

The Importance of Ultrasound Examination in the Studying of the Gall Bladder Anatomic Variations and Their Influence in Biliary Dyskinesia

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Abstract: *Significance and Purpose: It is important for surgical purposes to know the gall bladder variations in detail. The aim of this study is to investigate the frequency of the gall bladder shape related anatomic variations using ultrasonographic (US) exploration and their impact on Biliary Dyskinesia. Materials and Methods: 7294 (64.8%) hospitalized patients, 3112 (27.7%) ambulatory and 844 (7.5%) volunteers underwent US examination in the hospital between January 2010 – March 2013. The images were seen for possible anatomic variations and their influence in biliary dyskinesia. Results: In total 1250 patients were studied, 92 (0.82 %) showed gall bladder anatomic variations related to shape, 33 patients (0.29%) presents with anatomic variations of the construction of the gall bladder, 8 patients (0.07 %) anatomic variations of positioning and 13 patients (0.11%) with anatomic variations of genesis. 53 (36.3%) of the patients with above anatomic variations represented the status of Biliary Dyskinesia. Discussions: The anatomic variations of the gall bladder are favoring factors of gall stones forming and inflammation. The association with other congenital malformations should increase detailed control of all the elements of the biliary tract. Conclusion: Pointing out these anatomical variations before the surgical intervention may prevent possible iatrogenic traumas. Anatomic variations of the gall bladder may stimulate Biliary Dyskinesia.*

Keywords: Anatomic variation, ultrasound, gallbladder, biliary dyskinesia.

1. Introduction

Detailed study of anatomy ultrasound of the gallbladder is realized here first in the Albanian population. He joins the large number of such studies committed in population and in other time. We started this study years ago with the ultrasound studies achieved with volunteers, mainly students, in the Department of Morphology of the Faculty of Medicine.

During activation in clinical practice of ultrasound imaging examinations we were able to take tactical advantage everyday widely of this service.

The anatomy of the gallbladder and the presence or the absence of the anatomical variations is the morphological precedence that determines the architectonic scheme of biliary ducts (20,21,32). In this way, the results we are presenting have opened the green light for another study of the full architectonic morphological vascular system that we aim to achieve in the future. Building on the model of the gallbladder as the central determinant element, will complete our data on the hepatobiliary anatomy thus, these data will get practical real value for our abdominal surgeons.

2. Purpose of the Study

The primary objectives of the study are focused on anatomic study of Vesicae Felleae through ultrasound examination.

This study was finalized by:

- 1) Defining the ultrasound of the most frequent anatomical model.
- 2) Studying the anatomical variations and congenital anomalies of the vesicae felleae. There was made the statistical description of the distribution of variations and

anomalies associated with the size, shape, construction, localization.

- 3) Identification to the impact of anatomical variations and congenital anomalies in biliary dyskinesia. The above evidence is studied in correlation with biliary dyskinesia, not only in terms of frequency, but also in pathological gravity.

3. Material and Method

With the opportunities available, we were initially oriented towards the study, whose methodology was based on the realization of imaging procedures. These procedures are diverse and widely applicable in QUST, where the author of the study is employed full time. In general these methods include Ultrasound, Cholangiography, CT scanner, Scintigraphy, MR Cholangiography etc.

In the complexity of these examinations was preferred Ultrasound. Ultrasound imaging is the method chosen for the study and diagnosis of pathologies of the gallbladder. This is not only because of its realization at any time, in any clinical situation, and its recurrence whenever deemed necessary, but above all for the high diagnostic sensitivity without comparable with other imaging methods. Routinely used to assess the gallbladder frequency convex probe (3 5-5MHz). However, smaller frequencies can be used when is required an increase in the penetration depth in obese patients or when. The gallbladder is deep (eg, in hypersthenic patients). Related to this, in very thin patients (asthenic and hyposthenic) and in pediatric age where the gallbladder is very superficial, using a linear probe increases the quality of the image.

The material in this study (Table no. 1)

The study includes a 3 – year period; January 2010 – February 2013.

The study includes 11,250 cases in the study. Of which distinguish three categories:

- a. Patients hospitalized in different services of QSUT. These constitute the dominant measure of the material obtained in the study – 7294 (64. 8%).
- b. Outpatient – 3112 (27. 7%).
- c. Volunteers (generally students from the Faculty of Nursing and Medicine, University of Medicine in Tirana) offered in the study – 844 (7. 5%).

Patients involved pose no serious damage to the morphology of the biliary system. The total of the cases above consists of:

- 1) Male - 5924 (52. 7%)
- 2) Female - 5326 (47. 3%)

Study concerning the assessment of the size of gallbladder and its tone is realized with a contingent of 329 persons selected by the cases above. The selection was conducted by meeting two criteria; we think that affects not casual character:

- 1) Priority was given to the persons (patients or outpatients) who could perform easily double examination: fasting and 2 hours after meals.
- 2) Were excluded from the study all cases with pathologies that affect the size of the gallbladder.

