

# Prediction of difficulties in laparoscopic cholecystectomy on the base of routinely available parameters in a smaller regional hospital

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**Abstract. – BACKGROUND:** Identification of preoperative factors that indicate difficulties in the operation are in the function of primary prevention of intraoperative complications and require selection of an experienced surgical team, planning of operating program and timely provision of information to patients about the increased likelihood of conversion.

**AIM:** Identification of preoperative factors of operative difficulties by analysis of routine clinical parameters.

**PATIENTS AND METHODS:** A prospective cohort study of patients who underwent laparoscopic cholecystectomy from February 2005 to December 2009. All patients were operated by the same surgeon. There were 369 operated patients. Conversion was done in 10 patients. Main outcome measures were: duration of stages of laparoscopic cholecystectomy and conversion; identification of predictive parameters; assesment of their predictive value; assesment of the predictive value of individual parameters in respect to the duration of stages of laparoscopic cholecystectomy; correlation of parameter predictive value and duration of laparoscopic cholecystectomy stage.

**RESULTS:** Multivariate stepwise linear regression analysis showed that previous history of acute cholecystitis, gallbladder wall thickness  $\geq 4$  mm, acute cholecystitis to admission, size of calculus  $> 2$  cm,  $> 5$  attacks of pain that lasted longer of 4 hours, diabetes mellitus, duration of symptoms longer then 36 months and pericholecystic fluid collection were significant for prediction of difficulties of laparoscopic cholecystectomy.

**CONCLUSIONS:** Based on clinical, laboratory and ultrasonographic parameters without the use of highly sophisticated diagnostic procedures and increasing medical costs it is possible to predict difficulties in the laparoscopic cholecystectomy.

*Key Words:*

Laparoscopic cholecystectomy, Operational difficulties, Clinical, Ultrasound and laboratory parameters, Smaller regional hospital.

## Introduction

Laparoscopic cholecystectomy (LC) is gold standard procedure in the treatment of symptomatic gallstones even in small community hospitals with limited resources. Efficiency and safety of LC depends on the experience and expertise of the surgeon and on the underlying pathology<sup>1</sup>.

In terms of smaller regional hospitals, in which there is smaller number of experienced surgeons, prevention of injuries of the bile ducts and vascular structures during LC is extremely important because very often there are no conditions for their definite successful treatment.

Preoperative knowledge of risk factors that indicate the occurrence of difficulties that can occur in different phases of the operation are of great importance for the safety of patients and a critical assesment of the competence of the surgical team for the performance LC. Preoperative identification of operative difficulties predictors is particularly important in non referential LC centers and in the hospitals in which open cholecystectomy (OC) became a rarity as a primary prevention in intraoperative injuries of the bile ducts and vascular structures. When there is a small number of trained surgeons, a surgeon must be aware of his capabilities so in the case when he knows that an operation is going to be difficult, he can perform it only in a situation when there is a trained surgeon to perform it

in its full capacity. The aim of the work is difficulties preoperative risk factors identification and model of difficulties generation on the basis of preoperative routinely available parameters (anamnesis, physical examination, ultrasound, biochemical-hematological findings) in patients who underwent LC in conditions of smaller regional hospital, where there are no highly sophisticated diagnostic procedures available (CT, NMR, ERCP, PTC), with no increase in treatment expences.

## Patients and Methods

A prospective cohort study of patients who underwent LC from February 2005 to December 2009 was conducted at the Surgical Department General Hospital Berane, Montenegro. All patients were operated by the same surgeon. There were 369 operated patients. In the study, there were no lethal outcomes. All patients were operated by using a standard four-port technique and a surgeon qualified for laparoscopic surgeries assisted. The acute cholecystitis (AH) is defined as acute pain in the right upper quadrant of the abdomen lasting longer than three hours and requires an urgent admittance and is accompanied with cholelithiasis, leukocytosis  $> 10 \times 10^9/\text{L}$ , body temperature  $> 37.5^\circ\text{C}$  and ultrasonographic signs – thickened gallbladder (GB) wall, edematous GB wall, a positive Murphy's sign or pericholecystic fluid collection (PFC).

