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Case Series

Laparoscopic cholecystectomy with infundibulum cystic artery first technique: A record-based case series

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ABSTRACT

Background and aim: Even though laparoscopic cholecystectomy LC became the gold standard for the treatment of gallstones, bile duct injuries, (BDI), are still more frequent than that recorded in the open cholecystectomy OC era. The aim of the study is to describe the experience with this modified technique through a retrospective case series.

Materials and methods: This record-based study was carried out at Dawadmi General Hospital in Riyadh, Kingdom of Saudi Arabia. The data were collected from hospital records from January 2008 to September 2017. It included all the patients undergoing Laparoscopic Cholecystectomy (LC) performed by the author using a modified infundibulum first technique with cystic artery identification. The number of eligible records was 502.

Results: The majority of patients were women (81.7%), having symptomatic cholelithiasis and chronic cholecystitis (83.7%). The median operative time was 43.1 minutes. Nine (1.79%) patients experienced intra-operative incidents, the most common being iatrogenic gall bladder perforation (4 patients). None of the patients had bile duct injury (BDI), while 3 required conversion to open cholecystectomy (OC). Overall, 8 (1.59%) patients had early post-operative complications. The overall morbidity rate was 2.99% (95% CI: 1.75–4.77).

Conclusion and recommendations: The modified LC approach based on identification of the cystic artery is associated with lower rates of intra- and post-operative complications, with low conversion rate. A multi-center randomized clinical trial is recommended to provide more evidence of the utility of this technique.

1. Introduction

Laparoscopic cholecystectomy (LC) is a well-established surgical procedure. It was started in Germany in 1985, then adopted and modified in France in 1988 [1,2]. It gained more popularity in the 1990s, and was approved by the National Institute of Health in 1993 as a safe and effective technique for management of symptomatic gallstones [3]. The advantages for LC in comparison with open cholecystectomy (OC) have been demonstrated over the last three decades, and it is now the most frequent surgical procedure in general surgery.

Nevertheless, the procedure is not without risks. Thus, in comparison with OC, the associated risk of bile duct injury (BDI) may be doubled or even tripled [4]. This is often due to the confusion between the common hepatic or common bile duct and the cystic duct. Davidoff [5] identified this confusion as the possible cause underlying such hazard of the infundibulum first technique of LC since 1991. Consequently in 1995, Strasburg [4] favored the Critical View of Safety (CVS) approach, and urged forsaking the infundibular technique [5]. The technique entails dissection above the plane of Rouvier sulcus as bile ducts are claimed to be always at or below it, and to start dissection along the so called yellow fibro fatty line of the gallbladder [6]. The CVS concept has gained the recognition of prominent surgical societies such as the Society of American Gastrointestinal and Endoscopic Surgeons [7], and the Institut de Recherche contre les Cancers de l'Appareil Digestif [8].

It is true that LC can be made safer by following the protocols of CVS. However, surgeons should make a maximum benefit of the visual and tactile laparoscopic senses in addition to the fine instrumental sensation, taking advantage of the delicacy of the specifically designed instruments to suit laparoscopic surgery, in order to reach near zero-level morbidity. The technique used in this study is the "safe infundibulum and cystic artery first." It is basically

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n Infundibulum First Dissection one, in addition to identification of the cystic artery going to and penetrating into the wall of the gallbladder as is seen from both the ventral and dorsal aspects. It is based on the concept that if this view is attained, there is hardly any possibility of incurring any injury to the bile ducts. The aim of the study is to describe our experience with this modified technique through a retrospective case series.

2. Materials and methods

This record-based study was carried out at Dawadmi General Hospital in Riyadh, Kingdom of Saudi Arabia. It is a 200 bed-capacity general hospital affiliated the Ministry of Health. The hospital provides basic and advanced medical and surgical services to the surrounding community.

The data for the study were collected from the operative room census and the hospital data base during the period from January 2008 to September 2017. All the patients undergoing LC performed by one same surgeon (the author) using this modified infundibular technique with cystic artery first were included in the study sample. The records of the patients suffering severe coagulopathy, ASA IV or higher, as well as pregnant women were excluded. The total number of eligible records was 502 consecutive cases. The diagnosis of acute cholecystitis (AC) was made according to Tokyo guidelines [9].

The study was reported following the PROCESS guidelines [10]. The research registry *UIN* 4559. It was exempted from ethical approval.

