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Use of biliary stent in laparoscopic common bile duct exploration

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Abstract
Introduction It is well supported in the literature that laparoscopic common bile duct exploration (LCBDE) for choledocholithiasis has equal efficacy when compared to ERCP followed by laparoscopic cholecystectomy. Decompression after supra-duodenal choledochotomy is common practice as it reduced the risk of bile leaks. We conducted a prospective non-randomized study to compare outcomes and length of stay in patients undergoing biliary stent insertion versus T-tube drainage following LCBDE via choledochotomy.
Methods and procedures The study involved 116 patients with choledocholithiasis who underwent LCBDE and decompression of the biliary system by either ante-grade biliary stent or T-tube insertion. A 7 French straight/duodenal curve biliary Diagmed^{TM} stent (9–11 cm) was placed in 82 patients (Biliary Stent Group). T-tube insertion was used for 34 patients (T-tube group). The length of hospital stay and complications for the selected patients were recorded. All *trans*-cystic common bile duct explorations were excluded from the study.
Results The mean hospital stay for patients who underwent ante-grade biliary stent or T-tube insertion after LBCDE were 1 and 3.4 days, respectively. This is a statistically significant result with a p value of less than 0.001. Of the T-tube group, two patients required laparoscopic washout due to bile leaks, one had ongoing biliary stasis and one reported ongoing pain whilst the T-tube was in situ. A complication rate of 11.2 %, this was a significant finding. There were no complications or concerns reported for the Biliary Stent Group.
Conclusion Our results show that there is a significant reduction in length of hospital stay and morbidity for patients that have ante-grade biliary stent decompression of the CBD post laparoscopic choledochotomy when compared T-tube drainage. This implies that ante-grade biliary stent insertion is likely to reduce costs and increase overall patient satisfaction. We support the use of ante-grade biliary stent insertion during LCBDE when primary closure is not preferred.

Keywords T-tube · Choledocholithiasis · Choledochotomy · General surgery · Common bile duct (CBD) · Biliary stent

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It is well supported in the literature that laparoscopic common bile duct exploration (LCBDE) for choledocholithiasis has equal efficacy, is cost effective and has lower associated morbidity when compared to the two-stage intervention of endoscopic retrograde cholangiopancreatography (ERCP) and laparoscopic cholecystectomy [1–4]. Surgically, CBD exploration is performed either via open or laparoscopic surgery using choledochotomy or *trans*-cystic duct exploration [1, 2, 4]. To aid closure, decompression of the biliary system via T-tube post supra-duodenal choledochotomy has been the traditional surgical practice. This is due to the possibility of distal common bile duct (CBD) obstruction and increased biliary pressures due to retained stones or oedema secondary to surgical instrumentation [5–7]. Despite this, there are many

opinions in the literature regarding the best method of choledochotomy closure in the laparoscopic era. The most common management options being either primary closure, T-tube drainage, or primary closure after ante-grade biliary stent insertion [4, 8, 9]. Primary closure has been shown to have reduced hospital stays as well as decreased morbidity when compared to T-tube drainage [4, 8, 10–13]. The Cochrane collaboration reports a rate of 8 % for retained stones after single-stage management of choledocholithasis with other recent series reporting a failed intra-operative clearance rate of between 3.3 and 11 % [2, 8, 14, 15]. Therefore, a surgeon may have a reasonable need to maintain drainage of the CBD postoperatively. Due to this, the aim of this study is to compare outcomes and length of stay in patients undergoing ante-grade biliary stenting versus T-tube drainage following choledochotomy and exploration of the CBD.

Materials and methods

This is a prospective non-randomised study conducted from 2005 to 2014 on 116 patients (elective and emergency) with known choledocholithiasis who underwent LBCDE performed by a single upper gastrointestinal tract surgeon. Only patients with confirmed choledocolithiasis were included in the study. CBD stones were diagnosed via history, physical examination, biochemical tests, and imaging (USS followed by MRCP/CT cholangiogram). Patients with known CBD stones underwent LCBDE via choledochotomy with decompression of the biliary system via T-tube insertion or ante-grade biliary stent insertion. The first 34 patients in the series underwent T-tube insertion (T-tube group). The following 82 patients in this study consequently underwent ante-grade biliary stent insertion for biliary tree drainage (Biliary Stent Group). Demographic data (age and sex), number of stones, length of hospital stay, and early complications were recorded on a excel spread sheet during their admission. Further complication data were recorded at outpatient clinic review (removal of T-tube), day of endoscopy (removal of stent), and on unexpected re-admission to hospital. Patients who underwent *trans*-cystic CBD exploration, open CBD exploration or patients who had their operations conducted by a different surgeon or trainee were excluded from this study.

