Normal Measurement of Diameters of the Common Bile Ducts in Different Aged Groups

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Background: *Computed tomography (CT) is widely used in diagnosis of biliary disorders in adults yet there is no data on the normal common bile duct (CBD) size of the average Thai adult. This study attempts to establish a reference normal measurement for CBD diameter for the Thai population.*

Material and Method: *In this retrospective study, CBD measurements were performed on axial oblique images, perpendicular to the long axis of the distal CBD. The mean diameter of the normal CBD was measured in 277 patients. The patients were divided into 7 groups according to their age. Analysis of variance (ANOVA) was used to compare data obtained from the seven age groups.*

Results: *Mean diameter of CBD ranged from 2.3 to 9.5 mm. The mean of the mean diameter of 277 subjects was 4.65±1.39 mm. The diameter of the CBD significantly increased with age ($p<0.05$), and are not significantly related to gender.*

Conclusion: *Diameter of CBD shows a considerable increase with age. The largest diameter of the CBD is up to 6.4 mm in patients who less than 60 years. An upper limit of 8 mm appears reasonable after the age of 60.*

Keywords: *Common bile ducts, Computed tomography*

J Med Assoc Thai 2016; 99 (Suppl. 4): S153-S158
Full text. e-Journal: *http://www.jmatonline.com*

Computed tomography (CT) is widely used in diagnosis of biliary disorders in adults. Most biliary tract diseases result in intrahepatic and extrahepatic biliary dilatation. In order to differentiate the diagnosis of asymptomatic bile duct dilatation, there is a need for magnetic resonance cholangiopancreaticography (MRCP) or endoscopic retrograde cholangiopancreaticography (ERCP) which are expensive and invasive tests. Therefore, it is necessary to understand the physiological change of bile duct in advancing age to reduce unnecessary testing for the detection of bile duct abnormalities.

The measurements of common bile duct (CBD) have been done by using ultrasonography. The study by ultrasound is an operator-dependent procedure. So it may not evaluate true diameter of common bile duct in some cases. In Thailand, to our knowledge, the size of the common bile duct has not been measured by CT scan. This study is performed to collect data by multidetector computed tomography (MDCT) on the diameter of normal common bile duct which may be more accurate than data from ultrasonographic studies.

Normal range for common bile duct diameter has been reported as 4-8 mm on MDCT[14]. The upper limit of normal common bile duct diameter has been reported as 4-10 mm on ultrasound[3,4,7,11]. Some previous studies have found that there is minimal increase in duct diameter with advancing age, whereas others have found a significant age-related increase in patients older than 75 years[7,12,16].

In this study we purposed to find the normal value of common bile duct diameter on MDCT. We also studied age related changes in the diameter of common bile duct.

Material and Method

Contrast enhanced abdominal CT examinations of 310 patients, age range from 21 to 90 years, were evaluated retrospectively. CT examinations were performed in a 6-month period, from January 2013 to June 2013, with preliminary diagnoses of various abdominal pathologies including oncologic follow-up, suspect of abdominal malignancy, trauma, acute abdominal pain, ileus, postoperative collections, and unexplained chronic abdominal pain.

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CBD could not be evaluated in 13 patients because of motion artifacts and some pathology causing non-visualization of common bile duct. Artifacts and pathologies causing non-visualization of the common bile duct are listed in Table 1.

The patients who had been diagnosed with pancreatic and biliary disorders (20 patients) that might have cause dilatation of the common bile duct were excluded from the study group. The disorders in the exclusion criteria are listed in Table 2. Gallstone was not included in the exclusion criteria because this uncomplicated disease is not expected to affect the common bile duct[9,13]. Finally, the study group included 277 patients.