In the series there were 260 (70.5 %) women and 109 (29.5%) men; the average age of the patients was  $52.2 \pm 14.1$  years. Acute calculous cholecystitis was an indication for LC at 89 (24.1%) patients and chronic calculous cholecystitis at 280 (75.9%) patients. Conversion to an open procedure was performed in 10 (2.7%) patients.

The LC was divided into the following phases: 1. placement of working instruments and pneumoperitoneum creation; 2. adhesion dissection around the GB; 3. identification and clipping of the artery and ductus cysticus; 4. dissection of the GB from the liver bed; 5. GB extraction from the abdominal cavity. Total duration of the operation is the time from Veress needle insertion to portal incisions closure. Technically complicated LC was characterized by one or more difficulties in some or all phases of operations that are prolonged or greatly prolonged the duration of surgery (average time LC + at least one SD).

Routinely available clinical, hematological-biochemical and ultrasonographic parameters in predicting operative difficulties were analyzed

and they were correlated with the duration of certain phases of operation, the total duration of operations and operational difficulties. All variables had dichotomous values.

### *Anamnestic Data*

We analyzed data on the gender (m/f), age ( $> 65$  years versus  $< 65$  years), course of disease ( $>$  disease duration 36 months vs  $<$  disease duration 36 months), pain ( $<$  five episodes of pain that lasted longer than 4 hours vs  $>$  five episodes of pain that lasted longer than 4 hours, duration of pain prior to admission  $> 3$  days vs duration of pain prior to admission  $> 3$  days), body temperature ( $> 37.5^\circ\text{C}$  vs  $< 37.5^\circ\text{C}$ ), diabetes mellitus (yes vs no), previous operations in the upper and lower abdomen (yes vs no), body mass index (BMI  $> 30$   $\text{kg}/\text{m}^2$  vs BMI  $> 30$   $\text{kg}/\text{m}^2$ ).

### *Ultrasound Parameters*

In all patients, the same sonographer performed the ultrasound examination at least 24 hours before the operation. The protocols were recorded and analyzed data on the major axis diameter of GB ( $\geq 10$  cm vs  $< 10$  cm), the small axis of the GB ( $> 4$  cm vs  $< 4$  cm), wall thickness ( $> 4$  mm vs  $< 4$  mm), adhesion of the GB (yes vs no), size of stones ( $> 2$  cm vs  $< 2$  cm), number of stones (solitary vs multiple) and presence of free fluid in the lodge of the GB (yes vs no).

### *Biochemical-Hematological Parameters*

We analyzed the values of sedimentation (SE)  $> 20/\text{h}$  versus  $< 20/\text{h}$ , leukocytes (Le)  $> 10 \times 10^9/\text{L}$  vs  $< 10 \times 10^9/\text{L}$ , total bilirubin  $> 20.5$   $\text{mmol}/\text{L}$  vs  $< 20.5$   $\text{mmol}/\text{L}$ , aspartate aminotransferase (AST)  $> 40$   $\text{IU}/\text{L}$  vs  $< 40$   $\text{IU}/\text{L}$ , alanine aminotransferase (ALT)  $> 50$   $\text{IU}/\text{L}$  vs  $< 50$   $\text{IU}/\text{L}$ , gamma-glutamyl transferase (GGT)  $> 49$   $\text{IU}/\text{L}$  vs  $< 49$   $\text{IU}/\text{L}$ , serum amylase  $> 120$   $\text{IU}/\text{L}$  vs  $< 120$   $\text{IU}/\text{L}$ , amylase in urine  $> 380$   $\text{IU}/\text{L}$  vs  $< 380$   $\text{IU}/\text{L}$ , C-reactive protein (CRP)  $> 5$   $\text{mg}/\text{L}$  vs  $< 5$   $\text{mg}/\text{L}$ .

### *Pathohistological Findings of Resected GB's*

All pathological examinations of resected GB's were performed by the same pathohistologist. Histological findings were classified into acute and chronic cholecystitis and analyzed the GB with fibrosis of GB's wall (yes vs no). The resulting (outcomes) variables were the total duration of surgery, duration of certain phases of operation and operational difficulties.