4. Statistical Analysis

All data were coded and thrown into the computer, from where they were ready for statistical analysis. In the study there were no cases with lack of information regarding one or several variables, therefore the analysis did not contain unknown values (missing values).

For categorical variables (nominal and / or ordinal), were reported frequencies (absolute numbers) and the respective percentages. For numeric variables there were reported arithmetic averages ± standard deviations (for the data subject to the normal distribution), and median and interquartile range (when data distribution was not normal). To compare the categorical variables the exact Fisher's test were applied. This statistical test was used e.g. for comparing the shapes and positions of the gallbladder by gender of the subjects involved in the study (men vs. women).

In all cases, were considered statistically significant values of P≤0.05.

All statistical analysis was conducted by the Statistical Package for Social Sciences, version 19 0 (SPSS - Statistical Package for Social Sciences Inc., Chicago, IL, USA).

5. Results – Conclusions

Our study was based on a wide case and enough to make generalizations needed on the main features of the detailed morphology of gallbladder in the albanian population. Drawing on the main purposes of our study these

generalizations are presented in the following conclusions. We collected the data in the study conducted by the methods described above and the most common anatomic model of gallbladder in general showed us the same as the description already familiar realized by all other authors.

Determination of the Size of Gallbladder

In 329 cases that underwent ultrasound examination to determine the length and width of the gallbladder, highlighted that in 95.33% of cases ranged from 8 – 12 cm length. The smallest gallbladder 8 cm was found at 3.74% of cases and greater than 12 cm were found in 0.93% of cases (average length 10 13 cm) [Table 2 and Chart 1]:

Table 2: Longitudinal Diameter

Length	Number	Percentage
<8 cm.	12	3. 74%
8-12cm.	313	95. 33%
>12 cm.	3	0. 93%

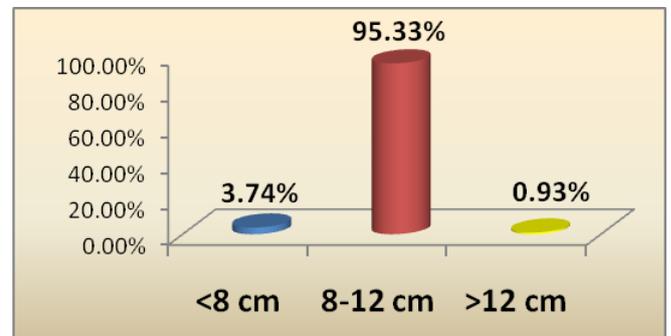


Figure 1: Longitudinal Diameter

Gallbladder width ranged 2, 5 cm – 3.5 cm in 90.88% of cases. At 3.95% of cases the width of less than 2.5 cm and 5.17% of cases over 3.5 cm (average width 13cm 3) [Table 5]:

Table 3: Transverse Diameter

Width	Number	Percentage
<2. 5 cm	13	3.95%
2.5-3.5cm	299	90. 88%
>3.5 cm	17	5.17%

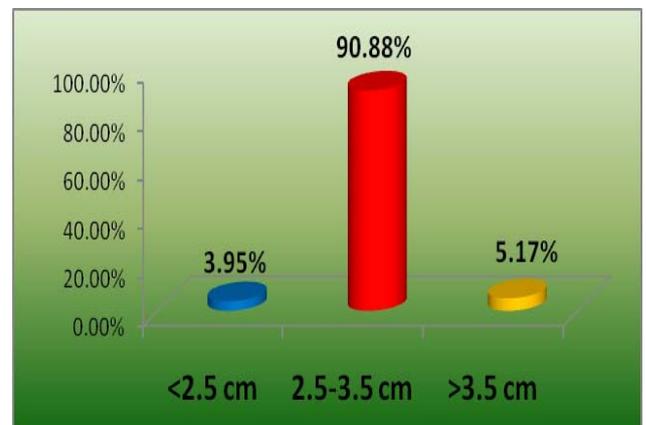


Figure 2: Transverse Diameter

Anatomical Variations and Congenital Abnormalities of Gallbladder

Anatomical variations of hepatic region follow the rules of anomalies in other regions and in generally do not remain solitary. In this context, in the variations of gallbladder can be found associative anomalies of the duct or other parts of the hepatic system. According to certain objectives variations are studied under sections above and we are summarizing the results.

Anatomical Variations of Gallbladder's Form

The most common form in which it found the gallbladder is pear shaped in which clearly can distinguish the fundus, the body, the neck and the cystic duct.

