Simple preoperative scoring system to predict difficult laparoscopic cholecystectomy

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Abstract

Preoperative scoring system to predict difficult laparoscopic cholecystectomy can be regarded as an instrument in the hand of the surgeon, which could help him to prepare for difficult operation, make better preoperative counseling of the patient, and in general, it is a further step towards the safe, modern, surgical practice. The study aimed developing a simple scoring system to predict difficult laparoscopic cholecystectomy preoperatively, which can be used in the daily clinical practice.

This is a retrospective study carried out in the 22 May Hospital, Aden, from 1st March 2018 to 29th February 2020. It included 405 patients who had laparoscopic cholecystectomy, and among them, 137 had difficult operation. 10 variables were subjected for multivariate study (binary logistic regression) which had shown association with difficult laparoscopic cholecystectomy on previous univariate analysis. Statistical software SPSS version 17 was used for this purpose and significance level was set to $p< 0.05$. The necessary predictors (independent factors) which were able to explain the outcome (difficult laparoscopic cholecystectomy) were identified with statistical significance. The effect size of these predictors was rounded and the new values were adopted as scores for each factor. A scoring system was constructed from these factors and their scores. The accuracy of the new score system was tested by the ROC analysis against the same sample.

7 predictors were identified. Depending on these variables, the prediction for easy laparoscopic cholecystectomy came true in 87% of cases and the prediction for difficult laparoscopic cholecystectomy came true in 85% of the cases. The returned area under the curve was 0.913, with 95% confidence interval. A score above 2.25 was considered difficult with sensitivity and specificity of 82.25% and 85.8% respectively. There were no cases with score above 9.

From the findings of the current study, it could be concluded that the new scoring system had good predictive capability to difficult laparoscopic cholecystectomy and it incorporates simple, few determinants, which could help surgeon and improve patient curative care.

Key words: laparoscopic surgery, gallstone, difficulty score, prediction, cholecystectomy

Introduction:

In many recently published studies, difficult laparoscopic cholecystectomy was observed in about one third of the operated patients which make preoperative assessment for difficult operation and planning for safe surgery is prudent [5, 6, 19, 24] . Undoubtedly, clinical and paraclinical assessment including imaging studies of patients with gallbladder stone disease, can reveal individual factors associated with difficult laparoscopic cholecystectomy and are indispensable parts in the management and decision making process [31]. However, the gained medical information through this process can be further organized in a structured way with the aid of a scoring system to forecast difficult operations. It can be regarded as an instrument in the hand of the surgeon, which could help him a lot. During the last decade, several scoring systems have been developed [3,16,19,23], but they are far from optimal [11]. They differ; some were used to predict difficult procedure, whereas others were used to predict risk of conversion or adverse outcome. Some of them depend on preoperative factors, others on perioperative factors or intraoperative

factors alone. For example, Cuschieri published in 1992 in a textbook an operative grading system to define the difficulty of laparoscopic cholecystectomy, which was slightly modified in 1998 [4]. Likewise, Parkland's grading system is an intraoperative based scale that can predict difficult laparoscopic cholecystectomy [1,18]. However, the use of scoring system which depends on preoperative factors have many advantages over scoring systems based on intraoperative determinants [2,13,25]. It can predict difficult operation beforehand; therefore the surgeon can be prepared for difficult situations which could face him during operation. Patient and their relatives can be counseled preoperatively for the possibility of difficult operation, prolonged hospital stay and increased cost in the face of the predicted difficult cases. Preoperative identification of difficult laparoscopic cholecystectomy provides important advantages not only for the surgeon, but for the organization of the operating block and technical resources [8].

However, the currently available scoring systems require meticulous revision [7]. Many of them are complex or depend on factors that are not sensitive. They are often restricted for theoretical or training purpose only [11].

Therefore, the aim of this study is to develop a simple preoperative scoring system to help predict difficult laparoscopic cholecystectomy which can be applied easily in the daily clinical practice.