Table 1. Artifacts and disorders causing non-visualization of the common bile duct

Artifact or pathology	Number of patients
Breath motion artifacts	6
Compression of giant liver mass	2
Cirrhosis with massive ascites	3
Periportal lymphadenopathy	2

Table 2. Pancreatic and biliary disorders included in the exclusion criteria

Pancreatic or biliary disorder	Number of patients
Acute cholecystitis	5
Acute pancreatitis	4
Periampullary mass	5
Stone or mural thickening and/or enhancement of the common bile duct	4
Biliary stent	2

All studies were performed on a CT with 64 detectors (Philips Brilliance CT scanner, Philips Medical Systems, Number 95284). Administration rate was 2-4 mL/s, and 300 mgI/mL of 100-150 cc (1-2 mL/kg) non-ionic iodine contrast media was used. Whole abdomen, the region between the diaphragm and the symphysis pubis, was scanned in 8-10 s. Dose parameters were 250 mAs and 120 kVp. The scan parameters were as follow: reconstruction interval 1.5 mm, slice thickness 5 mm. Evaluation was performed using a workstation on multiplanar reconstructed images.

The measurements were performed on the workstation by one resident in training, two times. The mean of two measurements was recorded in order to reduce intra-observer measurement errors. Taken into account that there was some difference in alignment of the common bile duct, all measurements were performed from distal part of the common bile duct, approximately 2 cm from the ampulla, on axial oblique images, perpendicular to the long axis of the common bile duct, determined with the alignment tool function of the workstation by the aid of coronal and sagittal oblique images (Fig. 1). These images revealed that the cross section of the common bile duct was ellipsoid rather than circle. The largest transverse diameter of the distal CBD was measured, and the shortest diameter was measured perpendicular to the former measurement (Fig. 2). Measurements were made from inner to inner walls. Mean of the largest and shortest diameters was calculated.

The mean diameters of the normal CBD were measured in 277 patients: 134 females, and 143 males.

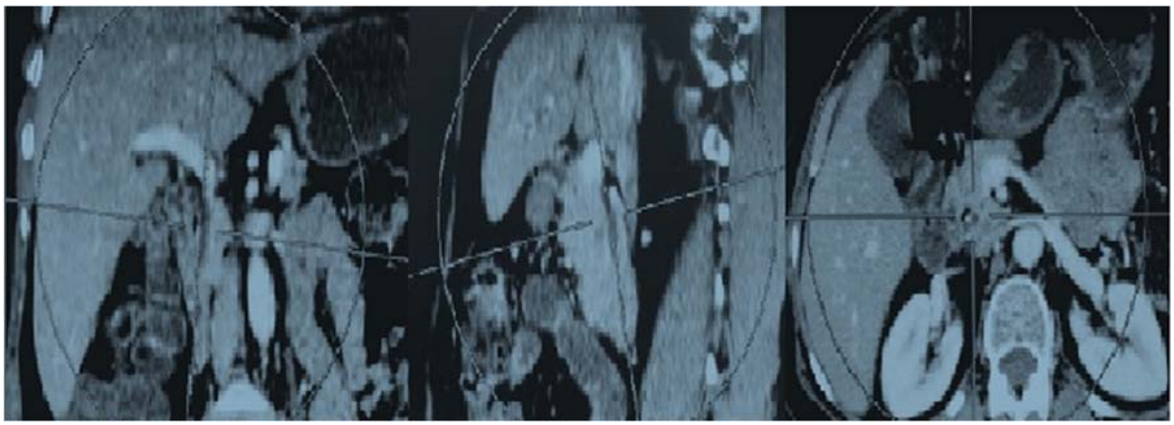

Fig. 1 With the aid of the alignment tool, coronal oblique (a) and sagittal oblique (b) images were used to find axial oblique image (c) perpendicular to the long axis of the common bile duct.

Age of the patients ranged from 21 to 88 with a mean of 54.8. The patients were divided into 7 groups according to their age: Group I 21-30 years, Group II 31-40 years, Group III 41-50 years, Group IV 51-60 years, Group V 61-70 years, Group VI 71-80 years and Group VII 81-90 years.

Statistical analysis was performed using SPSS (SPSS for Windows, version 15.0, SPSS Inc, Chicago, IL, USA).

The results were expressed as the mean ± standard deviation (SD). The measurements of the two genders were compared by Student's t-test. Analysis of variance (ANOVA) was used to compare data obtained from the seven age groups. The results considered significant when $p<0.05$. Pearson correlation was used to evaluate relationship between the age of thesubjects and the mean diameters of CBD.

