



Comparison of Different Cystic Duct Closure Methods in Laparoscopic Cholecystectomy: Silk Suture, Surgical Clip, Harmonic Scalpel and PlasmaKinetic

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Abstract

Background: Harmonic Scalpel and PlasmaKinetic have become popular with the promise of quick and effective vascular control. Their excellent outcomes encouraged surgeons to use these instruments for closure of the bile ducts with little or no data, establishing their efficacy or safety. Aim: The aim of this experimental study was to compare the safety and feasibility of different cystic duct closure methods (suture ligation, clip application, Harmonic Scalpel and PlasmaKinetic).

Methods: Sixty non-perforated gallbladders extracted during laparoscopic cholecystectomy were studied in this ex vivo study. Gallbladders were randomly divided into four groups and the distal end of cystic ducts remaining with sacs was reclosed by one of the four different methods. By means of a catheter, air insufflation was administered into gallbladders with a pressure-controlled pump. Bursting pressure and lateral thermal injury were measured for each group, and groups were compared with each other.

Results: In the Harmonic Scalpel group, a 1.4 mm lateral thermal injury was detected, while it was 1.6 mm in the PlasmaKinetic group. But, in terms of bursting pressure, there was not a statistically significant difference between the groups.

Conclusion: Cystic duct closure with the new devices may be an alternative to surgical clips. Further trials are needed to evaluate the feasibility and safety of PlasmaKinetic usage in the clinical setting.

Key words: Laparoscopic cholecystectomy, ultrasonically activated devices, vessel sealing systems, cystic duct ligation, bile leakage

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Introduction

Laparoscopic cholecystectomy (LC) is accepted as the gold standard treatment of symptomatic gallstones. Several methods have been developed [1,2] to close the cystic duct (CD) during a surgical procedure, but titanium clip application is

currently the most frequently used technique [3,4]. Although postoperative bile leakage is rare, it is a serious complication and occurs in 0.2-0.27 % of cases [5-7]. Therefore, studies have still been going on to perform LC in a safer, less complicated and cheaper way. For example, high-tech

electrosurgical instruments, such as Harmonic Scalpel (HS), have been used both for dissection of the cystic artery and CD [1,2]. Similarly, researches investigating the usage of PlasmaKinetic (PK) for the same purpose have been going on [8-10]. However, any study comparing the conventional methods (suture ligation and clip closure) with electrosurgical methods (HS and PK), in terms of bursting pressure, could not be found. This experimental study was undertaken to compare the conventional CD closure techniques with electrosurgical methods (HS and PK), in terms of the bursting pressure and lateral thermal injury.

Methods

This ex vivo study was approved by the local ethical committee, and was carried out between February 2008 and May 2009, with 60 non-perforated gallbladders (GB) extracted by LC. All of the patients underwent LC for symptomatic cholelithiasis, and closure of the CDs were performed through the application of non-absorbable metal clips (double clips to the proximal and single clip to the distal). In the operating theater, after removal of the specimens, GBs were randomly divided into four groups. Randomization of the GBs was undertaken consecutively and each group included 15 GBs (Table 1). In all groups, 10mm-sized, single en-

An 8-French polyvinyl catheter was inserted into GBs through the fundus, and the entry hole was closed with a purse-string suture to prevent leakage. GBs were then placed in a container filled with water. By means of the catheter, air insufflation with a pressure-controlled infusion pump was started into GBs. The pressure providing the first air bubbles from the GB or CD was recorded as bursting pressure. Bursting pressures for each GB and methods were recorded. The CD stumps were excised for histological examination, and lateral thermal injury was evaluated.

Histopathological evaluation

GBs in groups III and IV were then fixed in 10% buffered formalin and were subjected to pathological examination to assess the degree of lateral thermal injury. They were embedded in paraffin blocks, and 4 μ m sections were taken and stained with hematoxylin-eosin. Distance of the discernable injury was evaluated and measured with a computerized video-microscope system (DP Controller 3.2.1.276 Olympus Corporation) by a pathologist. Affected tissue coming after sealing was accepted as the injury area.

Statistical analysis

The bursting pressures of gallbladders in each group were measured and differences between the groups were calculated by using the Student's t test. The value of $P < 0.05$ was accepted as statistically significant.

Results

The age and gender distribution of the groups were not statistically significant. During the bursting pressure measurements, neither of the groups nor cases resulted in air leakage from the CD. All the GBs were ruptured with a pressure range of 320-410 mmHg without any leakage from the stump of closed CDs. The mean and standard deviation of bursting pressure in the suture group was 384.6 ± 15.97 (range 360-410 mmHg), in the clip group was 386 ± 18.43 (range 340-410 mmHg), in the Harmonic Scalpel group was 383.3 ± 22.88 (range 320-410 mmHg), and in the Plasma Kinetics group was 384 ± 22.29 (range 320-410 mmHg).