Variations of the form displayed in Table 4:

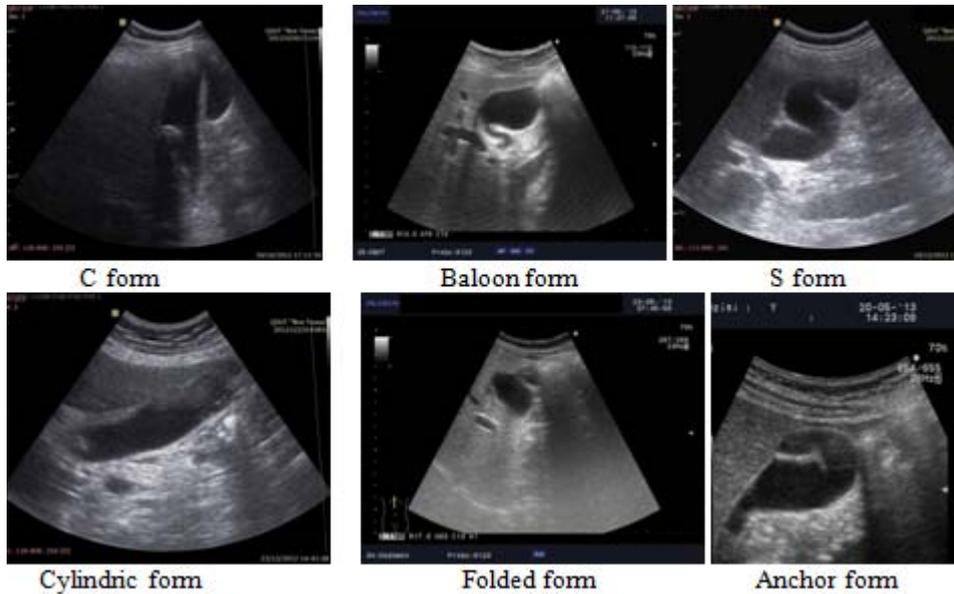
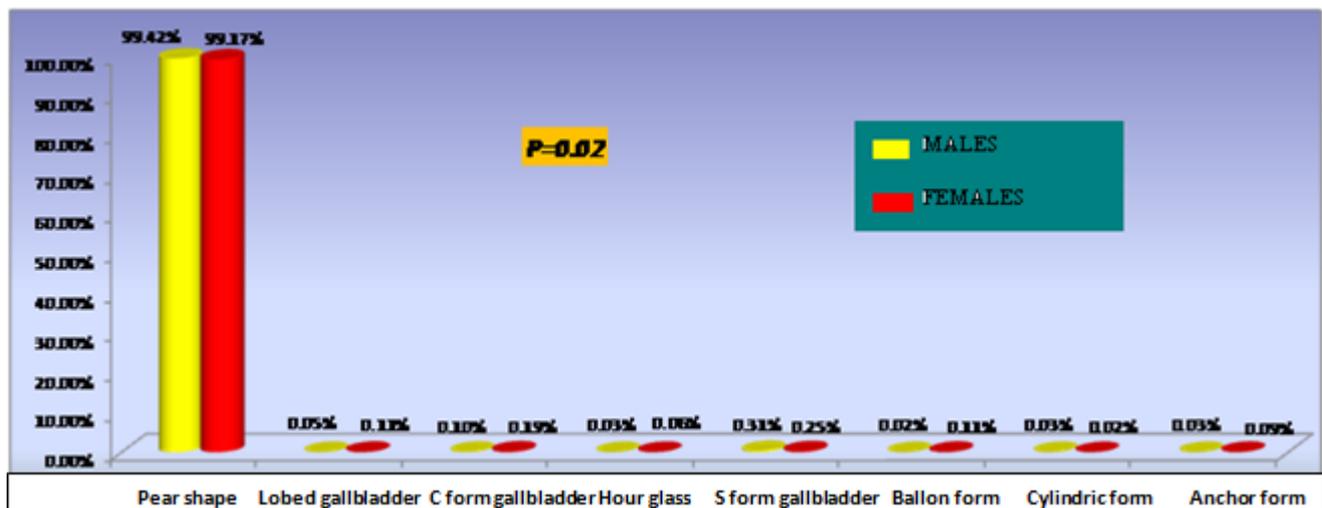


Table 4: Anatomical variations of the gallbladder shape

Nr.	Anatomical Variations	Males		Females		Males + Females	
		N	%	N	%	N	%
1	Pear shape Gallbladder	5865	99.42	5229	99.17	11094	99.31
2	Lobby Gallbladder	3	0.05	6	0.11	9	0.08
3	C form Gallbladder	6	0.10	10	0.19	16	0.14
4	"Hour Grass" Gallbladder	2	0.03	3	0.06	5	0.04
5	S Gallbladder	18	0.31	13	0.25	31	0.28
6	Ballon shape gallbladder	1	0.02	6	0.11	7	0.06
7	Cylinder shape gallbladder	2	0.03	1	0.02	3	0.03
8	Anchor shape gallbladder	2	0.03	5	0.09	7	0.06
<i>Sub-Total</i>		5899	100.00	5273	100.00	11172	100.00
Indeterminate Form		41	-	37	-	78	
TOTAL						11250	100.00