Surgical technique

The operation was performed under general anaesthetic with the patients placed in the supine position. Compression stockings along with sequential compression devices for deep vein thrombosis prophylaxis were applied to the lower limbs of each patient. All patients received prophylactic intravenous antibiotic prior to induction. The standard left-sided four port technique of cholecystectomy was used in each operation. Hasson cannulation or Visiport^{TM} technique was used to place the first port, usually 10 mm. A further three 5-mm ports were then inserted under vision in the right upper quadrant. In some cases, a further 5-mm port was placed into the left quadrant to assist with suturing of the choledochotomy or tissue retraction. Under vision from a 30° laparoscope with the gallbladder retracted over the liver, the hepatocystic triangle was identified using monopolar electocautery. 5-mm clips were then applied both to the cystic artery and duct. The artery was divided with scissors or electocautery with further division of the peritoneum to improve vision. The cystic duct was left intact to aid in retraction. A vertical supraduodenal choledochotmy was performed using laparoscopic scissors to the width of the choledochosope. Exploration and visualisation of the CBD were achieved with a 5-mm choledochoscope with normal saline irrigation. Stones were extracted under vision with the use of the Nathanson basket through the choledochoscope instrument channel. After removal of stones, the choledochoscope was used to visualise the CBD from the ampulla of vater to the hepatic ducts. This was done twice to confirm clearance. A T-tube or biliary stent was then inserted to aid closure. For the Biliary Stent Group, a 7 French straight or duodenal curve biliary Diagmed^{TM} stent (9–11 cm) was placed through the choledochotomy into the CBD and blindly directed across the ampulla of vater. Choledochoscope or fluoroscopy was then used to confirm position. The longitudinal choledochotomy was then closed with 3.0 PDS. All patients that underwent LBCDE had a 10–15 French Blake's drain placed in the sub hepatic space. No suction was used on a closed drainage setup. Biliary stents were removed endoscopically 4–8 weeks post operation. T-tubes were removed in clinic 4–5 weeks post operation after T-tube cholangiogram confirmed duct clearance.

Statistical analysis

Student's t test and χ^2 test for independent data were used to analyse the two groups.

Results

A total of 116 patients were included in this study, 34 patients in the T-tube group and 82 patients in the Biliary Stent Group. There was no significant difference in the distribution of patients in each group with respect to age, sex and CBD stones as shown in Table 1. There were no deaths in this study. Postoperative complications were observed in 4 patients (11 %) in the T-tube group, and no

Table 1 Characteristics of patients

Patient characteristics	T-tube group ($n = 34$)	Ante-grade Biliary Stent Group ($n = 82$)	p Value*
Age (years) mean ± SD, range	45.9 ± 12.5 (26–63)	43.8 ± 10 (24–66)	0.31
Sex			
Male	6 (18 %)	21 (26 %)	0.47
Female	28 (82 %)	61 (74 %)	
No. of CBD stones mean ± SD	2.5 ± 1.5	2 ± 1.3	0.11

* Result of student's t test or the χ^2 test

Table 2 Patient outcomes

Patient outcomes	T-tube group ($n = 34$)	Ante-grade Biliary Stent Group ($n = 82$)	p Value*
Postoperative hospital stay (days) mean ± SD, range	3.4 ± 1 (2–6)	1 ± 0.2 (1–2)	<0.001
Complications	4 (11 %)	0	0.0065

* Result of student's t test or the χ^2 test

complications were observed in the Biliary Stent Group ($p = 0.0065$) (Table 2). Two patients returned to theatre for biliary peritonitis. One was due to accidental T-tube removal whilst the other was an ongoing leak post planned removal. Biliary stasis occurred in one patient causing delayed discharge and another patient required earlier T-tube removal due to ongoing T-tube site pain. The mean postoperative hospital stay was 3.4 ± 1 for the T-tube group and the 1 ± 0.2 Biliary Stent Group ($p = < 0.001$) (Table 2).

Discussion

LCBDE and cholecystectomy as a single-stage treatment of choledocholithiasis have been shown to be superior when compared to the two-stage management. Exploration of the CBD via choledochotomy is a procedure that is indicated in patients with a dilated CBD (>7 mm) that have a large stone (1 cm), intrahepatic, multiple, impacted stones, or those that have failed *trans*-cystic clearance [4, 9, 16, 17]. Drainage of the biliary tree post CBD exploration has been common practice since before the laparosocopic era. Initially T-tube placement was used to decompress the biliary system, decreasing bile leaks, avoiding stasis, and provide access for follow-up imaging and instrumentation of the CBD. With the movement towards LCBDE, the best technique for closure of a choledochotomy has been reassessed.

