

DISCUSSION

Gallstone disease constitutes a significant health problem in developed societies, affecting 10% to 15% of the adult population whereas the lowest frequencies were reported in Africans (<5%)^(109,110). Its prevalence differs not only between countries but also between ethnic groups. Age and gender also influence the prevalence of gallstone disease.

It occurs more commonly in female population. A female to male ratio has been reported in literature to range between 3:1 to 5:1⁽¹¹¹⁾, a similar female predominance was noticed in our study too where 45 patients were females (90%) and only 5 patients were males (10%).

Age also appears to have an effect on the incidence of gallstone disease. The increased incidence of gallstones with age is seen across all ethnic groups⁽¹¹²⁾. It was found that the differences in gallstone incidence between sexes decrease with advancing age. According to the Group for Epidemiology and Prevention of Cholelithiasis (GREPCO) study, the female-to-male ratio for gallstone disease was 2.9 between 30 to 39 years of age, 1.6 between 40 to 49 years of age and 1.2 between 50 to 59 years of age.⁽¹¹³⁾

A study in Taiwan confirmed that increasing age had a direct relationship with the development of gallstones simply due to the long-term exposure to other risk factors irrespective of locality or standard of living⁽¹¹⁴⁾. A Danish study also showed that an increased incidence of gallstone disease in patients ≥ 45 years compared with those aged ≤ 35 years⁽¹¹⁵⁾.

The mean age of presentation in this study was 44.60 ± 12.96 with a median 45 years in group 1 and in group 2 the mean age was 43.48 ± 13.59 with a median 42 years which is comparable to that reported in literature ranging between 46.1 to 53⁽¹¹⁶⁾.

It is well known that patients who have a long history of recurrent biliary colics and those who have history of acute attack may have dense adhesions in the region of the gallbladder. The anatomy may be distorted, the cystic duct may be foreshortened, and the common bile duct may be very closely and densely adherent to the gallbladder. Besides these adhesions may include duodenum or colon inside them⁽¹¹⁷⁾.

That's why there was stress on these points in the present study especially, because of the belief that cautery should be avoided in the presence of adhesions as this increase the risk of injury to vital structures.

In the present study, 5 patients have history of acute attack and 15 patients gave history of recurrent attacks of biliary colic in group I versus 12 patients with history of recurrent biliary colic and 5 patients with history of acute attack of cholecystitis in group II.

No technical difficulties were encountered during dissection, no cases of conversion and no relation was found between the previously mentioned conditions and the method of cystic artery control. Thus, we believe that cautery could be used cautiously in the presence of adhesions without any fear of thermal injury to the surrounding structures.

Also, it is well known that local pathology in Calot's triangle such as inflammation or fibrosis is considered to be one of the important factors contributing to the occurrence of biliary tree injury.

That's why it was important to classify the degree of inflammation encountered during dissection of Calot's triangle to detect its impact over the method of artery control. It was noticed that the degree of inflammation in Calot's area is more or less the same in both groups. No statistically significant difference was found between the grade of inflammation and the method of cystic artery control, thus concluding that cauterization of the artery could be applied as safely and efficiently as clipping regardless the degree of inflammation as long as cautery is precisely used while being adjusted at the appropriate power setting.

Since the introduction of laparoscopic gallbladder surgery, surgeons have been very interested in gallbladder vascularization. A great number of papers on this issue have been published^(118,119) although some vagueness still exists, because of the diversity of data and classification, yet, there have been relatively few reports on the laparoscopic anatomy of the hepatobiliary triangle, especially of the cystic artery.

Anatomic variations in and around Calot's triangle are frequent. Cystic artery variations based on its origin, position, and number are quite common, being found in 25% to 50% of cases⁽¹²⁰⁾. These anatomical variations are difficult to establish before surgery. They are only identified during dissection of Calot's triangle.

Thus, clean dissection, accurate visual identification and a profound knowledge of expected variations are considered to be the key points for safe laparoscopic cholecystectomy.