A statistical analysis used to compare the anatomical variations of the gallbladder between males and females resulted in a significant change / relevant (Fisher's exact test: P = 0.02; see Chart 3). In addition to changes in the prevalence of gallbladder in "pear shape" (99.42% in men and in women 99.17%), this difference is mainly attributed statistically significant change for gender in terms of prevalence of gallbladder in "balloon shape" and gallbladder in "C-shaped", as appropriate numbers presented in Table 6 (prevalence of gallbladder in "shaped balloon" was 0.02% in men and 0.11% in women; the other hand, the prevalence of gallbladder in "form C" was 0.10% in men and 0.19% in women).

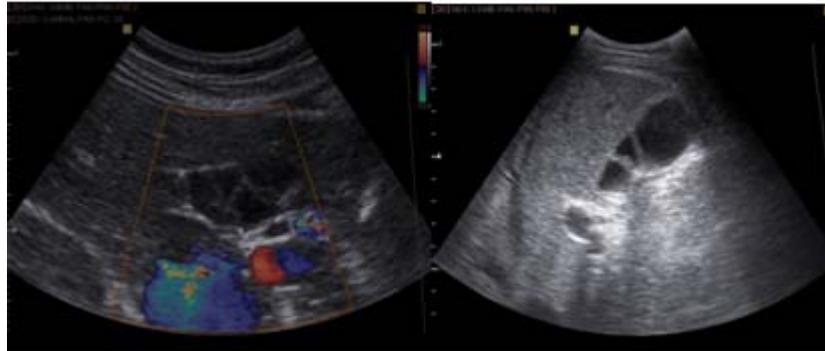


6. Construction Abnormalities

Diverticulosis. In a diverticulum the gallbladder has a cavity of large and small recess that communicates with the large or true cavity of gallbladder. The gallbladder in this anomaly presents spherical shape, different from the usual form of pear and a diameter of about 1 cm.

Septal gallbladder. In ultrasound is characterized by the presence of a septum inside the lumen of the gallbladder.

The septum may extend longitudinally or transversally. The gallbladder multiseptate is divided into erratic rooms that often reach a considerable numbers. These rooms communicate with each other. The accurate diagnosis of the multiseptate gallbladder, was considered safe when clearly discover septet in gallbladder. They appear as solitary or multiple bands echogene without posterior acoustic shadow, presenting gallbladder cavity divided into two or more rooms.



Septed Gallbladder

Ultrasound images showed gallbladder in Anchor shaped with a characteristic split that creates the image of a cap at the level of gallbladder fundus. When the connection between the two cavities was extensive bile flow is not interrupted and therefore "Phrygian cap" was asymptomatic.

In the case of close links between the two cavities prevented the normal flow of bile, bile stasis was created and favored the formation of biliary sludge and calculus. In these cases "Phrygian cap" manifested clinical signs of cholelithiasis.

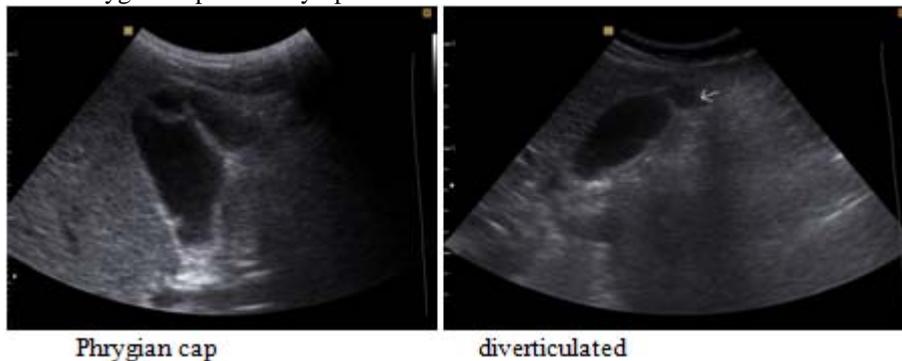
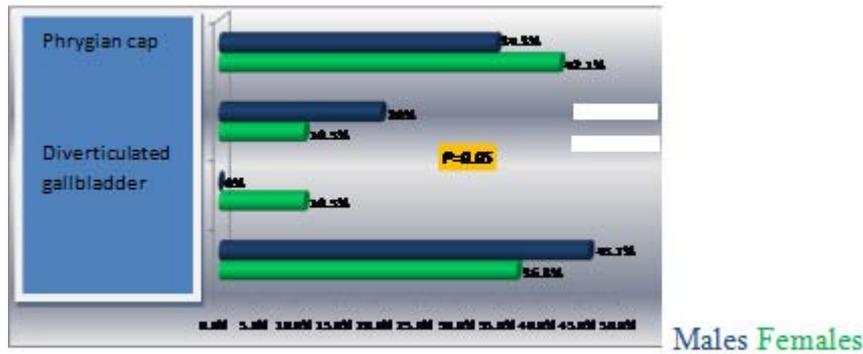