Research has identified a significant morbidity rate when LCBDE is combined with T-tube drainage. Multiple articles are quoting a morbidity percentage of between 10 and 15 % with T-tube insertion. Complications documented in the literature show bile rate leaks (4–10 %), leaks post T-tube removal, wound infection, uncontrolled percutaneous drainage of bile, premature tube dislodgement, localised pain discomfort, longer stays in hospital, prolonged biliary fistula, and late biliary stricture [1, 4, 10, 14, 18]. A recent Cochrane review has discouraged the use of T-tube insertion due to significantly longer operating times, significantly longer hospital stays and a trend towards increased complications when compared with primary closure for laparoscopic choledochotomy [8]. Due to this, there has been a movement away from T-tube use for decompression of the CBD after laparoscopic surgery [19].

Primary closure of the choledochotomy after CBD exploration is a technique that has been gaining increasing acceptance. It has decreased operative times, has statistically significant reduced hospital stays, statistically significantly decreased postoperative complications and expenses when compared to T-tube decompression [8, 10, 13]. The decreased morbidity rates are believed to be associated with avoiding complications directly related to the presence and removal of T-tubes [4, 10, 11]. Documented long-term results are also complimentary for this method [4, 20]. Associated morbidity has been documented at 6.1 % with bile leaks occurring in 2–5 % of patients that undergo primary closure [4, 8, 14]. Improvements in surgical technique, specifically direct visualisation of the CBD with a choledochoscope, have reduced rates of retained CBD stones. Recent large series suggest that retained stone rates for single-stage surgical management of choledocholithiasis are between 3.3 and 11 % [2, 8, 14, 15]. Unfortunately primary closure of a choledochotomy does not provide biliary decompression which can be critical in this clinical situation. An animal study in 2002 has shown increased stenosis related to primary closure of the CBD. Although this has not yet been observed in the human population, this combined with rates of incomplete ductal clearance advocate a potential need for biliary tree drainage [7, 9].

Ante-grade biliary stent insertion before closure of choledochotomy theoretically combines the benefits of T-tube decompression with the reduced morbidity of primary closure of the CBD. Placement of a biliary stent is a

relatively simple technique that enables effective biliary tree decompression immediately [21]. Published results have shown that this technique like primary closure decreases surgical time, has decreased morbidity, reduced hospital stay and increases patient comfort [9, 11, 16, 22–25]. Another major benefit is with retained stones. Not only does it maintain the patency of the CBD but it also decreases the difficulty of CBD cannulation via ERCP improving the success rate of postoperative ERCP stone extraction from 82 % to almost to 100 % [17, 26, 27]. The need for a second-stage endoscopic stent extraction is a significant limitation, increasing cost and risk associated with this technique. Documented stent specific complications in the literature include stent occlusion, early migration and duodenal erosion. Stents in situ for greater than 30 days have been associated with ampullary stenosis and stent migration leading to intestinal perforation [9, 16, 28–30].

This present study has compared outcomes and length of stay in patients undergoing ante-grade biliary stenting versus T-tube drainage after LCBDE via choledochotomy. This study has identified a significant difference in the length of hospital stay between both groups. The Biliary Stent Group mean 1 ± 0.2 compared to the T-tube group mean of 3.4 ± 1 reflects the current literature. Closure of the CBD with ante-grade biliary stent insertion decreases hospital stay when compared to T-tube decompression. Decreased hospital stay decreases cost as well as increasing patient satisfaction. In our facility due to the difference in length of stay, ante-grade stent insertion is more cost effective even when endoscopic costs are taken into consideration.

Our T-tube complication rate of 11 % was comparable with the current literature associated T-tube morbidity of 10–15 %. The complications identified in our study are also consistent with known complications associated with T-tube decompression. No complications in the ante-grade biliary stent drainage group were identified. The potential complications of erosion of adjacent organs, ampullary stenosis and distant stent migration leading to intestinal perforation described in the literature being associated with long-term stents was not observed. This is despite stent removal occurring between 4 and 8 weeks post-operation due to resource constraints. No complications occurred during endoscopic removal of the stents with one patient passing their stent spontaneously. These findings suggest that concerns in regard to stenting and second-stage endoscopic stent removal are unfounded. The difference in complication rates was again a statistically significant result supporting ante-grade biliary stent insertion as the preferred method of biliary tree decompression.

Our results show that there is a significant reduction in length of hospital stay and decreased complication rates for patients that have ante-grade biliary stent decompression of the CBD post LCBDE via choledochotomy when compared T-tube drainage. This implies that ante-grade biliary stent insertion is likely to reduce costs, patient morbidity and increase overall patient satisfaction. Therefore, we support the use of ante-grade biliary stent insertion during LCBDE when primary closure is not the preferred option.

Disclosure Matthew Lyon, Seema Menon, Abhiney Jain and Harish Kumar have no conflicts of interest or financial ties to disclose.

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