Method:

This study was conducted in the 22 May Hospital, Aden, from a period of 1st March 2018 to 29th February 2020. It is a retrospective study that included 405 patients who underwent laparoscopic cholecystectomy. Among them 137 cases had difficult laparoscopic cholecystectomy based on criteria mentioned in previous studies [6]. Data entry was done to statistical software IBM SPSS version 17 and included the dependent variable easy/difficult laparoscopic cholecystectomy and the preoperative independent which were noted to have statistically significant association with difficult laparoscopic cholecystectomy on univariate analysis [6]. In order to exclude confounding variables from further study a binary logistic regression analysis was used with forward LR method and the significant level was assumed at level $p < 0.05$. Null hypothesis (N0) was laid down assuming that the outcome (difficult laparoscopic cholecystectomy) can be explained without adding the predictors (preoperative variables), whereas the N1 Hypothesis assumed that the outcome cannot be explained without adding the predictors. The analysis was completed and the best fitting model was selected. Accordingly, the independent variable in the best fitting model were assigned different score based on the affected size. The accuracy of the scores was tested by the receiver operator curve ROC analysis and a critical value which showed favorable sensitivity and specificity was determined.

Results:

The classification Table in the beginning block (step 0) showed that the outcome cannot be explained without adding the predictor(s) (independent variables). Therefore, the null hypothesis was rejected and the alternative hypothesis was accepted, that difficult laparoscopic cholecystectomy cannot be explained without the independent variable(s) (preoperative factor(s)) to the model.

Table 1: The beginning block of the classification table of the binary logistic regression forward LR method

Classification Table a, b

Observed			Predicted		
			Difficult		Percentage Correct
			no	yes	
Step 0	Difficult	No	268	0	100.0
		Yes	137	0	.0
		Overall Percentage			66.2

a. Constant is included in the model.

b. The cut value is .500

The logistic model obtained in step 8, showed a better fit to data as it demonstrated an improvement over the intercept only model (null hypothesis). The Hoshmer Lemeshow test yield a X2(8) of 14.464 and was insignificant p= 0.07, suggesting a good model of fit to data (Table 2).

Table 2: Hosmer Lemeshow Test

Step	Chi-square	df	Sig.
1	.000	0	.
2	.052	1	.819
3	6.051	2	.049
4	12.249	8	.140
5	22.950	8	.003
6	28.135	8	.000
7	19.802	8	.011
8	14.464	8	.070

The model obtained in step 8 was able to distinguish between difficult laparoscopic cholecystectomy and not difficult laparoscopic cholecystectomy based on the 7 predictors. According to the classification table obtained in step 8, the sensitivity, specificity and the overall accuracy of the model were 93.3%, 74.5% and 86.9% respectively.

Table 3: Step 8 of the classification Table (a)

		Observed	Predicted		
			Difficult		Percentage Correct
			no	yes	
Step 8	Difficult	no	250	18	93.3
		yes	35	102	74.5
		Overall Percentage			86.9

a. The cut value is .500

Table 4: Variables in the equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 8	ERCP(1)	2.643	1.004	6.927	1	.008	14.050
	Previousoperation(1)	2.244	.506	19.681	1	.000	9.435
	GBthickness(1)	2.276	.358	40.375	1	.000	9.742
	pericholecysticfluid(1)	2.165	1.069	4.101	1	.043	8.712
	contracted(1)	1.601	.507	9.956	1	.002	4.956
	Gender(1)	1.087	.494	4.839	1	.028	2.964
	Impactedstone(1)	1.591	.419	14.415	1	.000	4.907
	Constant	-4.099	.552	55.072	1	.000	.017

Based on the odd ratios, patients who had previous ERCP, 14 times are more likely to have difficult laparoscopic cholecystectomy. Similarly patients who had thickened gallbladder wall are almost 10 times more likely to face difficult operation.

