The "Basket in Catheter" Technique: Facilitating Transcystic Bile Duct Exploration and Optimising the Management of Suspected Ductal Stones.

Ahmad H M Nassar (FRCS)[1,2], Haitham Qandeel (FRCS)[3]

Khurram S Khan (FRCS)[2,4] , Hwei J Ng (MRCS) [5]

Subreen Hasanat (MB BCh)[3] , Haneen Ashour (MB BCh)[3]

Laparoscopic Biliary Service, University Hospital Monklands, Airdrie, Scotland.

(1) University Hospital Monklands, Lanarkshire, Scotland, U.K.

(2) School of Medicine, Dentistry and Nursing, University of Glasgow.

(3) The Hashemite University, Zarqa, Jordan.

(4) University Hospital Hairmyres, Lanarkshire, Scotland, U.K.

(5) Royal Alexandra Hospital, Paisley, Scotland, U.K.

Corresponding Author: Mr Ahmad H. M. Nassar: University Hospital Monklands, Airdrie, Scotland, ML6 0JS, U.K.

Email: Anassar@doctors.org.uk and Ahmad.Nassar@glasgow.ac.uk

Tel +447711346603 Twitter @ahmadnassar

Original article

Keywords: Laparoscopic cholecystectomy, Basket in catheter technique, Intraoperative cholangiography, Transcystic bile duct exploration, bile duct stones.

Presented at the Moynihan Prize session of the ASGBI Annual Meeting, May 2021.

Short Title: "Basket-in-Catheter transcystic exploration"

Conflicts of interest; None declared.

Abstract

Background: The 'Basket-in-Catheter' (BIC) technique facilitates basket-only laparoscopic transcystic exploration (LTCE), increasing its success rate. Using the cholangiography catheter as a sheath is easier and safer than inserting the wire basket alone. This study evaluates its benefits in confirmed and suspected ductal stones.

Methods: Retrospective analysis of prospectively collected data on ~~consecutive~~ patients with preoperative or operative suspicion of bile duct stones or with positive and equivocal intraoperative cholangiographies (IOC) who had. LTCE attempted using blind basket trawling, without choledochoscopy, were reviewed. The incidence and outcomes of blind basket LTCEs attempted before and after introducing the BIC technique, whether or not stones were retrieved, were analysed.

Results: Blind basket LTCE was attempted in 732 patients. Of 377 (51.5%) patients undergoing successful stone retrieval only 62% had preoperative clinical and radiological risk factors for ductal stones, 25% had operative risk factors and 13% had silent stones discovered on IOC. Another 355 patients (48.5%) had negative trawling although one half had preoperative risk factors for ductal stones and 47.6% had operative risk factors e.g cystic duct stones or dilatation. This cohort had equivocal cholangiography in 25.9%. Following basket trawling repeat IOC confirmed resolution of abnormalities. As no stones were retrieved, these were not considered duct explorations.

Conclusion: The BIC technique facilitates safe and speedy bile duct clearance when stones are confirmed, avoiding choledochotomies, without significant complications. BIC duct trawling is also beneficial in patients with suspected ductal stones, helping to resolve equivocal IOCs. It helps surgeons to acquire and consolidate ductal exploration skills.

INTRODUCTION

Systematic reviews and meta-analysis conclude that laparoscopic trans-cystic bile duct exploration (LTCE) is safer than choledochotomy exploration and is the ideal treatment for common bile duct (CBD) stones. LTCE has significantly lower rates of biliary morbidity, hospital stay and costs. It also has optimal rates of stone clearance and operative time[1-3] .

When LTCE is used to clear CBD stones at the time of laparoscopic cholecystectomy (LC) it helps to reduce the rates of some complications including bile leakage, retained stones and pancreatitis without adding to the operative time[4].

LTCE is therefore the first choice treatment for CBD stones with outcomes not dissimilar to that of simple LC[5]. The Basket-in Catheter (BIC) technique was introduced by the first author in April 2009 and has since been used as the default technique for basket only LTCE. A preliminary report showed the technique to result in a significant (15%) increase in successful LTCE, reducing the need for choledochotomies[6].

LTCE is also increasingly being adopted as an effective and safe treatment of bile duct stones in the elderly as it is in younger patients[7]. It can be performed urgently with equivalent efficacy and morbidity compared to the elective setting[8].

As the insertion of the sharp-tipped naked-basket may be hindered by CD anatomy or condition e.g inflammation, resulting in failure or complications, using the BIC technique allows easier, quicker and safer access into the CBD (supplementary media File 1).

The primary aim of this study was to evaluate the use of the BIC technique for LTCE and its possible advantages compared to “naked basket” exploration in patients with small distal CBD stones, those with preoperative or operative risk factors suspicious of

stones or in those with equivocal intraoperative cholangiography (IOC). This practice model would be suitable for units dealing with gallstone disease but without the specialised skillset or the choledochoscopes required for a bile duct exploration service. The secondary aim was to compare the operative and postoperative outcomes of LCTE before and after the introduction of the BIC technique and to study the benefit vs. risk balance of using it in patients who have “negative” explorations.