Histologically, evidence of the diffuse eosinophilic area without distinguishable cell cytoplasmic borders between elongated-pyknotic nuclei and even sometimes united and indistinguishable as a separate nucleus was accepted as the area of injury.

Table 1. Details of the groups, and CD closure techniques.

Group I	CD was ligated with 2/0 silk suture
Group II	CD was closed with 10 mm single titanium clip
Group III	CD was sealed with HS and the power of device was set to level 3
Group IV	CD was sealed with plasma kinetics

doclips (Auto Suture, Madison, WI) on the distal end of CDs to the GBs were unlocked and removed on the back table. The distal end of CDs was then closed ex vivo by one of the four different methods (suture ligation, clip application, HS and PK), respectively. A 2/0 silk suture was used for the suture ligation method. For sealing CD with electrosurgical instruments, a 5-mm harmonic dissector (Ultracision, Ethicon Endo-Surgery, Inc., Cincinnati, OH, USA) and 5-mm PlasmaKinetic sealer were used. The power level for PK and HS was set at lower energy level (Vapor pulse 3) 35 W, and power level '3', respectively.

With the histopathological examination of CDs, the mean and standard deviation of the lateral thermal injury detected in the HS group was 1.36 ± 0.06 (range 1.2-1.4 mm), while it was 1.55 ± 0.06 (range 1.4-1.6 mm) in the plasma kinetics group. Distance of the discernable injury for PK cases was longer than HS cases. But, in terms of bursting pressure and lateral thermal injury, there was no statistical significance between the groups.

Discussion

During the LC procedure, closure of CD is frequently performed with double titanium clips 1 cm above its junction within a common biliary duct (CBD). Since CD contains rich collagen, like arteries, sealing of the duct with instruments such as HS or PK seems to be feasible. Extensive series of CDs sealed with HS have been published in the literature, and no difference in comparison with surgical clip application, in terms of complication, has been reported in this series. There is a lack of human studies about the usage of PK for sealing of CD, but some experimental animal trials are available [8,10]. Although PK is not recommended for CD closure in some studies, some others encourage surgeons to use this instrument in division of CD [2,11]. But most of the studies have emphasized the need for further research.

The width of the thermal injury and the probability of necrosis on the CBD create the general concern of the studies that do not accept PK usage as feasible for sealing bile ducts. In experimental studies, morbidities such as bile leakage and peritonitis due to necrosis have been shown. PK usage is recommended in the cases having sufficient length and well-dissected CDs; otherwise, energy overdose can lead to necrosis and leakage in cases with a tiny and short CD. In the studies reporting PK usage as a safe procedure for sealing CD, it was shown histopathologically that the sealing process is feasible and safe [12].

In our study, in all of the four groups, neither leakage from the closed stump of CD nor a tear was observed; the GBs ruptured elsewhere without any tear in the closed CD. Bursting pressure changed with the range of 320-410 mmHg. When it is considered that biliary system pressure does not reach this limit under any circumstances, it can be proposed that all of the

four methods are safe enough in the closure of CD, and no difference between the methods was detected. Anyway, a collagen-rich structure of the ductal system is further evidence of this sealing procedure being accepted as safe arterial sealing. The most important point to note here is the necessity of the CD sealing process being performed at a safe distance from the CBD. In their study, Akira and friends reported that major bile ducts could be sealed safely by vessel sealing systems [10].

In our study, the lateral thermal injury was found to be 1.4 mm in the HS group, while it was 1.6 mm in the PK group. Previous studies showed that there was only a minimal extent of the injury to adjacent tissue up to 0.5-2 mm, which correlates with our results [13]. These distances should be kept in mind while sealing the CD with high-tech instruments in order to avoid any thermal injury in the CBD. Therefore, before starting sealing of the duct, if the distance away from the CBD can be maintained during dissection, the sealing process will be more secure. Moreover, tension on the CD during the sealing process should be avoided because it may cause bursting of the tissue before it is sealed completely. The traction on the GB for exposure of the Callot triangle should be done with minimum force, in order to not cause separation of the tissues before completion of the sealing process.

As is reported in the study of Shamiyeh and co-workers, the use of high-tech devices may be contraindicated in the case of a short CD and whenever difficulties in the closure of the CD are expected, such as in the case of acute cholecystitis or porcelain GB [9].

As a result, for sealing the CD, HS can be used as safely as conventional methods, but further studies are required to evaluate the feasibility and safety of PK, especially to identify the correct power level.

Conclusion

No significant difference was found in all groups regarding bursting pressure and lateral thermal injury. According to our experience, the use of high-tech instruments (PK and HS) is a feasible and safe alternative to titanium clips for CD closure during LC.

Conflict of interest statement

The authors do not declare any conflict of interest or financial support in this study.

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