The relatively small number of patients included into this series (369) reflects the disease inci-

dence and surgeon performance in a small community hospital for a given period of time. The number of patients available here has proved sufficient in other studies. Bouarfa et al<sup>2</sup> have shown that it is possible to successfully predict intraoperative complexity for LC, from preoperative patient data collected from 337 patients. The fact that all the patients were operated by the same surgeon and assistant, therefore, removing the surgeon as a major variable in analysing surgical complexities, renders statistical analyses possible.

### Statistical Analysis

Patients were divided into two groups: patients with difficulties during LC and patients in whom a LC was performed without difficulties. The two groups were compared using the Student's *t*-test or the Mann Whitney's U-test for independent (continuous) variables and the  $\chi^2$  test for dependent (categorized) variables. The linear-Pearson's and non-parameter Spearman's correlation quotient were used to test interrelation. The model of interrelation is tested using multivariate linear regression analysis, and to analyze predictors of some outcomes (difficulties) the binary multivariate logistic regression was used. All analyses were performed using a statistical data processing package SPSS 18.02 (Chicago, IL, USA).

## Results

Average duration of LC was 43.9±19.1 min (19 to 128), and average duration of operation until the

moment of conversion to open procedure was 43±25.5 min (25 to 61). Linear regression model of duration of operation with difficulties as predictors show that duration of operation depends mostly on the time of dissection of Callot's triangle (beta = 0.377) and the dissection of GB (beta = 0.376), and it least depends on the time of extraction of GB from abdominal cavity (beta = 0.108).

Difficulties during LC were present at 185 (50.1%) patients. Difficulties during accessing peritoneal cavity were at 82 (22.2%) patients, difficulties in dissection of adhesions of GB with surrounding structures at 77 (20.9%) patients, difficulties at dissection of elements of Callot's triangle at 88 (23.8%) patients. Difficulties in dissection of the GB from the liver bed were present at 132 (35.7%) patients and difficulties in extraction of GB from abdominal cavity were present at 44 (11.9%) patients.

Difficulties during the making of pneumoperitoneum and placing the working ports were significantly more at obese patients ( $p < 0.01$ ), patients with diabetes mellitus ( $p < 0.01$ ) and PFC ( $p < 0.05$ ) (Table I).

Dissection of adhesions of the GB and surrounding structures was significantly more difficult in patients with more than five attacks of pain which lasted longer than four hours ( $p < 0.01$ ) and ultrasonographic confirmed adhesions of GB ( $p < 0.01$ ) (Table II).

Difficulties in dissection of Calot's triangle elements were present in 88 (23.8%) patients and were significantly higher in fibrosis of GB wall ( $p < 0.01$ ), impacted stone of cystic duct or Hartmann recessus ( $p < 0.01$ ) and C-reactive protein higher

**Table I.** Relationship of difficulties in creating pneumoperitoneum and placement of instruments(n=82) with various parameters in the multiple logistic regression type Forward Stepwise.

Parameter	Odds ratio	95% confidence interval
BMI >30kg/m <sup>2</sup> (n = 126)	128.803	35.910-461.995
Diabetes mellitus (n = 68)	3.855	1.509-9.844
Pericholecystic fluid collection (n = 22)	14.250	1.895-107.169

BMI: body mass index

**Table II.** Relationship of difficulties in dissection of the GB adhesions(n=77) with surrounding structures with various parameters in the multiple logistic regression type Forward Stepwise.

Parameter	Odds ratio	95% confidence interval
> 5attacks of pain that lasted longer of 4h (n = 43)	11.588	1.926-69.705
Adhesions of the GB (n = 81)	612.589	120.582-3112.129

GB: gallbladder

**Table III.** Relationship of difficulties in dissection of Calot's triangle elements (n= 88) with various parameters in the multiple logistic regression type Forward Stepwise.