A cystic artery passing through the hepatobiliary triangle, crossing the biliary ducts from the ventral or dorsal side, and on laparoscopic visualization found within the hepatobiliary triangle is the most common pattern of the cystic artery approaching the gallbladder reported to be found in 80%–96% of cases⁽¹²¹⁾.

In the present study, the cystic artery was identified in 50 patients (100 %), the artery was identified more frequently inside the Calot's triangle in 92% of patients while it was detected outside Calot's triangle in 8% of patients.

This is consistent with the results of several studies that pointed to the positional variation of cystic artery as illustrated in the following table:

Table (XII): Positional variation of cystic artery.

Number	Studies	Number of studied cases	Relation to calot's triangle	
			Outside	Inside
1	Tejaswi (17)	100	35%	65%
2	Flisinski et al (122)	34	2.94%	97.06%
3	Michel NA (25)	200	19%	81%
4	Daseler et al (14)	580	31.2%	69.8%
5	Desilva et al (15)	50	14%	86%
6	Futura et al (118)	110	11%	89 %
7	Baliya et al (123)	200	4.5%	73.5%
8	Suzuki et al (32)	244	11.1%	76.6%
9	Ding et al (33)	600	13%	85.5%
10	Khalilur (125)	60	3.35%	96.65%
11	Chen et al (34)	72	13.9%	86.1%
12	Saidi (20)	102	3.9%	96.1%
13	Khalil M (124)	60	2%	98%
14	Katri et al (18)	158	3.4%	96.6%

This wide range of variation could be explained by variation in the number of studied cases or variation in cystic artery origin being attributed to embryological basis and ethnic groups or the method of study whether autopsy or intraoperative assessment.

As regard the cases of cystic artery being detected outside Calot's triangle, it was found lateral to the cystic duct in 3cases and in 2 cases it was anterior to the duct. This is consistent with Suzuki et al⁽³²⁾ who reported the presence of cystic artery outside Calot's triangle in 7.4% (18 patients) of their cases where the artery was found arising from below and lateral to the cystic duct in 5.7% of cases and in 0.8% there was a single artery along and anterior to the cystic duct.

Another aspect of cystic artery variation encountered in our study is its number where a single cystic artery was detected in 92% of patients and two arteries were controlled in 8% of patients.

Presence of a single cystic artery is the most prevalent pattern. Suzuki M and colleagues and Hugh TB and colleagues reported a single cystic artery in 76.6% and 72% of their patients respectively^(11, 32). M Imran⁽¹²⁶⁾ reported its presence in 91% of his patients while Katri et al⁽¹⁸⁾ reported its presence in 83% of their patients. This difference may be attributed to a different geographical zone population sample.

The difference between Katri et al results and those of the present study may be due to fewer number of cases included in our study or may be attributed to the surgeon

preference where some surgeons fully dissect and skeletonize the main artery while others seek the branches, thus keeping close to the gallbladder wall taking into consideration that cystic artery is better to be divided near the gallbladder in order to preserve its branches to the common bile duct as well as avoiding biliary tree injury.

The two arteries controlled in 8% of our patients may be either dual cystic arteries or the usual superficial and deep branches of a single cystic artery being controlled separately. Incidence of dual cystic artery ranges from 2 to 25% according to Bincy and Somayaji⁽¹²⁷⁾, Ding et al⁽³³⁾ as well as Saidi et al⁽²⁰⁾, however its occurrence varies among different populations.

Double cystic arteries can be divided depending on position with respect to hepatobiliary triangle. Ding et al⁽³³⁾ named cases where the cystic arteries existed not only in the hepatobiliary triangle, but also outside it, i.e. the compound cystic artery type. In their research, only 3 of 600 (0.5 %) Chinese patients had a cystic artery travelling through the hepatobiliary triangle superficial to the cystic duct with the accessory artery approaching the gallbladder outside the triangle; accessory cystic artery was defined as any artery supplying the gallbladder with an abnormal origin but with the normal artery still present. The same pattern was present in 13 (5.3 %) of 244 Japanese patients operated by Suzuki et al⁽³²⁾ who generally reported occurrence of double cystic artery in 27 cases (11.1 %). On the other hand, in a study carried out in Pakistan double cystic arteries were seen both passing through the hepatobiliary triangle.

