

Meta-Analysis: Intraoperative Cholangiography During Laparoscopic Cholecystectomy for Prevention of CBD Injury

Mohammed Sulaiman Alrashed^{1*}, Abdullah Matuq Alaithan², Hibah Abdulali Al Zayer³, Fares Mohammed Al Hassri⁴, Fadi Mohammed Albulayhishi², Ahmed Dakhel Alrehaili², Johar Mohammed Johar Aljohar², Husam Mohsen Bin Alhasel⁵, Turki Mohammed Yahya Albarakati⁶, Ahmed Osama B Shahadah⁷, Abdullah Mohammed Abdullah Aljumah², Alaa Hussain Ahmed Alhamrani², Hamad Abdulaziz Mohammed Alsubaie², Raed Jafar T Albahrani² and Wael Muzil Alanazi⁸

¹Al-Imam Muhammad Ibn Saud Islamic University, Riyadh, Saudi Arabia

²King Faisal University, Al Hufuf, Saudi Arabia

³Maternity and Child Hospital, Dammam

⁴Primary Health Care, Medina, Saudi Arabia

⁵Ibn Sina National College, Jeddah, Saudi Arabia

⁶Umm Al-Qura University, Mecca, Saudi Arabia

⁷Taibah University, Medina, Saudi Arabia

⁸Sulaiman Alrajhi Colleges, Al-Qassim, Saudi Arabia

***Corresponding Author:** Mohammed Sulaiman Alrashed, Al-Imam Muhammad Ibn Saud Islamic University, Riyadh, Saudi Arabia.

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Abstract

The use of routine IOC in LC procedures has gained prominence recently. Many scholars and practitioners have attributed the growing prominence of IOC to the fact that it is considerably safe to use as compared to traditional surgery models, which are considered as relatively risky. This heightened risk is based on the fact that the visibility of the anatomy of the bile duct is significantly reduced during such operations. Moreover, many practitioners have noted that the risks are associated with post-operative effects, like post-operational wounds taking too long to heal or that the incisions made during surgery in the traditional operational model are very large, thus exposing the wound to other infections. Importantly, the use of IOC in LC procedures has equally been noted as a non-invasive mode of operation. With such non-invasive attributes being associated with the use of routine IOC, many studies note that the process is relatively safe. Moreover, the use of dyes in the process, coupled with X-Ray scanning, enhances the visibility of the anatomy of the bile ducts.

This study uses a systematic review methodology, through the CASP modality, to offer a consummate discussion on the relevance of IOC in LC procedures. The study has undertaken a critical analysis of five peer-reviewed articles under the sub-themes of the significance of using IOC in the LC procedures, the disadvantages of using routine IOC in LC procedures and contemporary issues surrounding the concept of routine IOC in LC procedures. These articles were limited to those published from 2012 to 2017 to ensure that the most recent publications were reviewed. Moreover, the reviewed studies were limited to the Middle East and Saudi Arabia as the preferable geographical scope of the study. Conclusively, the study revealed that there are several benefits associated with the use of routine IOC in LC procedures. This is based on the fact that these procedures are considered safe as the gallbladder is not easily injured during the surgery procedure, whereby the visibility of the inner anatomy of the bile duct is enhanced. However, regardless of the benefits associated with routine IOC procedures in LC, this study affirms that there are several controversial issues associated

with the use of routine IOC in LC procedures. These include issues such as the accuracy of the platform and the cost implications of IOC procedures.