The scoring system for preoperative categorization of patients into easy and difficult laparoscopic cholecystectomy is shown in Table 5.

Table 5. Preoperative scoring system to predict difficult laparoscopic cholecystectomy

Scoring factors	Score value if factor present	Score value if factor not present
ERCP	2.5	0
Gallbladder wall thickness >4 mm	2.5	0
Previous abdominal surgery	2	0
Pericholecystic fluid collection	2	0
Impacted stone	1.5	0
Contracted gallbladder	1.5	0
Male gender	1	0

Minimum score is 0 and the maximum score is 13. In the study group, the obtained scores were ranged between 0 and 9.

The accuracy of the scoring system was tested by ROC analysis (Figure No.1) and revealed an area under the curve of 0.913, with standard error of 0.016 and a significance level, $p< 0.001$ and asymptotic confidence interval of 95%.

A score value of 2.25 was selected as a cutoff value to differentiate between easy and difficult laparoscopic operation, with a sensitivity and specificity of 82.25% and 85.8% respectively.

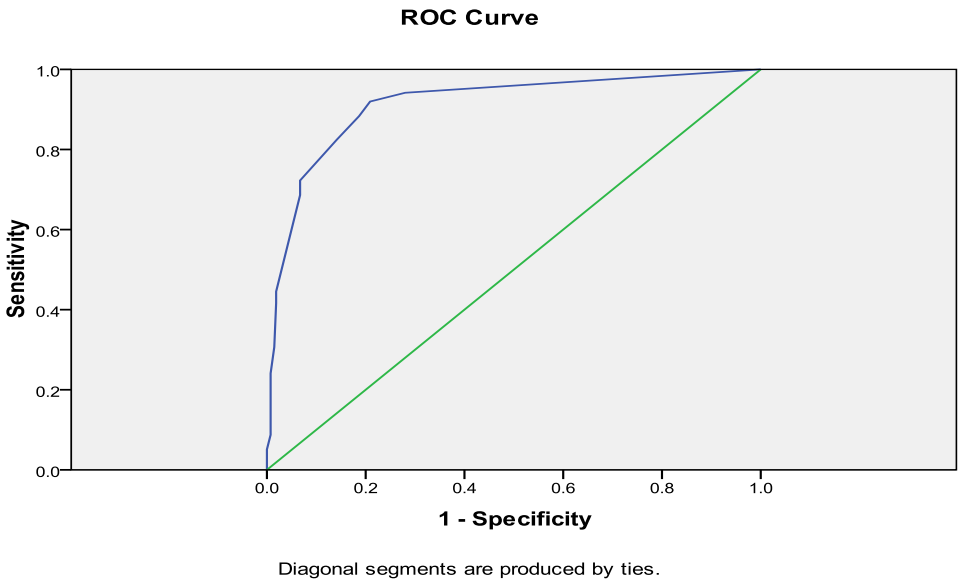

Figure No. 1: ROC curve and its area under curve for predicting the operative outcome based on preoperative scores.

Discussion:

The currently proposed scoring system is characterized by its simplicity because it utilizes readily available clinical and paraclinical (imaging study) information. It depends on few determinants which can be easily memorized and it uses simple score numbers which can be easily counted.

The current study highlighted that patients with higher preoperative score are more likely to have difficult laparoscopic cholecystectomy. This observation can be concluded from the positive values of the regression co-efficiencies. Increasing the score by one unit, the odd ratios of the predictors will increase accordingly. Also it can be noted from the classification table of step 8 of the regression model that the prediction for not difficult laparoscopic cholecystectomy is close to the prediction of difficult laparoscopic cholecystectomy. This observation is supported by the magnitude of PPV (positive predictive value) in comparison to the NPV (negative predictive values), 85%, 87% respectively and the overall accuracy of 86.9%. These results are favorably in agreement with what was mentioned by Joshi M et al [14]. They suggested a scoring system to predict difficult laparoscopic cholecystectomy which had a PPV and NPV of 63.6% and 84.6% respectively.