Parameter	Odds ratio	95% confidence interval
Fibrosis of the GB (n=115)	23.508	8.893-62.461
Impacted stone of cystic duct (n= 77)	8.040	1.961-32.962
CRP >5 mg/L (n=60)	5.517	1.137-26.771

CRP: C-reactive protein; GB: gallbladder

**Table IV.** Relationship of difficulties in GB bed dissection (n=132) with various parameters in the multiple logistic regression type Forward Stepwise.

Parameter	Odds ratio	95% confidence interval
Fibrosis of the GB (n=115)	9.632	3.177-29.199
Body temperature > 37.5°C (n=55)	3.902	1.025-14.857
Previous history of AC (n=76)	65.272	19.763-215.576
AC to admission (n=89)	15.224	4.593-50.459
Calculus >2 cm (n=140)	2.988	1.216-7.341

GB: gallbladder; AC: acute cholecystitis

than 5 mg/L ( $p < 0.05$ ) (Table III). During dissection of GB from the liver's tissue, difficulties were significantly higher in fibrosis of GB wall ( $p < 0.01$ ), body temperature > 37.5°C ( $p < 0.05$ ), previous attacks of AC ( $p < 0.01$ ) and AC at admission ( $p < 0.01$ ) and stones bigger than 2 cm (Table IV). At 44 (11.9%) patients extraction of the GB from the abdominal cavity was difficult. The difficulties were significantly more frequent in the GB wall thickness bigger than 4mm (n=75) (OR 13.175; 95% CI 5.621-30.878;  $p < 0.01$ ) and duration of symptoms longer than 36 months (n=127) (OR 3.568; 95% CI 1.431-8.897;  $p < 0.01$ ).

Using multiple linear regression model to the occurrence of a higher number of operational dif-

iculties are significantly affected: previous episodes of AC, thickened GB wall > 4 mm, AC to admission, stones larger than 2 cm, recurrent pain that lasts longer than 4 hours in more than five episodes, diabetes mellitus, duration of disease longer than 36 months and PFC (Table V).

## Discussion

LC is more technically demanding procedure than the conventional OC with a higher risk of intraoperative injury of biliovascular structure. The aim of our study was the identification of routine preoperative clinical parameters as predictors of

**Table V.** Model of higher number of operational difficulties in multiple linear regression.

Variables of the model	unstandardized B	SE	SC Beta	t	p	Stat coll Tolerance
(Constant)	801	.275	2.914	.004		
Previous history of AC	1.264	.135	.351	9.394	.000	.538
GB wall thickness > 4 mm	1.152	.150	.320	7.702	.000	.436
AC to admission	.660	.124	.196	5.328	.000	.554
Calculus > 2 cm	.448	.087	.157	5.135	.000	.800
> 5 attacks of pain > 4 hours	.550	.162	.129	3.403	.001	.525
Diabetes mellitus	.412	.106	.111	3.876	.000	.909
Symptoms > 36 months	.304	.105	.105	2.886	.004	.571
PFC	.525	.226	.076	2.316	.021	.704

GB: gallbladder; AC: acute cholecystitis; PFC: pericholecystic fluid collection

operational difficulties during the LC. In our study we found statistically significant correlation of AC on admission and previous attacks of AC with difficulties during the dissection GB from the liver parenchyma.

Today, LC is accepted as safe and feasible surgical procedure of an experienced surgeon in the treatment of AC, although there is a greater risk of injury of extrahepatic bile ducts due to inflammation of changed GB wall, and altered and often unclear anatomy in Calot's triangle<sup>3</sup>. Early diagnosis and surgery reduce occurrence of complications associated with AC<sup>4</sup>. The intensity of inflammatory changes in the GB affects the degree of surgical difficulties, increases the possibility of conversion to open procedure and duration of operation<sup>5,6</sup>.