Keywords: *Intra Operative Cholangiogram (IOC); Common Bile Duct (CBD); Magnetic Resonance Cholangiopancreatography (MRCP); Endoscopic Retrograde Cholangiopancreatography (ERCP); Open Cholecystectomy*

Introduction

The inception of the use of laparoscopic cholecystectomy in the treatment of gallstone diseases has systematically replaced the open surgery treatment plan that was previously the norm [1]. But while its prominence in the treatment of gallstones has been echoed by many practitioners, many opine that the LC procedure comes with immense risk of bile duct injury courtesy of the restricted working area during the surgery and the finer manipulation of the tools that are used in LC procedures. The incidence rate of the use of LC in the treatment of gallstone disease remains very high. In fact, many practitioners note that the incident rate has risen from 0.06% to 0.3% [2]. Importantly, when gall bladder removal is undertaken through LC procedures, the incidence rate has been established to have risen from 0.5% to 1.4% [3]. Previous research studies focusing on the removal of the laparoscopic gallbladder has revealed many complications during the process. Most notably, incidences such as the infection of the wound (from the incision made), complications arising from bleeding, respiratory insufficiency and the injury to the intra-abdominal viscera have been noted to be quite heightened [2]. In fact, many findings have established that morbidity associated with these complications during the removal of laparoscopic gallbladder has systematically increased from 1% to 8%, indicating a great risk during the procedure [1].

The adoption of the intraoperative cholangiography (IOC) procedure has evidently mitigated the risk associated with LC procedures. IOC entails an improved surgery model where, instead of conventional surgery where a huge incision is made below the ribs just near the abdomen, a catheter is introduced into the bile duct (common bile duct, CBD) to aid in the drainage of the bile within the ducts. Moreover, it entails the injection of a special kind of dye to aid in visualisation during the procedure and avoids any form of damage that may result from poor visualisation during the procedure. While few studies have examined the benefits of combining IOC procedures and LC in the treatment of gallstones, there is a general belief that the use of IOC in comparison to the erstwhile surgery procedures has improved the process to an unprecedented extent. Most notably, the risk associated with the procedure has been significantly reduced [1].

Objectives and Justifications of the Study

The overarching aim of this study is to establish the relevance of IOC during LC in the prevention of any form of injury in the CBD during surgery. A critical study of the procedures involved in LC reveals that there is very high risk involved. As suggested in the introductory statements of this study, the procedure comes with significant risk that can be easily mitigated through the use of IOC. This study thus gives new insights into the appropriateness of IOC in LC. The study reviews various studies in terms of the significance of adopting IOC in LC. Furthermore, the significance of this study further stems from the fact that it reviews major developments in the medical field regarding the use of IOC in LC.

Literature Review

Many publications looking at the role of IOC in the diagnosis, prevention and management of injuries in the bile duct do not have a common stand. The use of the IC procedures in the management of bile duct injury still remains very controversial in the medical field to date. Many publications have quoted the safety of the procedure as the main rationale for its inception in the medical field [1]. The use of IOC is considerably safer in the treatment of CBD injury. This has been further corroborated by Flum, *et al.* [4] and Buddingh, *et al.* [3] who noted that the fact that IOC is relatively non-invasive as compared to the other LC procedures makes it clinically effective. Many practitioners, cognizant of the fact that the use of IOC is relatively safe and effective in LC procedures, are embracing its use.

Intraoperative cholangiography: a critical review of the procedure

As stated by Dip., *et al.* there are several risks associated with operations of the gall bladder [5]. The gall bladder is exposed to injury during these LC procedures and so there is need to make the process a safer to mitigate the risk of gall bladder injury. IOC entails a procedure where the practitioner places a catheter into the cystic duct and consequently drains the contents of the gall bladder (bile juice) into the common bile duct. Subsequently, a dye is injected into the bile duct (a dye that has a capability of blocking the X-Rays), followed by X-Ray scanning of the common bile duct [1].

The essence of the procedure in the first place is to systematically lower any risk of injury to the patient by improving the visibility of the contents of the common bile duct. The injection of the dye is critical to the achievement of this purpose. As noted by Ragulin-Coyne., *et al.* this is to allow the surgeon to clearly view the anatomy of the bile duct system beginning from the liver of the patient through to their small intestine [1]. This view, as earlier disclosed, enables the practitioner to have a clear view of the bile ducts just before the gallbladder is removed, hence lowering the risk of damaging the common bile duct.