2.1. Intervention technique

All patients had routine blood tests and abdominal ultrasound scans. Patients with raised alkaline phosphatase or bilirubin level or jaundice or history of jaundice had Magnetic Resonance Cholangio-Pancreatography (MRCP) done. Those positive for bile duct stones were referred to have an Endoscopic Retrograde Cholangio-Pancreatography (ERCP) and stone extraction; they were operated upon within the same week, 24 hours following the procedure.

A 4-port technique LC was performed under general anesthesia in accordance with the US protocol with regard to placement of the operative team and sites of the ports. The main operator was an experienced general and laparoscopic surgeon. No radiological intraoperative procedure was done. The laparoscopic instruments were provided by Karl Storz. Veress needle was used for evacuation of tense gallbladders, hydrops, and empyema cases. Provisional degree of operative difficulty was assessed with Nassar grading system [11].

The concept and technique of “safe infundibulum and cystic artery first” is based on the practical observation that when the cystic artery is seen penetrating the lower aspect of the gallbladder, and this is confirmed in ventral and dorsal views, this indicates with certainty the view of Calot's triangle. To discuss this situation further, the surgeon is faced with a number of probabilities as illustrated in Fig. 1.

Tissue plane 1: accurate dissection plane; even if the CBD is nearby it can be pushed aside during dissection.

Tissue plane 2: classic injury, hidden cystic duct, and false infundibulum plane. *Tow* probabilities are encountered in this plane:

1. The wide curved CBD CHD RHD probability (Fig. 2): only the RHA, which can be identified by gentle dissection as having no clear relation to the GB as seen from both the ventral and dorsal views, will be encountered. This happens because of the very close juxta-GB position of the CHD either due to anatomical or pathological reasons. The situation requires a bailout behavior and/or procedure that is to seek help from a more experienced surgeon, or to start dissection at a point further away close to GB wall but above the plane of Rouvier's sulcus.
2. The second probability is that of narrow curved CBD, CHD (Fig. 3.) In this plane, the RHA would still be the one identified; however, the origin of the Cystic Artery (CA) may be seen or there may be a space in Calot's triangle to restart dissection, as aided by the visual signs (to be described later).

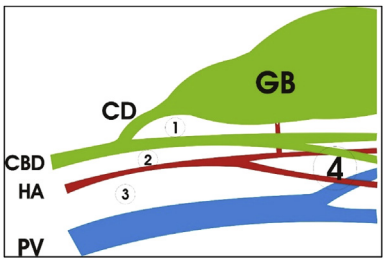

Fig. 1. Highly diagrammatic plan of various tissue planes explored during LC. CBD Common bile duct, HA Hepatic artery, CD Cystic duct, GB Gallbladder, PV Portal vein.

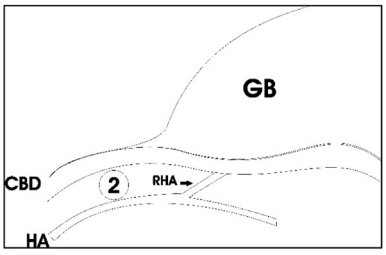

Fig. 2. Wide curved CBD CHD. CBD Common bile duct, CHD Common hepatic duct, RHA Right Hepatic artery, HA Hepatic artery.

Tissue planes 3 and 4: These planes are usually reported as “conversion was done due to a complex anatomy,” or “severe bleeding,” or “this may be a second GB” as the Portal Vein (PV) is perceived by the surageon, or else most of the BDI other than the classical one and most of the few unfortunate mortalities, again early bailout behavior and/or procedure is required.

The ductal artery, a CA branch to CD, if identified, is a very good sign that this is the right plane of Calot's triangle and the two structures connected with it are the CA and CD, however the degree of reliability it confers is not studied enough.

2.2. Laparoscopic visual signs

Three visual signs can be of help in a difficult LC due to anatomical or pathological reasons.

The virtue of colors: This observation is based on the color differences among the different structures of the hepatocystic triangle. Hence, it is highly variable not only according to the used instruments but also in relation to the degree of inflammation encountered. However, with the instruments used in this study, the color of the CBD and CHD was perceived as pearly, blue to green in color. The cystic duct had a faint rosy color when having its peritoneal covering and a much darker color when not.

