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Original Articles

Anatomy of the Cystic Duct – Factors Affecting the Stasis of Bile and Formation of Gall Stones

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Abstract

Background: *An increasing incidence of liver and gall bladder diseases bring about an increasing necessity of their precise diagnosis. Unrecognized anatomic variants of the extrahepatic billiary apparatus may cause confusion on imaging studies and complicate subsequent surgical, endoscopic, and percutaneous procedures. Although much have been written about the normal anatomy and related diseases of the gallbladder and biliary tract but no available data have been found about the variations of the cystic duct in Bangladeshi people. This study was aimed at determining the anatomical variations of gross morphological features of cystic duct in relation to age and sex in Bangladeshi people as well as to find out any congenital anomalies of the extrahepatic biliary system.*

Materials and methods*: A cross sectional descriptive type of study was carried out at the Department of Anatomy, Rangpur Medical College, Rangpur. The study was conducted on postmortem gallbladder with cystic duct from 60 unclaimed dead bodies of Bangladeshi people. Of which, 32 were male specimens and 28 were female specimens. The specimens were divided into two groups according to age, young age group A (20-40 years) and elderly age group B (41-65 years). The length and diameter of cystic duct was measured and number of valves in cystic duct was counted. Comparison was done between male and female of two age groups by Student's unpaired't' test.*

Results: *The length of the cystic duct showed a significantly higher value in elderly male than younger male and corresponding f emale groups of similar age. The number of spiral valves showed similar values in both sexes.*

Conclusion*: No relationship between cystic duct length, diameter and number of spiral valves with different sex and different age could be established in this study.*

Key words: *cystic duct*

Introduction

Cystic duct or in Latin, ductus cysticus functions as a single narrow passage which causes bile to flow to and from the gallbladder. The anatomy of the human cystic duct is complex. Its length, diameter, valves of Heister, angle between cystic duct and gallbladder might affect the emptying of gallbladder which cause stasis and predispose to formation of stone in gallbladder.

Much variation was found about the length and diameter of the cystic duct by different workers[1,2,3,4,5,6,7]. Most of the workers mentioned that the cystic duct usually 3-4 cm in length but Sanjay (2005)[5] stated that around 20% of cystic duct are less than 2 cm in length and the cystic duct frequently exhibits a tortuous or serpentine course. Hence there may be very little space to

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put clips or ligatures during cholecystectomy. The diameter was also variable, ranging from 1-5 mm.

Anatomically the gallbladder neck narrows and develops spiral mucosal folds before funneling into the duct. They project obliquely in regular succession in the form of oblique ridges or crescentic folds. These folds are known as spiral valve or valve of Heister. Apart from duct length and diameter, the presence of the "valves of Heister' in the lumen complicates the cystic duct geometry. The role of the valve as to whether it acts as an active or passive impedance device has been debated in the literature[6]. The number of crecentic fold in the cystic duct varies from between 2 and 14,[5] and prominent crecentic folds are 5- 12 in number[7]. The wall of the cystic duct is surrounded by a sphincter called the sphincter of Lutkins[8].

None of the previous workers described any relationship between cholelithiasis and the anatomical variations of gallbladder morphology.

With the above factors keeping in mind this study was aimed at to measure the length and diameter of the cystic duct and to count the number of spiral valve in the cystic duct which may impede the flow of bile and cause bile stasis which may be the causative factor of formation of gall stone.

Material & method

The present study was carried out on 60 (sixty) cystic duct from Bangladeshi adult people. Out of the 60 people 32 were males and 28 were females of 20 to 65 years of age. The specimens were divided into two groups according to age. Group A (20-40 years) and group B (41-65 years). All the specimens of gallbladder with cystic duct were collected from the unclaimed dead bodies of the Department of Forensic Medicine of Rangpur Medical College, Rangpur, autopsied on different dates from July, 2008 to June 2009. Samples (human gallbladder with cystic duct) were collected as block dissection of liver.

Parameters of the cystic duct studied:

a) Length of the cystic duct in centimeter (cm).

b) Diameter of the cystic duct in millimeter (mm).

c) Counting the number of the spiral valves.

Measurement of the length and diameter of the cystic duct:

The length of the cystic duct was measured before removal of the gallbladder from its fossa by metallic graduated scale in centimeter (cm) from just beyond neck of gallbladder up to the beginning of common bile duct.

The diameter of the cystic duct were measured from three points with a help of slide caliper with vernier scale, first in the proximal portion, second in the middle portion, third in the distal portion. The average of these three measurements were taken as the diameter of the cystic duct in millimeters.