In the early phase of AC submucosal edema facilitates dissection of the GB from the lodge and the anatomy of the Calot's triangle is not significantly altered. Progression of inflammation is characterized by multiple adhesion of surrounding anatomic structures of GB, fibrosis or necrosis of GB wall which difficulties creates in dissection elements Calot's triangle and the GB from its lodge. Eventually inflammation, leads to scarring and fibrosis. Aspiration puncture of GB has to be done for decompression of edematous thickened GB wall to allow placement of grasper and for better visualization of the Calot's triangle-reducing the risk of injury biliovascular elements<sup>7-12</sup>. Extensive inflammation and adhesions around Calot's triangle increase risk of bleeding and make anatomy unclear. Under such conditions, dissection of adhesions around GB, dissection of the elements of Calot's triangle and dissection of GB from the liver parenchyma is very hard and dangerous. Time of surgery is very important when it comes to the final outcome of the surgery. Most Authors believe that the surgery must be done between 48 to 72 hours since the first symptoms appear<sup>13-15</sup>. In many studies the rate of conversion to the open procedure is between 2 to 15%<sup>16-22</sup>, at AC to 35%<sup>22,24-26</sup>. With the improvement of the laparoscopic technique and more experienced surgeons the conversion rate to the open procedure is decreased and today ranges it between 1-6%<sup>27,28</sup>.

In our study, the conversion was performed in 10 (2.7%) cases-at 9 (10.1%) of 89 patients with AC and in 1 (0.3%) of 280 with chronic cholecystitis. Conversion rate in our series is similar to the results of Sakuramoto et al<sup>27</sup> and Kuldip and Ashish<sup>28</sup>, and lower than in some other studies<sup>20-23</sup>. Conversion rate for AC in our study is higher than the conversion rate of 4.5% published by

Sakuramoto et al<sup>27</sup> and lower than the rate of conversion of 14% published by Rosen et al<sup>18</sup>. Kama et al<sup>17</sup> reported conversion rate of 50%, while Jeremy et al<sup>21</sup> and Alponat et al<sup>22</sup> published conversion rate of 32%. The most common reason for conversion was inadequate visualization of elements of Calot's triangle and unclear anatomy (6 patients), bleeding from the GB lodges and lost stones (2 patients), perforation of the GB with lost stones (1 patient) and injury of common bile duct (Strasberg E1) at one patient with Mirizzi syndrome and empyema of the GB. The injury was repaired with choledochenterostomy sec Roux en Y. These reasons for conversion are in correlation with data from other published studies<sup>16,20,27</sup>. Patients who underwent conversions were histopathological examined and the findings showed extensive inflammation. All patients were operated after 96 hours from the onset of symptoms and within 24-48 hours after admission to the hospital. All patients had histopathologically confirmed acute inflammation in the field of chronic cholecystitis with inflammatory cell invasion in the form of secondary neutrophilic infiltration, oedema, presence of erosion of mucosal wall or strong neutrophilic infiltration with visible abscess formation, hemorrhage and ulceration of mucosa of GB associated with fibrosis or muscular subserose layer. Sakuramoto et al<sup>27</sup> state similar informations in their study.

As to US parameter, the thickened GB wall > 4 mm was statistically significant indicator of operational difficulties. In healthy population, 97% of individuals have GB wall thickness < 2 mm<sup>29</sup>. Thickened GB wall at preoperative US is a sign of present inflammation or fibrosis due to cholecystitis<sup>22</sup>. Jantsch et al<sup>30</sup> claims that GB wall thickness > 4 mm is a frequent finding in AC. Inflammation progression is characterized by multiple adhesions of surrounding anatomic structures with GB and fibrosis or necrosis of GB wall-which creates difficulties when dissecting Calot's triangle elements and GB from its bed. Inflammation in the end leads to creation of cicatrix and fibrosis. In the study published by Jantsch et al<sup>30</sup>, in 84% of patients with thickened GB wall > 4 mm had difficulties during LC. Similar results were published by other Authors<sup>27,31</sup>. Thickened GB wall was identified as a risk factor in LC to OC conversion in almost all studies and the critical wall thickness differs depending on a particular study. Fried et al<sup>16</sup> and Corr et al<sup>32</sup> conclude that GB wall which is 3 mm and more thick significantly makes more difficult dissection of GB. Many Authors note that GB wall which is thick 4

mm, 6 mm and 7 mm or more presents a factor that significantly makes more difficulties during LC<sup>33-35</sup>. In our series thickened GB wall > 4mm was significantly related to more difficult dissection of Calot triangle elements and GB, which correlates to the majority of studies<sup>16,27,33,35</sup>.