An important point to be considered is that when superficial and deep branches of cystic artery don't share common origin, it was reported that approximately half of superficial cystic arteries have been shown to enter through the hepatobiliary triangle while deep cystic arteries are often quite small in length and diameter being easily missed during dissection⁽¹²⁸⁾, thus some cases of double cystic artery may be missed.

Another possibility of controlling two arteries is that these are the usual anterior and posterior branches of cystic artery being controlled separately. Early separation of cystic artery at their origin was reported by Michel⁽³⁵⁾ being found in 11-25% of the patients operated on.

In the present study, the origin of cystic artery was not clear, thus we can't guarantee whether the two controlled vessels were either dual arteries with a different origin or compound cystic artery type.

As regard the method of cystic artery control, several devices exist nowadays for its safe and adequate control yet monopolar electrocautery is the method adopted in this study to assess its safety, efficacy and impact on the operative time.

Monopolar electrocautery is the most widely available electrosurgical tool in any operating theatre and it is the most frequently used method of delivering electrosurgery because; it delivers a greater range of tissue effect.

In 1995, a survey by the American college of surgeons stated that 86% of surgeons prefer monopolar to bipolar technology and despite the recognized advantages of bipolar electrosurgery it has not been accepted in laparoscopic surgery being used only by 14% of

surgeons. Most complain bipolar high frequency electrosurgery is difficult to use, time consuming and produces excessive charring⁽¹²⁹⁾.

An increasing trend among surgeons was noticed to use monopolar cautery for cystic artery control during laparoscopic cholecystectomy and some papers were published about this issue inspite of the fact that safety of using electrocautery alone to divide the cystic artery has been questioned for fear that it may not be adequate to seal the artery or may cause collateral tissue injury, but this has not been our experience.⁽¹⁸⁾

In the present study, cystic artery size was graded as small in 28%, medium in 64% and large in 8% in cautery group whereas in the clipping group, it was found small in 16%, medium in 48 % and large in 36%.

No statistical difference was found between size of cystic artery and the method of its control. On the contrary, katri et al⁽¹⁸⁾ mentioned in their study that the size of the artery was the only factor identified to affect the decision to choose between cautery and clipping for its control. However, cautery was safely used for large sized arteries.

The same point was mentioned by M.Imran et al⁽¹²⁶⁾ who divided the patients involved in their study into two groups depending on the size of the artery, they used monopolar cautery in patients whose cystic artery width was < 1 mm and clips in patients whose cystic artery width was >1 mm.

Cystic artery was controlled using monopolar cautery in 25 patients. First Calot's triangle was opened by lateral and inferior traction on the gallbladder neck and then cauterization was applied after adequate dissection of Calot's triangle as well as good visualization of cystic artery.

Inferolateral traction produces significant increase in the distance between the cystic duct and the critical hilar structures. Deziel et al⁽¹³⁰⁾ suggested that infrolateral traction produced the greatest distance between the critical biliary structures. Similar suggestions have been made by Hunter and Berci during SAGES (Society of American Gastrointestinal Endoscopic Surgeons) discussions.

In addition, the measurements obtained from the study proposed by Charles et al⁽¹³¹⁾ confirmed these perceptions where the proximity data was measured from the cystic duct to common hepatic duct, right hepatic duct as well as the cystic artery which showed that Inferolateral traction produced a statistically significant increase in distance between the cystic duct and all the three biliary structures.

By noting the distance between these critical structures and the increased distance afforded by inferior lateral traction, the laparoscopic surgeon can reduce the risk of thermal injury. The same study mentioned that the electrocautery had a depth of penetration of 1.03 mm versus 2.13 mm depth of penetration seen with YAG laser i.e.cautery is much safer than laser.