Counting the number of spiral valves in the cystic duct:

For counting the number of spiral valves, a longitudinal incision was given from the inferior surface of gallbladder through the lumen of cystic duct from the neck to the common bile duct, with the help of fine pointed narrow scissor, and then very narrow strip of cystic duct wall on each side of longitudinal incision over cystic duct was incised with the help of sharp pointed straight scissor. So as a result superior half portion of cystic duct was removed by fine scissor dissection and remaining inferior half portion of cystic duct was exposed for viewing the spiral valves. The number of spiral valves was counted by visual identification with the help of magnifying glass from proximal end to distal end (fig 1).

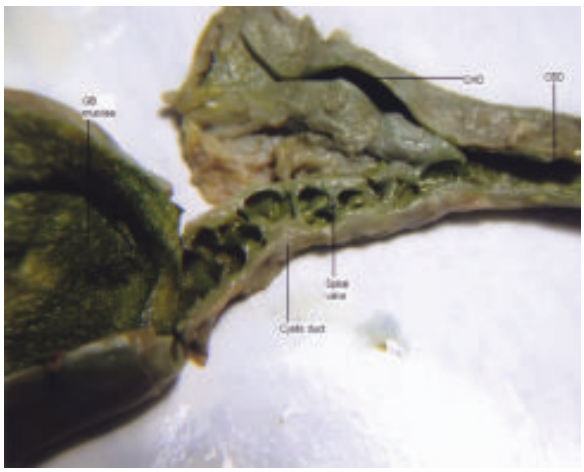

Fig.-1: *Photograph showing the spiral valves (valves of Heister) in the exposed cystic duct of the gallbladder*

Ethical clearance :
The study was approved by Ethical Review Committee of Rangpur Medical College, Rangpur.

Results:
Results are shown in Table I & II.

Length of the cystic duct:

Table: 1 shows the mean length of cystic duct in two age and sex groups. Whereas the mean length (3.23±.56 cm) of cystic duct of group B male was significantly higher than the mean length (2.63±.95 cm) in group A male (p=<.05), the mean length (2.71±.50 cm) of cystic duct in group B female showed somewhat lower value than Group A female (3.1±.55 cm) though the difference did not reach a significant level. When comparison was done among sex groups, it was found that the younger females have a longer cystic duct than their male counterpart but the elderly males showed a significantly longer cystic duct than the opposite sex groups (p<.05).

Diameter of the cystic duct:
Table 1 shows the mean diameter of cystic duct in two age and sex groups. The mean diameter (2.50±.65 mm and 2.33±.49 mm) of cystic duct have tendency to be higher in group B in both sexes than the mean values (2.28±.46 mm and 2.19±.40 mm) of group A but the difference was not significant. Again when comparison was done between sex groups of similar ages it was found that males have a greater cystic duct diameter than their female counterparts but the difference was not significant.

Table-I
Morphological parameters of the cystic duct in relation to age and sex

Characteristics	Group A		Group B		P values
	male	female	male	female	
Length (cm)	2.63 ± .95	3.10 ± .55	3.23 ± .56	2.70 ± .50	Group A Male vs. Group B Male- .04
	(1.40 - 5.00)	(2.20 – 4.20)	(2.40 - 4.00)	(2.00 - 3.50)	Group B Male vs. Group B Female-.02
Diameter (cm)	2.28 ± .46	2.19 ± .40	2.50 ± .65	2.33 ± .49	
	(2.00 - 3.00)	(2.00 - 3.00)	(2.00 - 4.00)	(2.00 - 3.00)	

Results are shown in mean ±SD, difference between mean were analyzed by unpaired students t-test. Figure in parenthesis indicate range. P value P ≤0.05 was taken as significant.

Number of spiral valves in cystic duct of the gallbladder:
Table II shows the mean number of spiral valves of the cystic duct of the gallbladder in two sex groups. The ranges & mean number of spiral valves showed similar values in both sexes.

Table-II
Number of spiral valves in the cystic duct in relation to sex

Sex	Range	Mean ± SD	p value
Male	3-7	4.591.19	>0.05
Female	3-7	5.00.94	

Results are shown in mean ±SD, difference between mean were analyzed by unpaired student's t-test. P value P≤0.05 was taken as significant.