In our study we found a significant correlation between stones larger than 2 cm and difficulties during LC. Similar data are found in reports of Nachnani at al<sup>36</sup>, Jansen at al<sup>37</sup> Sakuramoto at al<sup>27</sup>, Fried at al<sup>16</sup>, Kama at al<sup>17</sup> who in their studies found no correlation between size and number of stones with technical difficulties during LC. The reason for difficult LC in the cases when the stones are larger than 2 cm is the impaction of large stone in Hartmann string which makes difficult to adequately capturing and positioning of GB, adequate visualization of elements of the Callot's triangle, dissection of the GB from the lodge and its extraction from the abdominal cavity.

In numerous reports, significance of duration of the symptoms with difficulties during LC is analysed. In our work there was a significantly greater number of difficulties during dissection of the GB in patients who had symptomatic cholelithiasis for more than 36 months and more than five episodes of pain that lasted longer than 4 hours. Sanabria at al<sup>38</sup> in a study that involved 628 patients concluded that patients who had more than 10 attacks of severe pain had significantly more difficulties during the dissection of GB. Alponat at al<sup>22</sup> in the univariate and multivariate analysis did not found the correlation between difficulties during surgery and duration of symptoms. Kumar at al<sup>39</sup> in a report of 536 patients found a significant correlation of operational difficulties at patients who had more than five attacks of severe pain during disease. Repeated episodes of severe pain are mainly common consequence of repeated attacks of AC that leads to fibrosis of the GB wall. This makes dissection of the GB difficult due to its severe positioning and absence of avascular layer between liver parenchyma and its wall. In these cases there also difficulties during dissection of the cystic duct and artery.

Pericholecystic fluid collection (PFC) is a ultrasonographic sign of acute inflammation. In our work, multivariate analysis showed that PFC was a significant predictor of a number of operational difficulties, which is correlated with many published studies which stated that the pericholecystic effusion with other ultrasonographic signs of acute inflammation (edematous and thickened GB wall, Murphy's sign) is an important<sup>20,40-45</sup> predic-

tor of operational difficulties and a risk factor for conversion. Unclear anatomy and adhesions of the GB with surrounding structures in such patients are problems which surgeon is facing during surgery. It could be a potential cause of biliovascular lesions.

In many articles it has been published that gangrenous cholecystitis is more common in patients with diabetes mellitus<sup>46-49</sup>. The reason for this association involves the interaction of acute inflammatory response of the GB wall and existing microvascular atherosclerotic disease. In patients with diabetes, autonomic and peripheral neuropathy can cause some symptoms in later stage of disease. This can be cause of delays in timely diagnosis and can lead to greater risk of conversion<sup>50,51</sup>. Pathological progression of acute inflammation is the result of ischemia of the GB wall, which leads to necrosis and perforation. In our series, multivariate linear regression shows that patients with diabetes mellitus had a significantly higher number of difficulties during LC, similar to other numerous published studies<sup>46-51</sup>.

## Conclusions

Findings of routinely taken examinations in the preoperative preparation of patients for LC in a small regional hospital can help to identify predictors of operational difficulties during the LC.

On the appearance of a higher number of operational difficulties significantly affects previous attacks of AC, GB wall thickness greater than 4 mm, AC on admission, stones greater than 2 cm, recurrent pain that lasts longer than 4 hours in more than five episodes, diabetes mellitus, disease duration longer than 36 months and pericholecystic fluid collection. Preoperative prediction of difficulties helps surgeon to assess his options, to accelerate the decision for the conversion, to timely inform patients for better psychological preparation and obtaining approval for certain real open cholecystectomy. Patients with a higher number of predictors of difficulties need to be operated by competent and rested surgical team and must have priority in making operational programs in order to reduce health care costs and increase safety of surgery outcomes.

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## Conflict of Interest

The Authors declare that there are no conflicts of interest.

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