also has an effect on bile duct measurement, independent of the plane of measurement. Thus it is extremely important to designate the site of measurement. Wu et al (1) measured the extrahepatic bile duct at the same three locations as in our study, when possible. Their analysis, however, used the largest AP diameter for each duct, without specifying which location. Our findings correlated age with one specific location and separately with their average.

The two most commonly referenced studies for bile duct size report mean diameters of 4.1 mm (7) and 2.8 mm (8). In each of these studies, no healthy patient's bile duct diameter exceeded 7 mm. In these studies, the subjects were between 18 and 65 years of age. Despite the fact that our study included a substantial number of patients over 65 years old, the overall mean diameter of the duct was 3.5 mm, well in the range of the referenced studies.

A potential limitation of the current study is that the population was not uniformly distributed with respect to age, thus potentially underweighting the very young and very old. It is possible that including larger numbers of younger and older patients would have shown a statistically significant increase in the size of the bile duct. However, the cohort of consecutive inpatients and outpatients reflects the distribution of people presenting for abdominal US. Younger patients are less frequently sent for abdominal US. Older patients are more likely to be excluded because of cholelithiasis or prior hepatobiliary surgery. Nonuniformity notwithstanding, the cohort provides ample opportunity to reflect on association of age with duct diameter, without the bias of pediatric duct measurements. The fact that the regression slope CIs contain zero demonstrates that any such relationship of age with duct diameter is not confirmed in our study.

In some studies of bile duct size, only one observer makes all of the measurements, presumably to afford standardization. The number of people who performed the measurements in this study should not be considered a limitation. Instead, it more likely approximates the normal daily routine in which a variety of sonographers and physicians with varying amounts of experience make the measurements and, therefore, limits the bias that accrues from a single unblinded sonographer.

There are several minor factors that we did not account for in this study. The size of the common hepatic duct decreases slightly with a Valsalva maneuver (9), usually by 1–2 mm. The mechanism is thought to be pressure by the liver on the duct. We suspect that few, if any of our images were obtained during a maximal Valsalva maneuver. Wachsberg (10) demonstrated that the maximal bile duct measurement can increase during deep inspiration. Our study did not specify the respiratory phase for duct measurement. We did not take patient height or weight into account, but these are not usually considered to be factors in duct measurement. Finally, there was no way to exclude the possibility that a patient might have had cholelithiasis and choledocholithiasis previously but passed all of the stones, thereby, enlarging the duct permanently.

In conclusion, this investigation found no increase in the size of the extrahepatic bile duct with increasing age in an adult population. These data do not support the rule of a 1-mm per decade increase in the size of the bile duct. Physicians may wish to evaluate further any patient with a bile duct measurement greater than normal in a symptomatic patient regardless of age.

STATISTICAL CONSULTANT COMMENTARY

The authors were wise to consider a regression approach to their study. Many times a straight-line relationship can be useful in explaining the dependence of one variable on another variable or on a group of other variables. An equation defines the relationship, the dependent variable being predicted by the independent variable (or by a function of several independent variables) and parameters. In this study, the simple linear regression model is $Y = \beta_0 + \beta_1 X + \varepsilon$, where Y is the dependent variable (size of the adult extrahepatic bile duct), β_0 and β_1 are the unknown parameters (β_0 being the intercept and β_1 being the slope of the straight line), *X* is the independent variable (age) and ε is the unknown error. In this observational study, a relationship does not imply causation, only association. A controlled study must be carried out to determine causation.

This study tests the null hypothesis that β_1 (slope) is equal to 0.1 mm per year. The alternative hypothesis is that β_1 is less than 0.1 mm per year, not that β_1 is zero. The test is a one-sided *t* test incorporating the estimated value for β_1 obtained from the regression analysis. Care must be exercised in the interpretation of results. The *t* test using the estimated slope shows a significant difference from 0.1 mm per year; therefore, the null hypothesis is rejected. The authors conclude that the slope is less than 0.1 mm per year and, with 95% confidence, calculate a CI for its true value. The CI does not contain 0.1; however, it does contain zero. The overall conclusion then is a rejection of the null hypothesis noting that the true slope is less than 0.1 mm per year and that the data are consistent with a much smaller positive slope, including zero. The authors, therefore, found no evidence of association.

References

1. Wu CC, Ho YH, Chen CY. Effect of aging on common bile duct diameter: a real-time ultrasonographic study. J Clin Ultrasound 1984; 12:473–478.
2. Laing FC. The gallbladder and bile ducts. In: Rumack C, Wilson S, Carboneau JW, eds. Diagnostic ultrasound. St Louis, Mo: Mosby, 1998; 207.
3. Hernanz-Schulman M, Ambrosino MM, Freeman PC, Quinn CB. Common bile duct in children: sonographic dimensions. Radiology 1995; 195:193–195.
4. Kaude JV. The width of the common bile duct in relation to age and stone disease: an ultrasonographic study. Eur J Radiol 1983; 3:115–117.
5. Kaim A, Steinke K, Frank M, et al. Diameter of the common bile duct in the elderly patient: measurement by ultrasound. Eur Radiol 1998; 8:1413–1415.
6. Wachsberg RH, Kim KH, Sundaram K. Sonographic versus endoscopic retrograde cholangiographic measurements of the bile duct revisited: importance of the transverse diameter. AJR Am J Roentgenol 1998; 170:669–674.
7. Parulekar SG. Ultrasound evaluation of common bile duct size. Radiology 1979; 133:703–707.
8. Niederau C, Muller J, Sonnenberg A, et al. Extrahepatic bile ducts in healthy subjects, in patients with cholelithiasis, and in postcholecystectomy patients: a prospective ultrasonic study. J Clin Ultrasound 1983; 11:23–27.
9. Quinn RJ, Meredith C, Slade L. The effect of the Valsalva maneuver on the diameter of the common hepatic duct in extrahepatic biliary obstruction. J Ultrasound Med 1992; 11:143–145.
10. Wachsberg RH. Respiratory variation of extrahepatic bile duct diameter during ultrasonography. J Ultrasound Med 1994; 13:617–621.