Results

CBD was clearly visualized in 277 of 310 patients (89.4%), who had technically adequate abdominal CT studies and had no exclusion criteria.

Mean diameter of the CBD of 277 patients was 4.65±1.39. The largest diameter of CBD ranged from 2.0 to 10.8 mm. Mean of the largest diameter of 277 patients was 5.08±1.64. Mean diameters of the CBD of patients in each age group are listed in Table 3. Table 4 shows mean diameters of the CBD of all

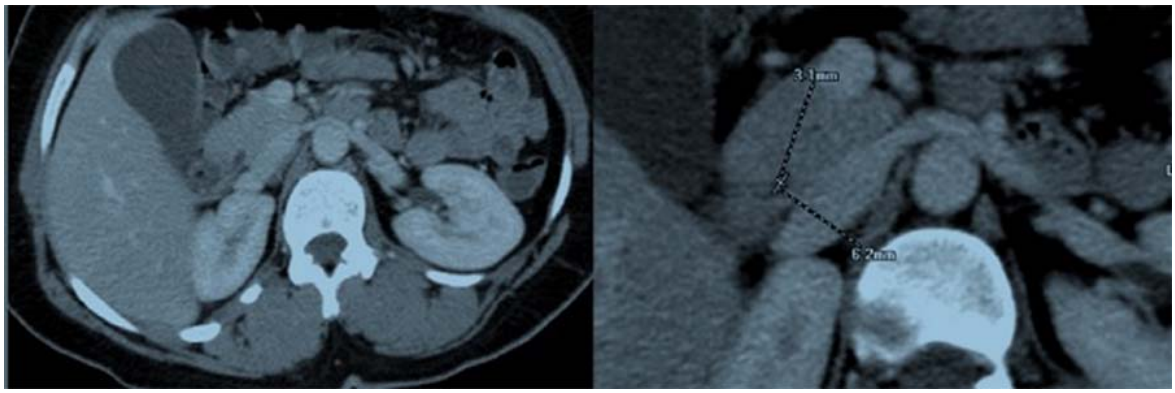

Fig. 2 Measurements were performed on axial oblique images. The largest transverse diameter of the distal CBD was measured, and the shortest diameter was measured perpendicular to the former measurement.

Table 3. The mean CBD diameter of subjects in each group

Group number	Age (years)	Numbers of subject	Shortest CBD diameter (mm)	Largest CBD diameter (mm)	Mean CBD diameter (mm)
I	21-30	39	2.98±0.76	3.33±0.83	3.16±0.78
II	31-40	40	3.40±0.63	3.75±0.66	3.57±0.62
III	41-50	40	3.74±0.77	4.52±0.90	4.13±0.77
IV	51-60	41	4.26±0.94	5.33±1.26	4.79±1.01
V	61-70	39	4.76±1.14	5.79±1.13	5.26±1.05
VI	71-80	39	5.17±0.70	6.17±1.24	5.67±0.87
VII	81-90	39	5.66±1.38	7.03±1.65	6.34±1.39

Table 4. Mean CBD diameter of all subject

Number of subject	Mean age (years)	Shortest CBD diameter ± SD (mm)	Largest CBD diameter ± SD (mm)	Mean CBD diameter ± SD (mm)
277 (M = 143, F = 134)	54.80	4.23±1.26	5.08±1.64	4.65±1.39

subjects.

When the mean diameters of the CBD were compared between age groups, significant differences were observed between all groups (Table 5). When the mean diameters of the CBD were compared between genders, the difference was not statistically significant ($p = 0.26$).

There was positive correlation with high coefficients (r) between the age of the patients and the diameters of CBD (Table 6).

Discussion

Ultrasonography (US) and computed tomography (CT) are well-established methods in the evaluation of the extra hepatic biliary system and represent as major diagnostic tools in suspected bile duct obstruction.