Discussion:
The cystic duct is relatively neglected in standard anatomical reference texts. Most of the information about its anatomy and function had been published in surgery, radiology and pathology journals and largely related to congenital anomalies and diseases. The cystic duct is a very complicated conduit that connects the gallbladder to the common bile duct and allows low viscosity hepatic bile to enter the gallbladder under low pressure and the expulsion of a more viscous gallbladder bile[6]. Anatomy of the cystic duct varies between individuals. Apart from the duct length and diameter, the presence of "valves of Heister" in the lumen complicates the cystic duct geometry.

Length of the cystic duct:

The length of the cystic duct in the present study was found between 1.40 cm and 5.00 cm in the total specimens. Whereas the mean length of the cystic duct was significantly higher in elderly male (group B) than the younger male (group A), it was found that the mean length was somewhat greater in the younger females than the elderly though statistically not significant. Again the length of the cystic duct was significantly higher in the elderly males than their female counterparts but it was somewhat greater in the younger females than their male counterparts though statistically not significant.

It may be assumed that the significantly longer cystic duct in the elderly male than the younger and also significantly longer than their female counterparts may be a predisposing factor in the elderly male for developing cholelithiasis. But it does not fulfill the traditional finding that the female suffer more from cholecystitis. Even in the present study the younger female had longer cystic duct than the elderly female. However, further study with larger sample size is necessary in this respect.

Ichii et al[9] studied on three dimensional reconstruction of biliary tract in 42 cases and found that the length of the cystic duct was 2 cm in 30 cases that had a shorter operating time compared to 12 cases with a cystic duct < 2 cm ($P < 0.01$). But in our study mean length of the cystic duct in both groups was greater than the statement of Ichii et al[9].

Diameter of the cystic duct:

The mean diameter of the cystic duct of middle adult male and female was greater than the young adult groups and males had higher values than the counter females but none of the difference reached significant level in the present study.

Deenitchin et al cited by Ooia et al[10] stated that subjects with gallstones had longer and narrower cystic duct than those without. Patients with cystic duct syndrome (non-calculus partial obstruction) have also been found to have a low gallbladder ejection fraction. These studies suggest a link between complex cystic duct anatomy and prolonged retention of bile in gallbladder. It was generally accepted that prolonged stasis of bile in the gallbladder might be a significant contributing factor to gallstone formation.[11] This is suggested that the fluid mechanics, in particular the relationship between cystic duct geometries and resistance to bile flow, of biliary system may play an important role in gallstone formation.

Bird et al[6] found that there appear to be no difference in length, minimum and maximum diameter between people undergoing cholecystectomy for gallbladder stone disease and those having liver surgery in which there was no evidence or history of gallbladder disease.

Number of spiral valves:

The role of the valves of Heister, in the flow of bile into and out of the gallbladder has always been a subject of speculation. It has been suggested variously that their function is to: impede the flow of bile into the gallbladder, prevent the flow of bile from the gallbladder, or to prevent the collapse of cystic duct. Al-Atabi et al[2] suggested that the existence of these valves helps both the filling and the emptying of the gallbladder by providing structural support and preventing the duct from total collapse. But Dasgupta and Stringer[13] described that the function of the internal spiral folds that are found in man and other animals may be to preserve the patency of this narrow, tortuous tube rather than to regulate bile flow. The spiral folds may thus constitute a structural device rather than a valvular mechanism. They constituted “an architectural device to maintain the uniform size of the duct in the presence of changing pressures in the gallbladder and common bile duct.” Considering the prevalence of gallstones in humans, anatomical variations or pathologic alterations in the cystic duct which may affect the flow of bile in the biliary system may be a contributing factor in the development of gallstones and their complications. Ooia et al[10] described the cystic duct as staggered baffles in a channel to represent the valves of Heister and lumen of the cystic duct. He found that the most significant geometric parameter affecting resistance is the baffle clearance (lumen size), followed by the number of baffles (number of folds in the valves of Heister), whilst the least significant

ones are the curvature of the cystic duct and the angle between the neck and the gallbladder.

In the present study, the mean number of spira valve showed similar results between male and female groups.

Dasgupta and Stringer[13] suggested that the cystic duct and spiral folds contain muscle fibers responsive to pharmacologic, hormonal and neural stimuli. There is, however, no convincing evidence of a discrete muscular sphincter within the duct. Although the cystic duct is unlikely to play a major role in filling and emptying, it appears to function as more than a passive conduit. Coordinated, graded muscular activity in the cystic duct in response to hormonal and neural stimuli may facilitate gallbladder emptying.

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