Table 6: Anatomical variations of the gallbladder construction (calculated within the group)

Nr.	Anatomical Variations	Males			Females			Males + Females		
		N	% group	% total	N	% group	% total	N	% group	% total
1	Septal Gallbladder	7	36. 8%	0.12%	16	45. 7	0.30%	23	42. 6%	0.20%
2	Hartman recess	2	10. 5%	0.03%	0	-	-	2	3. 7%	0.02%
3	Diverticulated gallbladder	2	10. 5%	0.03%	7	20. 0%	0.13%	9	16. 7%	0.08%
4	PHRYGIAN CAP	8	42. 1%	0.13%	12	34. 3%	0.22%	20	37. 0%	0.18%
	<i>Total</i>	<i>19</i>	<i>100. 0</i>	<i>0.31%</i>	<i>35</i>	<i>100. 0</i>	<i>0.65%</i>	<i>54</i>	<i>100. 0</i>	<i>0.48%</i>

A statistical analysis used to compare building of gallbladder variations between males and females which resulted in a significant change / relevant (Fisher's exact test: P = 0. 05; see Chart 6). This difference statistically significant is mainly attributed to the gender difference in terms of prevalence of "Hartman recess" and "diverticulated gallbladder" as the respective numbers presented in Table 9

(prevalence of " Hartman recess" was 10.5% in men and 0% in women, on the other hand, the prevalence of "diverticulated gallbladder" was 10.5% in men and 20% in women).



Anatomical Variations of Gallbladder Localization

Intrahepatic gallbladder is a very rare anatomic variation. In our study was found only in one case, the case was not associated with other congenital anomalies.

In our examinations were introduced two variants:

- Normal gallbladder with migration on the left lobe instead of the right lobe.
- Gallbladder localized on the left side as a result of situs inversus (5 cases).

Left Gallbladder

Table 7: Anatomical variations of gallbladder localization

Anatomical variations	Males			Females			Males + Females		
	N	% of group	% in total	N	% of group	% in total	N	% of group	% in total
Intrahepatic gallbladder	1	25%	0.02 %	0	-	-	1	12.5%	0.009%
Intraperitoneal gallbladder	0	-	-	0	-	-	0	-	-
Gallbladder with left localization	3	75%	0.05%	4	100%	0.08%	7	87.5%	0.06%
Retrohepatic gallbladder	0	-	-	0	-	-	0	-	-
<i>Total</i>	<i>4</i>	<i>100.0</i>	<i>0.07%</i>	<i>4</i>	<i>100.0</i>	<i>0.16%</i>	<i>8</i>	<i>100.0</i>	<i>0.07%</i>

Genesis Variations

Double gallbladder was confirmed as a rare congenital anomaly (2 cases). No other congenital anomalies were confirmed and patients were asymptomatic. Two cavities has

similar proportions and adjacent to each other and both cystic duct converged to form a common duct channel prior to discharge into choledocus, creating the configuration of the letter "Y".

Table 5: Anatomical variations of gallbladder genesis

Nr.	Variacionet natomike	Male			Female			Male + Female		
		N	% of group	% in total	N	% of group	% in total	N	% of group	% in total
1	Gallbladder agenesis	1	50%	0.02%	3	27%	0.06%	4	30.8%	0.04%
2	Gallbladder hypogenesis	0	-	-	7	64%	0.13%	7	53.8%	0.06%
3	Double gallbladder	1	50%	0.02%	1	9%	0.02%	2	15.4%	0.02%
	<i>Total</i>	<i>2</i>	<i>100.0</i>	<i>0.04%</i>	<i>11</i>	<i>100.0</i>	<i>0.21%</i>	<i>13</i>	<i>100.0</i>	<i>0.12%</i>

A statistical analysis used to compare the anatomical variations of genesis gallbladder between males and females resulted in a significant change / relevant (Fisher's exact test: P = 00:01; figure 5). This difference statistically significant is mainly attributed to the gender difference in terms of prevalence that "hypogenesic gallbladder" and "double

gallbladder" as the respective numbers presented in Table 8 (prevalence of "hypogenesis gallbladder" was 0% in men and 70% in women, on the other hand, the prevalence of "double gallbladder" was 50% in men and 0% in women).