The geometric discrepancy sign of the false infundibulum: Infundibulum means funnel in Latin; however, as perceived through the laparoscopic image it is actually more of a Tulip flower base or a glass of champagne base. The discrepancy and dissimilarity of the gentle incurve of one side of the infundibulum and the straight line

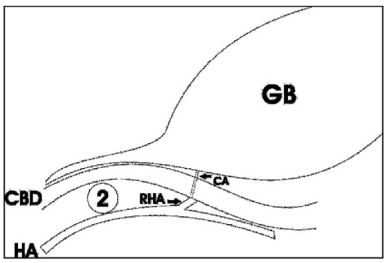

Fig. 3. Narrow curved CBD CHD. CBD Common bile duct, CHD Common hepatic duct, RHA Right Hepatic artery, HA Hepatic artery, CA cystic artery.

and angle of the other side that occurs in the false infundibulum cases [5] (which is formed actually by the CBD) should raise a high index of suspicion. It is mostly observed during dissection in tissue plane 2 where the angulated, curved CBD is mistaken for the infundibulum and the CD (Fig. 4).

The dimple sign: A dimple that can be seen in the area of Calot's triangle is most probably formed by chronic inflammatory process leading to fibrosis of the connective fatty tissue in between the constituent structures of the triangle (actually the laparoscopic quadrangle GB, CD, CA, CHD) leading to a clear dimple in the safe spot for dissection in between these structures. The dimple is sometimes accentuated by a superadded acute inflammatory swelling affecting the surrounding, still non-fibrosed tissues, making it an invaluable sign in the dissection of Calot's triangle in difficult chronic and acute cases of cholecystitis.

Diathermy was used very cautiously to avoid active and passive lateral injuries. The very base (most inferior) of GB attachment to liver (hepatic bed, or cystic plate) was consistently clipped after recording two incidents of visible bile leaks, attributed to Luschka ducts, and clipping of other two probable ones. The GB was dissected from its hepatic bed according to its relative attachment to it. If it had a mesentery, this was step wisely clipped then cut. If the body was loosely attached, it was peeled off by traction and counter traction. If firmly attached, dissection with a diathermy hook and applying clips to suspicious adhesions. As a rule, no drain was left except in very difficult cases or if there was minor biliary leak.

2.3. Data management

Data were extracted from the hospital medical records after securing required permissions from pertinent authorities. Data entry and statistical analysis were done using SPSS 20.0 statistical software package. Quality control was done at the stages of coding and data entry. Data were presented using descriptive statistics in the form of frequencies and percentages for qualitative variables, and means and standard deviations and medians for quantitative variables. Fisher exact 95% confidence intervals were computed for proportions.

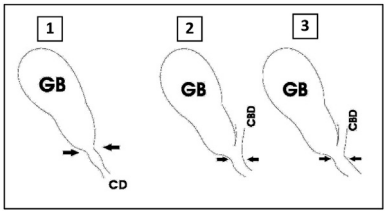

Fig. 4. The geometric discrepancy sign of the false infundibulum (1) Normal champagne glass base (2–3) False infundibulum.

3. Results

The study involved a series of 502 patients undergoing LC with a modified infundibular first technique. The majority were women (81.7%) as shown in Table 1. Their age ranged between 12 and 81 years, with mean 40.0 years. Most of the patients (83.7%) were suffering from symptomatic cholelithiasis and chronic cholecystitis. A higher percentage of patients with acute cholecystitis (25.0%) were having high grades of provisional operative difficulty (grade III and IV) compared to 10.0% of those with chronic cholecystitis and symptomatic cholelithiasis.

As shown in Table 2, the operative time ranged between 20 and 105 minutes, with median 43.1 minutes. Nine 1.79% patients experienced intra-operative incidents. The most common incident was iatrogenic gall bladder perforation with spillage of stones (4 patients). Hemorrhage was recorded in two patients. Both were from the cystic artery, and controlled safely by diathermy. A laparoscopic Pringle maneuver with a soft clamp was performed to control the bleeding temporarily in one of them. Bile leak was witnessed in two patients both from a minor accessory duct of Luschka, for which an intra-peritoneal drain was left. Meanwhile, none of the patients had bile duct injury (BDI). Only 3 (0.60%) cases required conversion to open cholecystectomy (OC). All three had acute on top of chronic inflammation. As a bailout procedure, two fundus first LCs were performed, one in the Inner Sub-Serosal (ISS) plane and the other started in the ISS to end as a total mucosectomy of the GB. Both had grade 4 difficulty score.