The IOC is also quite significant to the removal of the gallstones that may be present within the bile duct. The use of the dye that blocks X-Rays within the bile ducts has been noted to be quite essential to the achievement of this goal [6]. The dye enhances the visibility of any other solid component of the bile ducts, thus allowing the practitioner to have a clear understanding of the contents of the bile duct before undertaking any procedure. In essence, the use of IOC is meant to achieve two very critical goals: enhance safety through improved visibility of the bile ducts and to effectively look for gall stones present within the bile ducts.

Ding., *et al.* provide an insightful discussion on the relevance of IOC to LC procedures by noting that it identifies unknown stones within the CBD [7]. Evidently, this is attributed to the dye injected within the bile ducts. Moreover, the use of IOC in LC, as noted by Flum., *et al.* offers a better definition of the extra hepatic biliary anatomy, a phenomenon that is quite essential in enhancing the safety of the procedure as the surgeons are able to have a clear view of the anatomy of the bile ducts [4,5].

But while the relevance of IOC has been echoed by many scholars, there are several controversies surrounding the procedures. Many studies seem to be in agreement of the fact that the use of IOC in LC procedures enhances the safety of the patient through improved visibility of the ducts [5]. However, certain scholars have noted by Ding., *et al.* (2148), the role of IOC during routine LC still remains shrouded with controversy.

Objections against routine IOC in LC procedures

As earlier noted, many scholars such as Flum., *et al.* and Livingston., *et al.* aver that the use of IOC in LC procedures comes with other complications as well [4,6]. While most studies are in agreement about the relevance of routine IOC in LC procedures, several disadvantages have been noted regarding the procedure. Mir., *et al.* stated that regardless of the perceived benefits of routine IOC in LC, the costs associated with the procedure are quite exorbitant [8]. Comparatively, the procedure comes with an inflated cost in relation to traditional surgery procedures

Many studies admit that the cost implications of routine IOC are beyond the means of the majority in comparison to conventional treatment procedures. In fact, the study by Flum., *et al.* concluded that only a minority of healthcare centres perform cholecystectomy with routine IOC [4]. According to Flum's study this is based on the fact that there are high hospital charges attributable to routine IOC procedures. This study, like many other studies, have projected that to be able to prevent a single injury of the bile duct through the use of routine cholangiography, the cost implications amount to \$371,356. This is considerably high. These studies have been further corroborated by Mir., *et al.* who also noted that routine IOC is associated with inflated costs [8]. Surgeons' routine use of IOC is correlated with the exorbitant rates of postsurgical procedures [5]. While the study admits that there are improved outcomes associated with the use of this procedure in LC, the operating costs still remain a problem.

But other than the costs associated with routine IOC, a number of studies have noted that the use of the procedure has significantly increased the operating time during LC procedures. Moreover, there have been several instances of false positive results which have led to unnecessary common bile duct exploration. Mir, *et al.* have offered a consummate discussion regarding the concept of false positive results from the use of routine IOC in LC [8]. The study emphatically asserts that the false-positive rates of positive IOC may be as high as 60% [9]. Not many studies have provided an elaborate discourse on the perceived inaccurate results generated by routine IOC; however, Mohandas, *et al.* noted that the origin of false positives in routine IOC is traceable to the images of the anatomy of the bile duct or the presence of air bubbles within the bile duct [9]. Misinterpretation of the images within the bile ducts due to the presence of the air bubbles within the ducts has been noted to be the culprit behind false-positives.

Conclusively, many studies seem to be divided on the use of routine IOC in LC procedures. From this literature review, two critical issues seem to be highlighted in the discourse regarding the use of routine IOC in LC procedures. One is the fact that the procedure is quite relevant in the enhancement of the safety of the patient during LC. However, regardless of the benefits considered to be synonymous with the employment of routine IOC in LC procedures, many scholars have still not endorsed the procedure citing several issues with the procedure [3]. There is a logical progression to the assertion made by the majority of the articles reviewed in this study that the merits of employing routine IOC in LC procedures do not necessarily qualify the procedure as being an obvious strategy in LC. A further discussion is required regarding the procedure based on the many objections that have been levelled against the process [6].