METHODS:

Retrospective analysis of prospectively collected data stored on a database of consecutive patients undergoing LC and ductal exploration by one surgeon (AHMN) and his trainees was carried out. The BIC technique became the standard initial approach to LTCE between April 2009 and March 2020. Data collected include demographics, type of admission, risk factors for bile duct stones (deranged liver function tests with biliary pain, acute cholecystitis or pancreatitis, recent or current jaundice, or bile duct dilatation or stones reported on ultrasound scanning), operative factors suggesting an increased risk of bile duct stones e.g. CD stones and CD or CBD dilatation, the methods used to resolve equivocal IOC or remove confirmed CBD stones and the outcomes of these procedures. The study included all patients with the above criteria for suspected bile duct stones who underwent IOC and transcystic stone retrieval and those who had stone-negative basket trawling for suspected stones or equivocal IOC. Patients who required either choledochoscopy or choledochotomy were not part of this cohort as these are advanced procedures requiring special expertise and equipment.

All patients admitted with biliary emergencies are referred to the biliary unit, according to the hospital protocol, and are managed with an intention to treat during the index admission in those who are fit for surgery once optimised. In the absence of risk factors for malignancy (painless, deep or long duration jaundice and loss of weight)

magnetic resonance cholangiopancreatography (MRCP) is not a routine part of the diagnostic protocol for those with suspected bile duct stones. Computerised tomography (CT) scans are only performed when malignancy is suspected and in some patients with sepsis or pancreatitis. Endoscopic retrograde cholangiopancreatography (ERCP) is not relied upon for pre-operative bile duct clearance except in those with clinical evidence of severe cholangitis requiring biliary decompression, those with radiological criteria of severe pancreatitis or are permanently unfit for general anaesthesia for medical reasons. Such patients undergo MRCP and only proceed to ERCP upon confirmation of CBD stones. All patients deemed fit for general anaesthesia (GA) are offered index admission four port LC with routine IOC using a 5Fr ureteric catheter through an open cannula inserted into the right subcostal port.

Laparoscopic trans-cystic bile duct exploration algorithm

When IOC confirms CBD stones, patients will undergo attempted transcystic exploration as guided by the cholangiography images with the number and size of stones located in the distal CBD judged suitable for LTCE. Blind basket trawling using the BIC technique will be attempted as the first step. Once the IOC is obtained, the cholangiography catheter is left in the CBD and a disposable basket, suitable for the size of the stones, is inserted and advanced for a predetermined distance into the catheter, allowing the basket tip to emerge from the distal end of the catheter in the CBD. The basket is opened and the catheter is gently manipulated in and out to engage the stone/s, then pulled back gradually. The basket is not closed but the wires are allowed to trap the stone/s as they travel through the intramural CD. As the basket emerges from the CD, the cholangiography introducer is advanced closer, allowing its tip to control and secure the stone as the basket exits the CD opening (Supplementary media file 2). The stones are removed and the procedure is repeated until all stones

have been removed and three negative basket passes are made. The IOC is repeated, confirming stone clearance before proceeding with LC. If the stones were difficult to engage the exploration is carried out under X-ray control. Contrast is injected into the CBD and the basket is passed into the catheter (Supplementary ***figure 1a***). Manipulation of the basket is done under fluoroscopy until the stone appears to be engaged, as shown by it moving with the basket (Supplementary ***figure 1b***). Should cannulation be difficult due to the CD/CBD junction configuration or the presence of CD valves, further dissection of the CD towards the junction and performing a second incision further proximally, guided by the initial IOC, would facilitate this step.

Patients with strong clinical or radiological preoperative risk factors for CBD stones or with equivocal IOC are also considered for BIC trawling of the CBD. Should no stones be retrieved after three passes, the IOC is repeated and if normal, the LC will be concluded after ligating and dividing the CD. Such procedures where no stones are retrieved were not considered ductal explorations.

Balloon dilatation of the cystic duct is not attempted as dilating the visible part of the cystic duct does not necessarily ensure that the intramural part will allow stone extraction. Blind LTCE should not be attempted where the IOC shows a long intramural CD opening low into the CBD. In such a case, attempted blind extraction may result in stone impaction in the intramural CD making LTCE difficult (Supplementary ***figure 2***) and risking retained stones. Such manipulation may also allow stones to migrate proximally into the common hepatic duct with such anatomical configuration making transcystic exploration impossible.

Extraction of large stones may be facilitated by crushing them in the CD stump or making a longitudinal incision on the CD towards the CD/CBD junction.

Informed consent was obtained from all patients throughout the period of data

collection with explanation of the rationale for one-session management of bile duct stones. The management was in line with the approved hospital protocols and not contrary to the guidelines of national and international societies. Ethical approval was not required for anonymised retrospective analysis of data that was registered with local audit departments according to their requirements.

Statistical Analysis

Qualitative data were given as frequency and percentages. For continuous data, median and interquartile range was used and p value was calculated using unpaired student t test. For categorical variables, p values and odds ratio with 95% confidence interval was calculated using two-tailed Fisher Exact Test. P value of < 0.05 was considered to be statistically significant. GraphPad Prism version 9.0.2 used to calculate statistics.