From the coordinates of the ROC curve as illustrated in Figure 1, can be noted that, when the score results are larger, the test is more specific. By increasing the specificity of a test, the false positive results decrease, however it has reciprocal effect on sensitivity. Therefore, it is not easy to determinate the best cutoff score. In the current study a balanced cutoff score was selected at score 2.25, which showed the closest percentage of sensitivity and specificity to each other (82.25% and 85.8% respectively). By looking up the cutoff value in the ROC curve (Figure 1), it shows a favorable distance from the left upper corner.

Wennmaker et al [33] made an effort to make a simple preoperative model, but they intended to predict complicated laparoscopic cholecystectomy in patients with acute biliary presentations. They depended on only three factors as follow; clinical diagnosis of acute cholecystitis, C- reactive protein level above 10.5 mg/dl and pericholecystic fluid collection Their model had an AUC of 0.86 and sensitivity and specificity at cutoff value of 2.5 of 77.7% and 81.7% respectively.

In the current study, the returned area under curve in the ROC analysis was above 0.9 which is considered to be a fairly good to excellent instrument.

Sudhir M and Ray P, [27] studied the preoperative scoring system at Command Hospital, Bangalore, on 100 patients. Their studied score had a returned area under curve of 0.729.
Acharya A and Adhikari SK [2] proposed a preoperative scoring system composed of 11 factors. Their proposed system had an ROC of 0.856. Similarly, Raza M and Venkata RM [22] studied a modified scoring system and had an ROC of 0.876.

In the current study the factors of the scoring system were selected based on the identified predictors of the final regression model. These factors had assigned different values. This is in contradiction to the study by Kumar A et al [16], who proposed a preoperative scoring system, and their selection of preoperative predicting factors, based on their revision of various clinical studies. They assigned equal score for each factor.

Vivek MAK et al [32] proposed a comprehensive predictive scoring method for difficult laparoscopic cholecystectomy. It incorporates 22 parameters with total score of 44. It was considered a score above 9 as difficult with sensitivity of 85% and specificity of 97.8%. However, their scoring method incorporates preoperative as well as intraoperative parameters, which excludes its use as a standalone preoperative predictive tool for difficult laparoscopic operations.
Rhandawa JS and Pujahari AK [21] developed a preoperative scoring method, with the intention to differentiate between easy, difficult and very difficult laparoscopic operation, based on 11 preoperative scoring factors. The maximum score was 15. The ROC showed an AUC of 0.82 with 95% confidence interval.

Boraii S et al [7] evaluated Rhandawa and Pujahari scoring method and they suggested to remove insensitive factors without negative effect on outcome.
Soltes M et al suggested a scoring system to predict 5 level of difficulty of laparoscopic cholecystectomy [26], however several studies suggested that preoperative grading scales for surgical difficulties are not completely compatible, and surgical complications could happened in any grade of difficulty [9].

The current study depends on the primary endpoint of difficult procedure. This is in contradiction to other studies where open conversion was selected to be the primary end point. For example, Clock score and G10 scoring systems used to predict the need for open conversion [28, 29]. The former uses preoperative parameters, the later depends on intraoperative findings. The prediction value in their study was conversion rate to open procedure. However, open conversion is relatively infrequent and confounded by several parameters other than difficulty of the procedure [22].

The proposed scoring system in the current study incorporates 7 predictive factors. For example, male gender is a factor incorporated in the current difficulty score. This correlates with other studies [17, 20].