Table 3 shows a total of 8 (1.59%) cases of early post-operative complications. According to Clavien [12] classification, there were five Grade I cases, namely two cases of suppuration at epigastric port wound site, two with minor bleeding at epigastric port wound site, and one of bile leak aborted spontaneously after 2 days. In Grade II a, there were two cases of bile leak for more than 4 days, and both had ERCP done. One of them had bile leak from a duct of

Table 1
Characteristics of the patients in the study sample (n = 502).

	N (502)	%
Gender:		
Male	92	18.3
Female	410	81.7
Age (years):		
Range	12–81	
Mean ± SD	40.0 ± 13.3	
Median	37.0	
Diagnosis:		
Acute cholecystitis	82	16.3
Chronic cholecystitis/symptomatic cholelithiasis	420	83.7
Nassar Grade III/IV operative difficulty:		
Acute cholecystitis	21	25.0
Chronic cholecystitis/symptomatic cholelithiasis	41	10.0

Table 2
Duration of LC and associated intra-operative incidents among patients in the study sample (n = 502).

	N (502)	% (95% CI)[a]
LC duration (minutes):		
Range	20–105	
Mean ± SD	40.0 ± 21.3	
Median	43.1	
Intra-operative incidents:		
Hemorrhage	2	0.40 (0.07–1.31)
Gall bladder perforation	4	0.80 (0.22–2.02)
Bile duct injury (BDI)	0	0.00
Conversion to open cholecystectomy (OC)	3	0.60 (0.12–1.74)
Total	*9*	*1.79 (0.82–3.38)*

[a] Fisher exact 95% confidence interval.

Table 3
Early and late post-operative LC complications among patients in the study sample (n = 502).

	N (502)	% (95% CI)[a]
Early post-operative complications:[@]		
Grade I:		
Suppuration at epigastric port wound	2	0.40 (0.07–1.31)
Minor bleeding at epigastric port site	2	0.40 (0.07–1.31)
Bile leak aborted spontaneously in 2 days	1	0.20 (0.01–0.98)
Grade II a:		
Bile leak for >4 days	2	0.40 (0.07–1.31)
Grade II b:		
Intra peritoneal hemorrhage	1	0.20 (0.01–0.98)
Total	*8*	*1.59 (0.69–3.12)*
Late post-operative complications:		
Sub-hepatic abscess	0	0.00
Bile leak	2	0.40 (0.07–1.31)
Hemorrhage	1	0.20 (0.01–0.98)
Retained bile duct stones	1	0.20 (0.01–0.98)
Port site sepsis	2	0.40 (0.07–1.31)
Port site hernia	1	0.20 (0.01–0.98)
Total	*7*	*1.39 (0.61–2.74)*
Overall complications	**15**	**2.99 (1.75–4.77)**

[a] Fisher exact 95% confidence interval (@) Clavien classification [13].

Luschka and was having a stone in the CBD which was removed. The other had slipped cystic duct clips. Lastly, there was one Grade II b case with intra-peritoneal hemorrhage that necessitated re-laparoscopic exploration. No active source of bleeding was found, so a tube drain was left and the patient was discharged on the 5th postoperative day. None of the patients had Grade III or IV early post-operative complications.

Concerning the late post-operative complications, the same table indicates that they occurred in only 7 (1.39%) patients. These were mostly bile leak (0.40%) and port site sepsis (0.40%). None of the patients had sub-hepatic abscess. The overall morbidity rate was 2.99% (95% CI: 1.75–4.77).

4. Discussion

This study findings demonstrate that the “Infundibulum, Cystic Artery First” technique, as a modification of the “Infundibulum First” technique, is a safe and effective mean for LC performance. It combines the advantages of application of the CVS concept with respect to avoidance of the classical bile duct injury and the merits of being simple, easy, time saving, and offering a clear operative field. This is made easier with the aid of the newly observed video laparoscopic visual signs. These are namely the virtue of colors, the geometric discrepancy sign of the false infundibulum, and the dimple sign. They are not visual illusions as they have been repeatedly observed during the course of all operations especially the difficult ones. They reflect the advantages of the magnified, colored, high definition image in interpretation of the anatomical and pathological facts as is seen on the screen.