Materials and Methods

Five peer-reviewed articles were subjected to a critical assessment using the CASP-Critical Appraisal Skills Program Methodology. The CASP tool is a critical component of a literature review, especially for randomised trial studies. The selection of this method in the study is based on the fact that the study intended to identify, if any, methodological flaws that may exist in the studies reviewed in this paper and, thus, come up with a cogent decision regarding the paper.

As earlier disclosed, the study relied on a literature review, specifically, a systematic review under the CASP model. This method involves an elaborate analysis of selected studies-peer reviewed journals with specific emphasis on the study methodology, the research questions that the paper focused on in the study, the objectives of the study, the ethical issues of the study, sampling modality, data collection modalities, results of the study, findings and the implications of the findings of the study for practitioners. The peer-reviewed articles were selected from major online journal repositories.

Literature search and parameters

Health science databases were perused to find appropriate journals for review. The following databases were searched for articles: EbscoHost, CINAHL, MEDLINE, Science direct, and ncbi. The search intended to locate articles from cohort studies, empirical research, and cohort studies and peer review. The search gave priority to articles published within the past five years-from 2012 to 2017. Further priority was given to publications undertaken from the Middle East and Saudi Arabia.

Intraoperative Cholangiography, Laparoscopic Cholecystectomy and CBD injury were used as the metadata in searching for articles in the identified journals. Within ncbi, the initial search came up with 78 articles. Upon introducing the year of publication, which must be between 2017 and 2012, the search results were reduced to 48. The search criterion was further amended to include articles from the Middle East and Saudi Arabia and this systematically reduced the search results to 18 articles. When "full text" was introduced, 16 articles remained in the search results. In terms of the relevance of the remaining articles to the study topic, 5 articles were selected for the review.