In the present study the diathermy setting was adjusted at power =4 to ensure minimal amount of energy taking into consideration that the coagulation current is effective with the power setting in the range of 30 to 50 W⁽⁶⁰⁾.

Short pulses were applied thus following the recommendations of the European association of endoscopic surgery (EAES) ⁽¹³²⁾ stating that to avoid thermal damage monopolar electrocautery should be used with short bursts (1-2 sec). The same recommendation was proposed by S.strasberg emphasizing on applying short bursts of cautery for 2 to 3 seconds or less to minimize thermal spread to the surrounding structures⁽¹³³⁾. The pulses applied were 4-10 with a mean of 5.28 ± 1.49 and median=5.

Another important precaution which was considered is avoiding the use of diathermy near the metal clips on the cystic duct as several cases of cystic artery stump pseudoaneurysm were reported by some authors as Bergey E et al ⁽¹³⁴⁾ and Petrou A et al⁽¹³⁵⁾ who related its occurrence to either direct injury or diathermy heat transmitted via surgical clips .

Cauterization was applied precisely taking into consideration that the cauterized structure should be elevated off the surrounding tissue so that there is no unintentional arcing injury to the nearby structures, this is consistent with S.strasberg technique for critical view of safety dissection ⁽¹³³⁾.

Also ,cauterization was applied close to the gall bladder wall, being applied in most of cases lateral to lund lymph node which is an important landmark as cystic artery lies very close to it (usually posterior or inferior to it). Kunasani ⁽¹³⁶⁾ explains that lateral

dissection from the lymph node is the safe area in laparoscopic cholecystectomy.Also,Qama et al ⁽¹³⁷⁾ explained in their published study that identification of the lymph node is helpful for the surgeon to dissect in the right direction for removal of the peritoneum or adherent omentum from the Calot's triangle for the exposure of underlying cystic artery and duct. This further helps in prevention of injury to the Calot's structures.

Keeping lateral to the lymph node will gurantee safe cauterization without biliary tree injury. A stastically significant relationship was found between LN of lund and cautery application where it was applied lateral to the lymph node in 64% of patients with p value =0.017 .

The same finding was noticed by Katri et al⁽¹⁸⁾ where electrocautery control was more frequently applied lateral to the lymph node when compared with clipping (70.2% versus 60.4%, respectively) yet there was no statistically significant association between the method of control and its site in relation to the lymph node.

Also, Ahmed A. ElGeidie ⁽⁵³⁾ in his published study about a new technique of clipless laparoscopic cholecystectomy pointed to the importance of dissecting the cystic artery up to the gallbladder wall lateral to lund LN sufficiently away from the hilar structures to minimize the risk of diathermy current spread as one of the perquisites that should be fulfilled to obtain the best outcome when adopting this technique however he didn't mention the frequency of keeping lateral to the lymph node in his cases.

Cystic artery was efficiently controlled in all patients involved in the present study; there was neither intraoperative nor postoperative bleeding.

This is consistent with Katri et al ⁽¹⁸⁾ who efficiently cauterized the identified cystic artery in 77.5% of their patients.

The same result was published by Lima et al ⁽¹³⁸⁾ who used monopolar cautery for cystic artery division in 500 patients admitted for minilaparoscopic cholecystectomy without reporting occurrence of intra or post operative bleeding.

Similarly, Imran et al ⁽¹²⁶⁾ reported that six patients (1%) out of 600 suffered from intra-operative hemorrhage which required conversion to open operation. One patient in group 1 (clipping group) had hemorrhage from a supra-duodenal vein injury. The patient was operated by open technique and bleeding from a supra duodenal vein was controlled by pressure and ligation of the vein. Two patients, also in the same group had a difficult dissection of the gall bladder from its fossa in the liver due to hepatomegaly and an overhanging left lobe, so the procedure was converted to open cholecystectomy. The other 3 patients, earlier cases in group 2, had bleeding from the cystic artery which required conversion to open surgery. Thus concluding that the complication rate of the two groups was the same (statistically insignificant)