Our results show that the average CBD diameter as measured by CT is 4.65±1.39 mm, with a range of 2.3 to 9.5 mm. Compared to the results of available research papers using other imaging modalities; it is well within the reported range. Jonson et al[6] showed that the average diameter in patients with normal cholangiography was 5.9 mm. By using ultrasound measurement, Kaim et al[10] found that asymptomatic patients without prior biliary surgery had a mean CBD diameter of 6.2 mm. Parulekar et al[11] also analysed 258 asymptomatic patients' routine ultrasounds, and found mean CBD diameters are 4.1 mm. Senem et al[14] measured 604 Turkey CBD diameters using multi-detector row CT, and found the average diameter to be 4.77 mm. Our finding that the average Thai patients' CBD of 4.65±1.39 mm as measured by CT is well within the range of currently reported range values of normal CBD diameter.

The reason that the average CBD diameter reported in available medical literature varies is complex, and, most likely, multi-factorial. One possible source of this discrepancy is the fact that the CBD cross-section is oval in shape when distended, which can affect its measurement when using different modalities. For example, ultrasound measurement of CBD measures anteroposteriorly (AP), whereas other cross-sectional imaging such as CT or MR enables measurement of the largest and shortest diameter. Another source of variation in ultrasound study is the depth of inspiration, which Wachsberg found can result in changes of CBD diameter[15].

Most authors support the proposition that age is significantly related to CBD diameter, although the nature of the relationship is still debated. Some believe that there is a linear relationship between CBD diameter and gradual advancement in age[1,7,12,16], while others consider the relationship indirect[10], or that it only dilates after the age of 60. Our findings also suggest that there is a significant difference ($p<0.05$) between diameters of CBDs in younger and older patients, with patients older than 60 years having significantly larger CBD diameter. When patients' age is further divided into decades, a trend becomes apparent: as patients' age increases from the third to the ninth decade of life, the average CBD diameters also increase in an approximately linear fashion. The mean diameter of the CBD was up to 6.4 mm in subjects under 60 years. Only 4 cases (3.4%) out of 117 subjects (age over 60) had a CBD diameter over 8 mm. Thus, an upper limit of 8 mm appears reasonable after the age of 60.

Previous studies suggest that gender has no

Table 5. Comparison of diameters between groups

Compared groups	*p*-value
Group I-II	<0.05
Group I-III	<0.05
Group I-IV	<0.05
Group I-V	<0.05
Group I-VI	<0.05
Group I-VII	<0.05
Group II-III	<0.05
Group II-IV	<0.05
Group II-V	<0.05
Group II-VI	<0.05
Group II-VII	<0.05
Group III-IV	<0.05
Group III-V	<0.05
Group III-VI	<0.05
Group III-VII	<0.05
Group IV-V	<0.05
Group IV-VI	<0.05
Group IV-VII	<0.05
Group V-VI	<0.05
Group V-VII	<0.05
Group VI-VII	<0.05

Table 6. Correlation between age and the diameters of CBD

Diameter	r
Shortest diameter	0.88
Largest diameter	0.93
Mean diameter	0.94

significant effect on CBD diameter[11,12,14] and our studies also support this observation ($p = 0.26$).

There is limitation to this retrospective study. Some medications such as Morphine, calcium antagonists, and Nitroglycerine can cause dilatation of CBD[17]. Although list of medications were checked from patient's cards, they may not be a complete record in some cases.

Conclusion

This study shows that the average CBD diameter of the Thai population measured by CT is 4.65 mm. CBD diameter significantly increases proportionally to age for each subsequent decade of life. The largest diameter of the CBD is up to 6.4 mm in patients who are less than 60 years. An upper limit of 8 mm appears reasonable after the age of 60. Otherwise, no significant association was found regarding gender. This can serve as a useful reference tool when medical professionals are faced with clinical decisions involving biliary obstruction and the need for further investigation or intervention.

What is already known on this topic?

The measurements of common bile duct (CBD) have been done by using ultrasonography which study by ultrasound is an operator-dependent procedure. So it may not evaluate true diameter of CBD in some cases.

Normal range for CBD diameter has been reported as 4 to 8 mm on MDCT.

Some previous studies have found that there is a minimal increase in duct diameter with advancing age, whereas others have found a significant age-related increase in patients older than 75 years.

What this study adds?