Search terms and keywords used

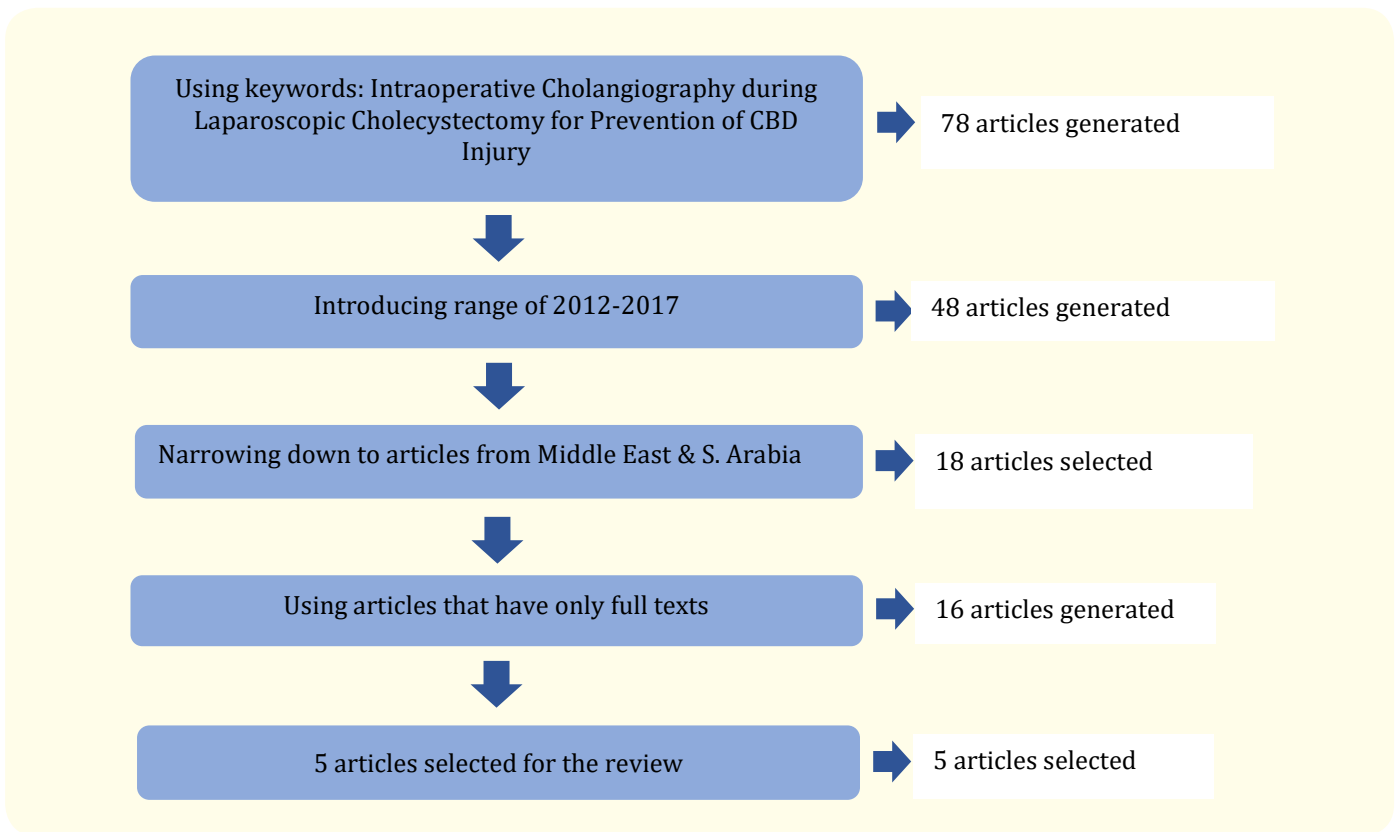
To find the relevant articles to be used in the review, several keywords were used in the online repositories of journals. Boolean search logic was used to ensure that the literature returned during the search included at least two of the terms that were included in the search.

The table below gives a summary of the keywords that were used in the literature search. Critical appraisal of the articles was undertaken under three themes:

1. Significance of the use of routine IOC in LC
2. Demerits of using routine IOC procedures in LC
3. Contemporary issues in the use of routine IOC in LC

Keywords used	
Intraoperative Cholangiography	Gallbladder surgery
Laparoscopic Cholecystectomy	Gallstones removal
CBD Injury	

The flowchart for systematic search of articles:



The study identified three themes that were used to select the appropriate articles reviewed in this study. These thematic areas and the corresponding articles reviewed are as outlined below:

Theme	Corresponding Article
Significance of the use of routine IOC in LC	Importance of critical view of safety in laparoscopic cholecystectomy: a survey of 120 serial patients, with no incidence of complications
	Effect of laparoscopic cholecystectomy techniques on postoperative pain: a prospective randomized study.
Demerits of using routine IOC procedures in LC	Laparoscopic cholecystectomy for cholelithiasis in children with sickle cell disease.
	Indocyanine green fluorescence imaging in hepatobiliary surgery
Contemporary issues in the use of routine IOC in LC	Anatomic variations of intra- and extra-hepatic biliary system in the Kingdom of Saudi Arabia

Results and Discussion

Significance of routine IOC in LC

The fact that routine IOC is non-invasive seems to be its biggest merit in LC processes. Through a survey of 120 serial patients with no incidence of complications, Kaya, *et al.* affirm that the non-invasiveness of the IOC procedure seems to enhance the safety of the patients who are being treated by using LC procedures [10]. The use of IOC as adduced in this study does not come with instances of intraoperative and even postoperative complications. Of all the patients subjected to this study, wound infection, which is not usually synonymous with the routine IOC procedures, was detected in only 4.1% of the patients. Most notable is the fact that all the patients operated on through the IOC model were discharged within three days of their operation. Considerably, this is an indication of a safe procedure that eliminates quite a number of risks during LC surgeries.