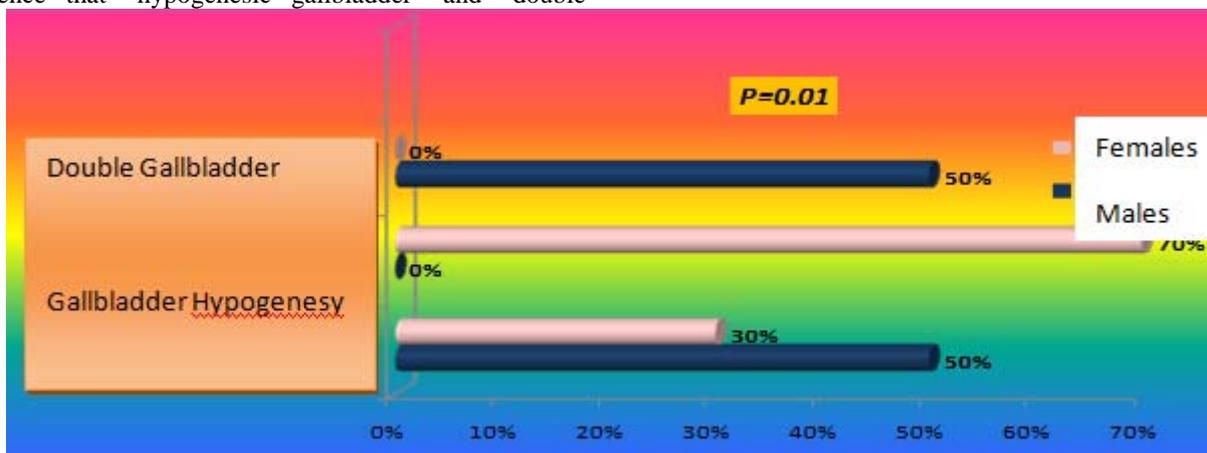


Chart 5: Anatomical variations of genesis

Biliary Dyskinesia And The Impact Of Anatomical Variations Of The Gallbladder

Anatomical variations of the gallbladder create significant conditions for biliary fluid viscosity. On the other hand, to how we treat in the previous chapters, anatomical variation, often are associated with morphological changes of the biliary duct system. In our study we also evidence the frequency of dyskinesia pathology depending on analyzed

variations. In the following table we have placed in columns sorted by frequency of clinical data associated with the pathology of Biliary Dyskinesia and rankings in a row, but according to frequency, anatomical variations of the gallbladder. We note that the anatomic variation the most often is associated with biliary drainage disorders resulted in septal gallbladder and the symptom that often accompany these anatomical variations was pain.

Table 7:

Variation	M	F	Hospitalized	Ambulatory	Pain	Calcul	Sludge	Gall-Bladder	Total
Septal	7	16	6	17	3	6	3	2	15
Shaped "S"	18	13	11	20	7	3	3	1	14
Phrygian CAP	8	12	6	14	7	2	1	1	11
DIVERICUL	5	7	5	7	4	1	2	1	7
FORM "C"	6	10	6	10	3	2	0	0	5
HYPOGENESIA	0	7	1	6	0	3	0	2	5
PORCELANOSA	1	1	0	2	0	0	1	0	1
TOTAL	45	66	35	76	24	17	10	6	45

To argue the impact of the anatomical variations and congenital anomalies of Biliary Dyskinesia pathology, we made statistical analysis of clinical signs of cases with gallbladder morphologically normal and those with morphological deviations. We have summarized the data in the following tables and graphs.

Table 8: Distribution of surgical pathologies in patients with normal gallbladder (total: 11,094)

Nr.	Surgical Pathology	Males		Females		Males + Females	
		N	%	N	%	N	%
		1	Gallbladder calculosis	211	54.7%	487	60.7%
2	Gallbladder and choledochus calculosis	14	3.6%	23	2.9%	37	3.1%
3	Cholecystitis acuta calculosa	106	27.5%	237	29.6%	343	28.9%
4	Cholecystitis chronic acalculosa	20	5.2%	31	3.9%	51	4.3%
5	Cholecystopancreatitis	23	5.9%	6	0.7%	29	2.4%
6	Cholangiocarcinoma	1	0.3%	3	0.4%	4	0.3%
7	Porcelanosa	1	0.3%	1	0.1%	2	0.2%

8	Gallbladder polyps	10	2.6%	14	1.7%	24	2.0%
	<i>Total</i>	386	100.0	802	100.0	1188	100.0

Chart 7 Distribution of surgical pathologies in patients with normal gallbladder

Table 9: Distribution of morbidity in patients with variations of gallbladder (total: 156)