Ali et al ⁽¹³⁹⁾ mentioned that out of the 46 patients who had cystic artery cauterization, one patient developed intraoperative bleeding from the cystic artery in the course of its skeletonization which was controlled by prompt clipping, another patient developed rather severe bleeding from torn cystic artery and was converted to open surgery. He also stated that conversion rate due to bleeding from cystic artery in laparoscopic cholecystectomy of clipping is 1.5% in comparison with 2% in the form of cauterization. Thus concluding that apart from conversion due to other causes, the incidence rate of conversion due to bleeding from cystic artery during clipping and cauterization is insignificant.

As regards the duration of cauterization, it was found to be significantly shorter than the clipping time where the cauterization time ranged from 20 to 55 Sec versus 40 to 60 Sec for clipping.

This variation in timing of control can be explained by falling of clips from the applicator or mismatch of the clip size with the applicator or frequent change of instruments.

Our result as regard the cautery time is comparable with those published by Ali et al ⁽¹³⁹⁾ stating that the mean time in their study was 35 sec for cautery and 50 sec for clipping. The mean operative time for laparoscopic cholecystectomy was 52.0 ± 11.74 minutes in group 1 (cautery) and 47.6 ± 10.12 minutes in group 2 (clipping).

It is evident that the operative time in cauterization group was slightly longer than the clipping group. This may be attributed to more dissection and skeletonization of the cystic artery in group 1 before applying the monopolar electrocautery. It seems to be safer to clearly dissect longer length of the cystic artery and to go further away from vital structures at the hilum, before coagulation and excision. This will help in avoidance of blind cauterization of assumed cystic artery and decreases possibility of intra-operative ductal or arterial injuries.

However, there was no statistically significant relationship between the method of cystic artery control and the operative time. The same result was reported by Katri et al ⁽¹⁸⁾ where the mean operative time for their cases was 49.4 – 21.1 minutes and there was no statistically significant difference related to the method of control of the cystic artery.

Since The use of monopolar electrocautery in the Calot's triangle is still considered taboo by most surgeons and the fear existing about its safety and efficiency for cystic artery control, this was reflected in the form of frequent insertion of drain in group 1 (cautery group) in 14 patients (56%) versus 9 patients (36%) in group 2 (clipping group) yet, no statistically significant relation was found between the use of drain and the method of control.

The follow up done in this study for a period of 6 months revealed no evidence of complications; no fever, no abdominal collection, no bowel injury or jaundice on clinical, laboratory and ultrasonography bases.

This result is consistent with Katri et al who used monopolar cautery for cystic artery control in 77.5% of their patients without any evidence of operative or postoperative bleeding or bile duct injuries.

Also, it is consistent with Lima et al ⁽¹³⁸⁾ who used monopolar cautery for cystic artery division in 500 patients admitted for minilaparoscopic cholecystectomy stating that there was no mortality, no need for conversion, no intestinal damage, no bleeding and no damage to the main bile ducts thus concluding that the use of electrocutery for occlusion of the cystic artery is a safe, quick and cost-efficient technique. In addition, they reported that monopolar cauterization of cystic artery has been the first choice in their service to patients undergoing needlescopic cholecystectomy.

Also, R.Contreras et al ⁽¹⁴⁰⁾ studied the safety, effectiveness and the cost of monopolar cauterization in 48 patients admitted for laparoscopic cholecystectomy and they mentioned that none of their patients developed either operative or postoperative hemorrhage, there were no associated complications or delayed thermal injuries. Thus concluding that monopolar electrosurgery provides complete homeostasis and seems to be a safe alternative to standard clip closure or to harmonic scalpel dissection of the cystic artery while leaving less foreign material in the patient. Furthermore there is significant cost savings with monopolar energy which adds no additional cost compared to harmonic or clip closure.