The clinical value of IOC in the LC procedures, according to this study, makes it a golden standard in the LC procedures. In the UK alone, between 34% and 39% of the surgeries have led to some form of bile duct injury, most commonly mistaking the bile ducts with a cystic duct. The findings of the study emphatically reveal that such mistakes can effectively be reduced through the adoption of routine IOC measures. Common risk factors such as injuries as identified in the study can be effectively reduced through routine IOC. Specifically, this study admits that the majority of bile duct injuries are attributable to the injury on the Calot's triangle. The use of IOC significantly reduces any episode of inflammation of the Calot's triangle thus limiting, to a significant extent, any risk of injury during LC procedures.

LC techniques used by practitioners have many implications in terms of the post-operative experiences of patients [11]. This is to say that the selection of LC procedures influences the post-operational experience of patients in many ways. In a study of 90 patients undergoing elective laparoscopic Cholecystectomy through randomised trials using various LC techniques, it was established that minimally-invasive surgical techniques of LC such as the use of routine IOC have such benefits as reduced pain and surgical trauma among patients. Moreover, the study noted that the employment of an IOC strategy in LC comes with increased potential to perform as day case surgery, coupled with the fact that it is cost effective. Though many other scholars disagree with the assertion that IOC is cost effective, the admission by this study that minimally-invasive techniques of LC such as routine IOC lower the extent of post-operational pain seems to be in agreement with the findings of many other studies reviewed earlier.

Laparoscopic procedures such as IOC are considered as examples of minimally-invasive techniques. As noted in the study, postoperative LC pain can be clustered into two main components. These include shoulder pain and abdominal pain. A comparative study undertaken by Yilmaz, *et al.* comparing SILC, IOC and CLC techniques of LC noted that SILC did not confer in any way any form of benefit on post-operative pain to patients as compared with CLC [11]. However, the use of IOC is considered as very effective considering the fact that it is less invasive compared to other techniques described above.

Demerits of IOC in LC

The use of Indocyanine green as a dye in routine IOC has been noted to be of significance to the improvement of the visibility of the practitioners during LC. Al Talhi, *et al.* have given a consummate discourse on the benefits of the dye during LC procedures [12]. ICG is intravenously injected into the patient and selectively taken up by the liver where it is finally secreted into the bile. The catabolism and fluorescence attributes of ICG, as established in the study, permits a wide range of visualisation methods in hepatobiliary surgery.

However, many scholars have noted that, regardless of its perceived effectiveness in the enhancement of visualisation during LC, the majority of the dyes used in routine IOC has a limited tissue penetration capacity. As established by Al Talhi, *et al.* this is limited to 5 - 10 mm [12]. This effectively limits the visualisation of deeper tissues through this method. Perhaps, this limitation is the reason behind the inaccurate results that have been noted in the use of these procedures in LC. Al Talhi, *et al.* further this thought by noting that, cases of false-positives or negative results have been noted to be quite prevalent [12].

The relevance of any diagnosis procedure is based on its ability to record the right results [13]. Any limitation of a diagnostic process that comes with inaccurate results renders the diagnostic process relatively redundant [13]. Many studies note that the inability of the various IOC techniques used in LC to record accurate results limits their use in LC procedures. The study notes that there still remains an urgent need for characterisation of the procedure to enhance the accuracy of results.

The patients with sickle cell disease have heightened incidences of formation of gallstones based on the fact that sickled red blood cells tend to haemolyse leading to high levels of bilirubin in bile which increases the chances of stone formation within the gall bladder. Admittedly, the use of IOC in LC is considered a standard procedure in the removal of gallbladder despite the fact that complications associated with IOC in LC in acute calculi cholelithiasis remain largely unresolved [13]. This review gives a very consummate discussion on the controversies associated with the use of routine IOC in LC procedures, especially in children with sickle cell disease (SCD).