Nr.	Surgical Pathology	Males		Females		Males + Females	
		N	%	N	%	N	%
		1	Gallbladder calculosis	7	7%	17	68%
2	Gallbladder and choledochus calculosis	1	1%	1	4%	2	5.7%
3	Cholecystitis acuta calculosa	2	2%	4	16%	6	17.1%
4	Cholecystitis chronic acalculosa	0	-	1	4%	1	2.9%
5	Cholecystopancreatitis	0	-	0	-	0	-
6	Cholangiocarcinoma	0	-	0	-	0	-
7	Gallbladder polyps	0	-	2	8%	2	5.7%
	<i>Total</i>	10	100.0	25	100.0	35	100.0

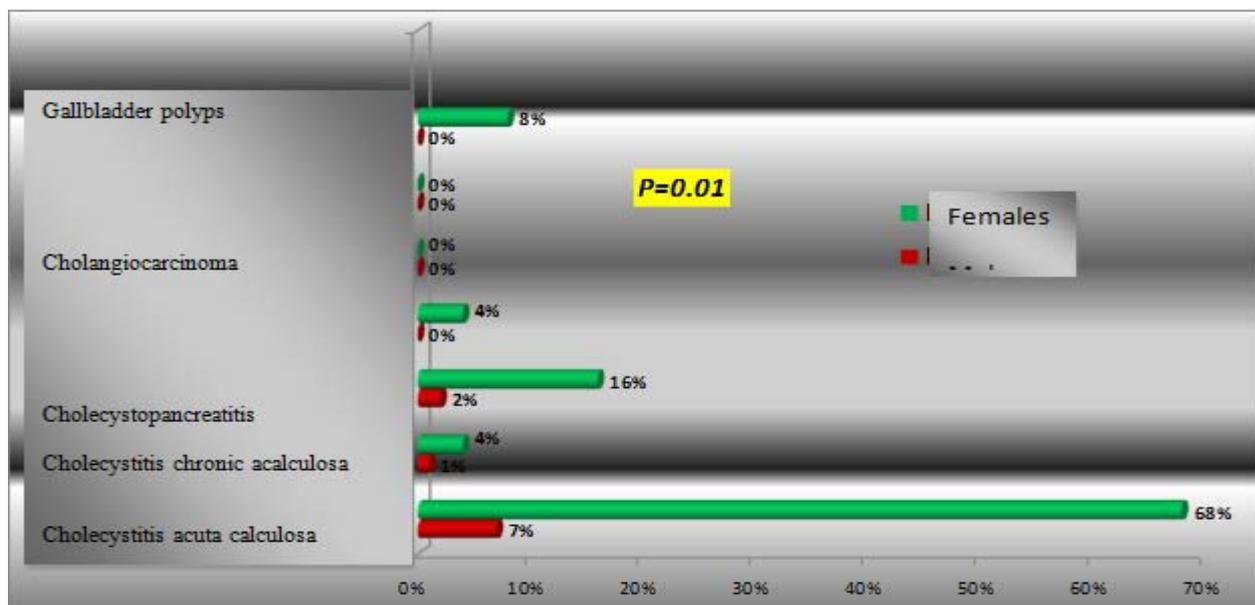


Chart 8: Distribution of morbidity in patients with gallbladder variations

The conclusion of this part of our study confirms the opinion that calculous bile and biliary sludge frequently encountered in cases with morphological deviations. The widespread use of laparoscopic cholecystectomy requires recognition of anatomical variations of the gallbladder to avoid damage during the intervention

7. Discussion

Dimensions of Gallbladder. Comparisons of the results in relation with the size of gallbladder, with those given by other authors are clearly compatible. Some of these data are presented below:

Grey (7-10cm dl, dt 2. 5-3cm, vol 35-40ml);
Oxford (5-12cm dl, dt 2. 5cm, vol 30ml);
Rouviere (8-10cm dl, dt 3-4cm, vol 30ml);
Chiarugi (8-10cm dl, dt 3. 5 cm, vol 30-40ml);
Sinelnikov (8-14cm dl, dt 3-5 cm, vol 40-70ml)

Not contracted gallbladder is approximately 10 cm long and 3-5 cm in diameter. Its width is presented with a magnitude of 2, 5-5cm, similar to that found by Chiari and Shah. The gallbladder is relatively constant in its growth. Gore et al. 2000' stated that the size may be increased during vagotomy in diabetes as a result of autoimmune neuropathy after obstruction of cystic duct or common duct even to extremely obese people, where gallbladder appear quite hypoplastic, which argued commonly associated with cystic fibrosis.

Gallbladder Form

The gallbladder in the form of pear was found in most of the samples in this study, connected with the findings of many researchers Moore and Dalleu, Chari and Shah 2008. Cylindrical form was surveyed by 1983. Hourglass shaped gallbladder the reported by Shaher 2005. Inverted gallbladder reported by Meilstrup in 1991 after a sonographically - guided study.