It is also found that patients with previous ERCP had more chance for difficult laparoscopic cholecystectomy and this correlates well with the finding of Vivek MAK. et al [32]. Similarly, Reinders JS et al concluded that laparoscopic cholecystectomy is more complicated after previous ERCP [22]. Goyal P et al [10] made a prospective study on 102 patients operated by a single surgeon and found an improvement in the predictive capacity of the Randhawa and Pujahari score after adding 3 new factors, namely previous ERCP , contracted gallbladder and diabetes mellitus.
Gallbladder wall thickness more than 4 mm is also a factor in the current predicting system. This is in consistence with previous studies like that in the preoperative scoring system proposed by Gupta N et al [12] or the original or modified Randhawa and Pujahari scores [21]. Kumar N et al [16] found that thickened wall of gallbladder on sonography had a positive correlation with difficulty in surgery, it also had more conversion rate [30].

Ultrasonographic pericholecystic fluid collection and impacted stone were found to be a predictor of difficult laparoscopic cholecystectomy and this correlates well with a study by Shaban H et al [25].

Conclusion:

The new scoring system has a good predictive capability to difficult laparoscopic cholecystectomy and it incorporates simple, few determinants, which could help surgeon and improve patient curative care.

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نظام تقييمي بسيط قبل العملية للتنبؤ بالصعوبات في عمليات استئصال المرارة بالمنظار

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الملخص

يمكن اعتبار النظام الحسابي من أجل التنبؤ بالصعوبة في عمليات استئصال المرارة بالمنظار كأداة في يد الجراح التي قد تساعده في التحضير لعملية صعبة، استشارة المريض بشكل أفضل قبل العملية، وهي تعتبر خطوة إضافية نحو الممارسة الجراحية الآمنة الحديثة. هدفت الدراسة الى تطوير نظام حسابي بسيط للتنبؤ بالصعوبة في عمليات استئصال المرارة بالمنظار التي يمكن استخدامها في الممارسة الطبية اليومية.

هذه دراسة استيعاديه، أجريت في مستشفى 22 مايو، عدن، من تاريخ أول مارس 2018 إلى تاريخ 29 فبراير 2020م. وتشمل على 405 مريض/ة اجريت لهم عمليات استئصال المرارة بالمنظار من ضمنها 137 حالة كانت العملية فيها صعوبة. وتم إخضاع 10 عوامل للدراسة متعددة العوامل التي سبق أن اثبت علاقتها بصعوبة استئصال المرارة بالمنظار ذلك من خلال الدراسة المسبقة بطريقة أحادية العامل. استخدمت في الدراسة برنامج SPSS إصدار17، واعتبرت قيمة $P\text{-value} \leq 0.5$ ذو دلالة إحصائية. تم تحديد العوامل الضرورية (العوامل المستقلة) والتي استطاعت تفسير المخرجات (صعوبة إجراء عملية استئصال المرارة بالمنظار) بدلالة إحصائية. تم التقريب الرياضي لحجم التأثير لهذه العوامل. تم إنشاء نظام حسابي جديد من هذه العوامل وحقها القيم. تم تقييم دقة النظام الحسابي الجديد من خلال التحليل ROC ضد نفس العينة.

تم تحديد سبعة عوامل تنبؤية. معتمدًا على هذه العوامل التنبؤ بعملية بسيطة لاستئصال المرارة بالمنظار أتت صحيحة في 87% من الحالات بينما التنبؤ بعملية صعبة لاستئصال المرارة بالمنظار أتت صحيحة في 85% من الحالات. وكانت المنطقة التي تم إرجاعها تحت المنحنى 0.913 مع 95% من فاصل الثقة. اعتبرت القيمة أكبر من 2.25 دالة على صعوبة مع حساسية وخصوصية تحليلية 82.5% و 85.8% كل على حده لم توجد حالات مع قيم أعلى من 9.

استنتج من الدراسة أن النظام التنبؤي الجديد لديه القدرة الجيدة في التنبؤ لعمليات الصعبة لاستئصال المرارة بالنظار، وتشمل على عوامل قليلة وبسيطة التي من شأنها أن تساعد الجراح وتحسن من الرعاية العلاجية.

الكلمات المفتاحية: عمليات بالمنظار، حصى في المرارة، حساب الصعوبة، تنبؤ، استئصال المرارة.