In the study, strict measures were undertaken to establish operating durations in SCD. The collected data of the patients entailed demographics, perioperative complications and the length of stay in hospital. The study revealed that if operators undertake very stringent measures during operations, then there is a likelihood that the operation time will be shortened. IOC can thus be performed in SCD patients with very few perioperative complications.

Arguably, LC has been shown to be superior to OC in several instances [13]. However, this study notes that, in SCD patients, the use of IOC has had significant complications, thus necessitating the use of alternative treatment plans. The study established that there are several perioperative morbidity following the use of IOC in SCD patients. This is based on the pathophysiological effects of Carbon IV oxide pneumoperitoneum within various organs [13]. These effects, as evidently deduced from the study, inherently correlate with the intensity of the intra-abdominal pressure as well as the duration of what the study refers to as “insufflations” on the operating table. In conclusion, therefore, this study makes the admission that the use of IOC may be beneficial to LC procedures, but there is need to take into account that this is based on the stringent measures that are undertaken during the surgery process. It is not automatic that the IOC is an effective LC procedure.

Contemporary issues in the use of routine IOC in LC

IOC needs a deeper understanding of what Yilmaz, et al. refer to as “biliary anatomy and variations” [11]. The study focused on finding out the pattern and various data on anatomical variations from the Middle East. Specifically, the study intended to evaluate the value of routine IOC in finding out the patterns of variations in anatomies in patients that are performing LC in a Saudi Arabian hospital. While the focus of the study was to profile patients depending on the anatomies of their hepatic biliary system, the methodological applications of emergent methods in the examination of these biliary systems revealed that there has been considerable progress in the examination of biliary systems in patients [11]. This is based on the finding of the study that any form of a successful hepatobiliary surgery is dependent on the accurate cognisance of the anatomy of both the extra and intra hepatic biliary system.

The study revealed that IOC during LC could have certain demerits even though it is a generally safer and effective method of LC. However, the criticality of this study stems from the fact that it suggests that the relevance of today’s hepatobiliary surgery is based on the visualisation of the anatomy of the system. The study proposes that the method embraced by practitioners during hepatobiliary surgery must be based on the fact that the anatomy of the system is well revealed. As an emergent issue in LC, the study seems to be endorsing various aspects of routine IOC based on the fact that it gives a comprehensive visualisation of the anatomy of the system.

Contemporarily, it is deducible that the future of routine IOC is pegged on the development of one critical component of the system—the need to enhance visibility of the hepatobiliary system. This is based on the fact that improved visibility leads to enhanced accuracy of the practitioner, thus improved operational procedures. Moreover, through improved visibility, an effective patient profile can be achieved before an operation is undertaken. In this regard, it is accurate to admit that the future of the treatment plan of LC is hinged on the need to enhance the visibility of the anatomy of systems.

Limitations of the study

Few publications on the use of routine IOC in LC originate from the Middle East and Saudi Arabia. Evidently, this had a lot of implications for the review based on the fact that many credible articles with a comprehensive undertaking of the use of IOC in LC were left out in the review. It was expected that a more open review would include a variety of articles to evaluate instead of limiting the scope of the study to certain geographical locations.

Conclusion

This study affirms that, regardless of the perceived benefits of routine IOC in LC, there are very salient limitations associated with the procedure in LC that require urgent yet systematic solutions. Regardless of the perceived benefits of the procedure, many analysts still opine that there are several grey areas that have obviously impaired the adoption of the system in conventional surgery procedures. Of more interest is the fact that there are several advances in the field of medicine to address the perceived weaknesses of IOC platforms. A need to focus on enhancing the visibility of the anatomy of bile ducts has been noted. It thus seems that the centre of the IOC strategy is based on its ability to give more clarity to the internal anatomy of bile ducts.

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