Two of the most significant variations are folding gallbladder fundus and neck, which usually is considered anterior folding. Meilstrup et al 1991 observed that the return of gallbladder could happen posteriorly or anteriorly thus leading to common forms and unusual to visualize the ultrasound and other imaging techniques. Futura et al. 2001 observed that there was a significant prevalence present in female subjects than in male subjects. This may be related to the formation of stones in the gallbladder and in the diseases of biliary system in women. The folded fundus of the gallbladder (Phrygian cap) reported in 3 - 7.5% of cases, is considered as a disproportion of the gallbladder between the magnitude and its lodge, but without pathological findings. Deutsch 1986 found this glitch to 0.33% and considered it as a not developed form of congenital septum. Gore et al 2000 found it in 1-6% of the population, and he observed a folded septum between the body and the fundus. The presence of the septum is reported from Csepel et al 2003, Chalkoo 2009 and Talpur et al 2010. Talpur found this glitch in 0.33% of cases. In our study, "Phrygian cap" was similar to the findings of Gore et al and Lichtenstein.

On the influence of variations in the complexity of the biliary pathology we can appreciate our findings in light of the references in the literature. In 1988 Bennion found in the literature 208 symptomatic cases of agenesis of gallbladder. 90.1% appeared with dexter hypochondrium pain, 66.3% with nausea or vomiting and 37.5% with intolerance to fats. 32% of these patients showed dilatation of the choledicus duct. According to Lindskog, expanding biliary duct without calculus, may suggest sliding of the calculus to the duodenum. However, by comparing the frequency of the choledocal calculus after colecistectomy with that after gallbladder agenesis, he concluded that in the second case the calculus predisposition is greater. In contrast, Ahlberg showed no changes in the composition of bile in patients with gallbladder agenesis, but suggested etiopatogenesy of obstruction of cystic duct or gallbladder contraction. Despite the controversy over the mechanisms of correlation to all authors note referred consistent results. Most patients presented with pain in the right upper quadrant of the abdomen, epigastralgy and backache.

Cases of gallbladder uni / multiseptale reported in the literature were associated with ductal abnormalities, as in the cases registered from us. Such as a major anomalies evident in one of our septal gallbladder is the presence of the pancreaticobiliar duct. Although, our study reconfirmed female predominance as in literature, and the average age was 29.4 years (range from 3 to 70 years).

8. Recommendations

Recommendations relating to forms of examination of vesica fellae in general and ultrasound examination in particular.

- Improvement of operational and diagnostic techniques requires detailed knowledge of anatomical variations and congenital anomalies. For this purpose, there must be a close collaboration between the service of surgery, anatomic laboratory, and imaging services.
- Total preoperator rating with sophisticated imaging methods is necessary in all cases with clinical context of cholecystitis when the ultrasound suspected congenital anomaly "Phrygian cap".
- Normal variations in the anatomy of gallbladder in some cases can confuse ultrasound interpretation. Approximately 15% of individuals have septa or party in the gallbladder.
- "Phrygian cap" is one of the most important differential diagnoses of double gallbladder, diverticulum of the gallbladder, and effusion pericholecystic.
- Gallbladder agenesis is a rare anomaly, often simulating calculus in bile. This condition should be remembered in the differential diagnosis of scleroatrophy gallbladder pathology eventually undefined during ultrasound examination.
- The solitary gallbladder agenesis is often asymptomatic. In the clinical context it can manifest in the upper dexter quadrant abdominal pain, nausea, and intolerance to fats. In case of doubt, it is obligatory the performance of MR - Cholangiography. For genetic theory reasons, should be investigated all the relatives with biliary symptoms.

- The safer diagnosis that we can propose for the confirmation of gallbladder agenesis is Selective Arteriography of the hepatic artery. Limited access is explained by the fact that it constitutes an invasive procedure.
 - US should be supplemented with ERCP and MRCP to reach a correct diagnosis with high appearance gallbladder morphological variants and adjacent anatomical structures other.
 - When the ultrasound examination evidenced by the presence of the Double Gallbladder, complicated or not, is recommended the implementation of preoperative cholangiography to detect if this anomaly is accompanied with other anomalous of the biliary system.
 - Endoscopy ultrasound (EUS) and MRCP should be performed when suspected gallbladder tripling in the gallbladder with the transcutaneous ultrasound examination.
 - Localization of gallbladder intraperitoneally, as argued in the relevant chapter, has the clinical consequence, its torsion. Diagnostic imaging criteria of the rotating gallbladder are signs of inflammation, effusion, horizontal position and cystic duct with localization on the right side of gallbladder
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