The average Thai patients' CBD of 4.65$\pm$1.39 mm as measured by CT is well within the range of currently reported range values of normal CBD diameter.

The largest diameter of the CBD is up to 6.4 mm in patients who are less than 60 years old.

Potential conflicts of interest

None.

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การศึกษาหาค่าปกติของขนาดท่อน้ำดีร่วมในกลุ่มประชากรอายุต่าง ๆ

วิเชษฐ์ ปียะวงศ์, วิทิต เลขวัต

ภูมิหลัง: *ในปัจจุบันมีการศึกษาเกี่ยวโรคทางระบบทางเดินน้ำดีด้วยเอกซเรย์คอมพิวเตอร์ (CT scan) มากขึ้นแต่ยังไม่มีการศึกษาเกี่ยวกับขนาดของท่อน้ำดีร่วม (common bile duct) โดยการใช้เอกซเรย์คอมพิวเตอร์ การศึกษานี้จึงต้องการหาค่าปกติของขนาดท่อน้ำดีร่วม ในกลุ่มอายุต่าง ๆ ด้วยการตรวจเอกซเรย์คอมพิวเตอร์และความสัมพันธ์ของอายุและขนาดท่อน้ำดีร่วม*

วัสดุและวิธีการ: *การศึกษานี้มีประชากรทั้งหมด 277 ราย แบ่งเป็น 7 กลุ่มตามช่วงอายุ โดยตำแหน่งของท่อน้ำดีร่วมที่ใช้ในการวัดภาพเอกซเรย์คอมพิวเตอร์คือ ส่วนปลายของท่อน้ำดีร่วมประมาณ 2 เซนติเมตร จากแอมพูลลา (ampulla) วัดในแนวตัดขวางตามแนวเฉียง (axial oblique) ตั้งฉากกับแนวยาวของท่อน้ำดี โดยวัดทั้งขนาดเส้นผ่านศูนย์กลางทั้งแนวที่ยาวที่สุดและสั้นที่สุดแล้วนำมาหาค่าเฉลี่ย จากนั้นข้อมูลที่ได้จากแต่ละกลุ่มจะถูกนำมาเปรียบเทียบโดยใช้ analysis of variance (ANOVA) และหาความสัมพันธ์ของอายุกับขนาดท่อน้ำดีร่วมโดยใช้ Pearson correlation*

ผลการศึกษา: *ค่าเฉลี่ยขนาดท่อน้ำดีร่วมโดยการตรวจด้วยเอกซเรย์คอมพิวเตอร์คือ 4.65±1.39 มิลลิเมตร ซึ่งสอดคล้องกับการศึกษาด้วยวิธีอื่น ๆ ที่เคยมีการศึกษามาก่อน เมื่อเปรียบเทียบค่าเฉลี่ยของท่อน้ำดีร่วมในแต่ละกลุ่มอายุนั้นพบว่าค่าเฉลี่ยของท่อน้ำดีร่วมจะค่อย ๆ เพิ่มขึ้นตามอายุที่มากขึ้นอย่างมีนัยสำคัญ ($p<0.05$) เมื่อพิจารณาเฉพาะในกลุ่มผู้สูงอายุ (>60 ปี) หากพบว่าค่าเฉลี่ยท่อน้ำดีร่วมมีค่ามากกว่า 8 มิลลิเมตร อาจเป็นไปได้ว่ามีพยาธิสภาพที่ระบบทางเดินน้ำดีและต้องพิจารณาหาสาเหตุเพิ่มเติม ส่วนค่าเฉลี่ยของท่อน้ำดีร่วมในเพศชายและหญิงนั้น ไม่มีความแตกต่างทางสถิติอย่างมีนัยสำคัญ ($p = 0.26$)*

สรุป: *ค่าเฉลี่ยขนาดท่อน้ำดีร่วมโดยการตรวจด้วยเอกซเรย์คอมพิวเตอร์คือ 4.65±1.39 มิลลิเมตร ค่าเฉลี่ยของท่อน้ำดีร่วมจะค่อย ๆ เพิ่มขึ้นตามอายุที่มากขึ้นอย่างมีนัยสำคัญทางสถิติ*