The most common intra-operative incident in the current study was the iatrogenic gall bladder perforation with spillage of stones, which occurred in 4 patients (0.8%). Keeping in mind the factors associated with increased risk of complications [13], retrieval of as much as possible of the stones was done definitely leaving less than 15 stones, to remove all pigmented stones, and all large stones. Our rate is considerably lower when compared with the findings reported by Duca et al. (2003) [14] in a study of 9542 consecutive LC cases. Their corresponding rate was as high as 15.9%. Our rate is also noticeably lower than the rate reported in a more recent series of 740 LCs in a study in Montenegro, where 5.27% of the patients had this intraoperative incident [15].

An important finding of the present study is the absence of any case of BDI in our series. This is an important indicator of the effectiveness and safety of our modified approach. This operative complication is actually considered the most serious one in LC [16.]. Thus, the rate of major BDI in LCs generally ranges between 0.3 and 0.5% [17,18]. Meanwhile, the application of a modified LC approach using a three-dimensional identification of the cystic infundibulum – cystic duct junction, led to considerable lowering of the incidents of BDI approaching zero percent as reported by Luo et al. (2003) [19].

The present study results also revealed a low rate of bile leakage as one of the common intra-operative incidents. Thus, the rates of minor and major bile leak are lower than those reported by Zarin et al. (2018) [20] in a study comparing infundibular and CVS LC techniques in Pakistan. The minor leak rates were 0.5% and 0.9% for the two techniques respectively, compared to our rate of 0.2%. Meanwhile, our rate of major leak (0.4%) is slightly higher in comparison with the rate in their CVS technique (0.14%), but lower than their rate of 0.5% in the infundibular technique. The cases of bile leak in our study was from a minor accessory duct of Luschka for which an intra-peritoneal drain was left.

Intra-operative hemorrhage is the most common cause underlying conversion of LC to OC. In our series, it was recorded in two patients (0.4%). Both were from the cystic artery, and were controlled safely by diathermy. A laparoscopic Pringle maneuver with a soft clamp was performed to control the bleeding temporarily in one of them. Our figure is clearly better when compared with the rate reported in a study in Italy, where 24 out of 530 LC patients (4.5%) had uncontrollable bleeding [21].

Moreover, in our series, the rate of conversion to open cholecystectomy was very low where it was performed for only 3 (0.60%) patients. This rate is clearly lower in comparison with that reported in an Italian study, where it reached 1.3% of the cases [22]. An even higher rate of conversion (2.6%) was reported in a Greek study of 1000 cases of LC using the CVS approach [23]. Further, a conversion rate of 3% was mentioned in a 100-patient series in a German study [24]. Meanwhile, a conversion rate as high as 6.9% was reported in a 348-case series of LCs in Nepal; such a high rate was attributed to the setting of the study, which was rural in a developing country [25].

Concerning postoperative morbidity, the results of the current study indicate an overall low rate (2.99%). It is considerably lower in comparison with the rate reported in a 200-patient series in a study in Spain, where it reached 9.4% of the cases [26]. This indicates a marked improvement of patients' outcomes when our modified technique is used. Similarly, our rate is lower in comparison with the figure more recently reported by Souadka et al. (2017) [27] in a study in Morocco where the total complications rate reached 4.5% in experienced hands.

Only one patient in our series had umbilical port site hernia, accounting for a rate of 0.2%. This is rather a rare complication of LC. It is often associated with certain risk factors such as diabetes, obesity, and wound infection [28]. Our rate is below the lower end of the range of incidence of this complication as reported in a review by Bunting (2010) [29] In this review of 5984 cases of LCs performed between 1995 and 2010, the overall rate of this complication was 1.7%, with a range between 0.3% and 5.4%.

Additionally, our modified technique consumed less operative time. Thus, our mean operative time is 40 minutes, compared to 50 minutes for the infundibular technique and as long as 73 minutes in the CVS technique as reported by Zarin et al. (2018) [20] in their 438-patient study. Meanwhile, our mean operative time is the same as the one reported in laparoscopic antegrade cholecystectomy in a series of 1740 patients in Italy [22].

5. Conclusion and recommendations

The study presents a modified LC approach based on identification of the cystic artery. This technique proved to be successful in

reducing the rates of intra-operative as well as post-operative complications, along with low conversion rate and short operative time. A multi-center randomized clinical trial is recommended to provide more evidence of the utility of this technique.

Ethical approval

Exempet from ethical approval.

Funding

None.

Author contribution

Momen A Nawar.

Conflict of interests

None.

Guarantor

Momen A Nawar, MSc, FRCS Ed, Consultant General Surgery.

Research registration number

4559.

Consent

All patients consented to the operation and possible research.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijso.2019.04.003.

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