In addition, Carvalho et al ⁽¹⁴¹⁾ reported the safety of monopolar cauterization of cystic artery in 1000 cases admitted for needlescopic cliplless cholecystectomy. They stated that cystic artery cauterization near the gallbladder neck by monopolar cautery proved to be safe and effective; there was no internal bleeding during surgery or in the postoperative period. They also mentioned that the decision to coagulate near the gallbladder neck and far from the bile ducts prevented the occurrence of thermal injuries.

Hiwa Ahmed ⁽¹⁴²⁾ also, published his experience about the use of monopolar electrocautery for sealing of cystic artery aiming at reducing the number of clips being used during laparoscopic cholecystectomy; he mentioned that fine dissection of the cystic artery was done for more than 1 cm then it was coagulated by monopolar diathermy.

He stated that monopolar cauterization ensures precise dissection and adequate control of cystic artery. In addition, Hiwa pointed to an advantage of cystic artery cauterization that during application of clips there is a chance of common bile duct injury also, in some cases the size of cystic artery is too small for application of ordinary clips

Discussion

thus chances of clip slipping early or late is possible. That's why cauterization of cystic artery will guarantee avoidance of the previously mentioned problems.

Ahmed el Geidie⁽⁵³⁾ reported one case of biliary leak which occurred due to the deficient intracorporeal ligation applied over the cystic duct not due to thermal injury. No bile duct injuries were recorded due to spread of monopolar diathermy current while dividing the cystic artery in his study which included 328 patients.

He explained that absence of this complication in his study patients was due to cauterizing the artery on the wall of the gallbladder far away from hilar structures after adequate arterial dissection.

SUMMARY

Laparoscopic cholecystectomy is the gold standard treatment for cholelithiasis with various methods existing nowadays for control of both cystic artery as well as cystic duct.

The aim of the present work was to compare monopolar cauterization with clipping of the cystic artery during laparoscopic cholecystectomy as regard to safety, efficacy and operative time.

The current study included fifty patients admitted for elective laparoscopic cholecystectomy randomized into two groups according to method of cystic artery control.

Group I, twenty five patients had monopolar electrocauterization of cystic artery. Group II, twenty five patients had clipping of the cystic artery.

There was no statistically significant difference between both groups as regard age, sex or associated co-morbidities.

Also, no statistically significant difference was found between both groups as regard history of acute attacks, recurrent biliary colics or degree of inflammation in Calot's triangle.

Cystic artery was efficiently controlled using monopolar cautery in 100% of cases, whether small, medium or large sized arteries with cauterization being applied more frequently lateral to lymph node of lund.

A statistical significant relation was found between cauterization of cystic artery and application of cautery lateral to lymph node with $p < 0.001$

Cauterization time (20-55 seconds) was significantly shorter than clipping time (40-60 seconds) with $p < 0.001$.

As regard the overall operative time, it was longer in cauterization group (35-75 minutes) versus clipping group (30-60 minutes) yet; no statistically significant relation was detected between operative time and method of cystic artery control.

No intraoperative bleeding was encountered in the present study and all our cases were completed laparoscopically with no cases of conversion.

No postoperative complications were detected during the follow up period in the form of fever, abdominal collection, bowel injury or jaundice.

Conclusion, monopolar electrocautery is a safe and effective method for cystic artery control during laparoscopic cholecystectomy, neither intraoperative nor postoperative bleeding occurred, besides no biliary tree injury was encountered.

CONCLUSIONS

- 1- Monopolar cauterization proved to be safe and efficient method for cystic artery control during laparoscopic cholecystectomy, neither bleeding nor bile duct injuries were encountered.
- 2- Cauterization time was significantly shorter than clipping time yet; no statistical significant relation was detected between the operative time and method of cystic artery control.
- 3- Monopolar cautery could be used safely even in the presence of inflammation in calot's triangle.
- 4- Fine dissection, precise cauterization and adequate knowledge of electrosurgery principles are the main keys for safe control of cystic artery during laparoscopic cholecystectomy using monopolar cautery.