RESULTS

*732 attempted LTCEs were carried out using blind basket tecnique during the study period, 355 where no stones were recovered and 377 where stone retrieval was confirmed. (**Figure 3**). The procedures were performed under the care of one surgeon with 112/732 (15.3%) carried out totally or in part by trainees. **Table 1** shows similar demographics, clinical presentations and incidence of preoperative imaging in the two groups of patients undergoing BIC trawling of the bile duct with or without stone retrieval.*

Negative basket trawling in patients with preoperative or operative risk factors for CBD stones, including equivocal cholangiography, was carried out in 355 patients. They were not considered ~~as~~ bile duct explorations as the negative trawling indicated either preoperative passage of stones or intraoperative transfer of stones to the duodenum as a result of the basket manipulation. Of these 183 (51.5%) had

preoperative clinical or radiological features, including jaundice in 22%. Operative risk factors; namely CD stones or wide CDs were recorded in 169 patients (47.6%) and IOC was equivocal in 25.9%. Pre-BIC “naked-basket” trawling was carried out in 23 patients while the last 332 (93.5%) of these procedures were carried out using the BIC technique.

The intraoperative difficulty grade of the cholecystectomy[9] is independent of ductal exploration and was subsequently similar whether or not stones were retrieved during basket trawling. As expected, stone detection on IOC, operative time and the utilization of Glucagon to facilitate the transfer of stones or fragments or improve contrast flow into the duodenum were significantly higher in the group requiring stone retrieval (***Table 2***). Successful removal of between 1 and 30 stones measuring 3 to 15 mm was achieved in this group. This was reflected in a significantly longer operative time.

Successful transcystic exploration and stone extraction using blind basket trawling was carried out in 377 patients (51.5%); 122 pre-BIC and 255 (46%) post-BIC introduction. 62% were emergency admissions. Preoperative risk factors for CBD stones were documented in 234 patients (62%). Operative risk factors for CBD stones; cystic duct stones and wide cystic ducts were recorded in 94 patients (25%). 13.2% of the stones were totally silent and discovered only on IOC. Abnormal IOC findings were recorded in 346 patients (91.7%). Following the exploration, transcystic biliary drains were inserted in 36 patients (9.5%), mainly due to uncertainty about stone clearance or persistent IOC abnormalities.

Table 3 compares the post-operative complications in patients who had basket only trawling with or without stone retrieval.

Although there were no differences in the total hospital stay between the 2 groups, the operative time was significantly higher in the stone retrieval group, as shown in table 2.

This would be expected as repeated basket passage or manipulation would have been necessary to engage and retrieve stones up to 30 in number and 15mm in diameter. Readmissions were also significantly higher in the cohort where stones were removed. The biliary–related causes of readmissions included dehydration resulting from bile loss through biliary drains or pain on removing transcystic biliary drains in five patients, right upper quadrant pain with deranged liver function tests settling spontaneously in three patients, as well as individual cases of postoperative pancreatitis, retained stones and bile leakage. Ten patients were readmitted with general complications including nonspecific abdominal pain in six, abdominal collections requiring antibiotics in two, urinary retention and port site haematoma.

Bile leakage occurred in 6 cases (0.5%). Three resolved spontaneously, one required re-laparoscopy and ERCP and one needed percutaneous drainage. Only one occurred in a naked basket LTCE. This was unrelated to the technique and resolved spontaneously. Five occurred in patients where BIC was used. Of these only two were related to the BIC technique having had bile leakage after the removal of transcystic biliary drains. No bile leaks were the result of bile duct injury.

Comparison between pre-BIC and post-BIC LTCE basket-only stone removal: The preoperative and operative characteristics of patients undergoing blind basket only exploration before (n=122) and after (n=255) the introduction of the BIC technique are shown in **table 4**. There was a significant increase in the incidence of BIC LTCE in patients with emergency presentations of gall stones, particularly acute biliary pain and obstructive jaundice. Although the number of CBD stones retrieved remained the same in the two cohorts, BIC use was associated with the recovery of significantly larger CBD stones than naked-basket trawling. BIC technique also resulted in significant reductions in the incidence of using transcystic biliary drains and in the operative time.

The postoperative outcomes of patients undergoing LTCE without and with BIC are

shown on **table 5.**

Although there were no significant differences in the conversion rate, reoperation or general complication rate between pre-BIC and post-BIC explorations, the incidence of retained stones decreased from 4.1% (5/122) to 0.78% (2/255). Six of the patients with retained stones needed ERCP and one resolved on conservative management using glucagon. Two open conversions occurred in the LTCE in the pre-BIC group. One was the first case in the series and resulted from failure to clear the stones. The other conversion, through a minilaparotomy, was to repair a small bowel injury occurring during adhesiolysis after transcystic ductal clearance was achieved.

DISCUSSION

The success of the transcystic approach to bile duct stones depends on surgical expertise and adequate equipment; namely the availability of IOC, choledochoscopy (3mm & 5mm) and a range of baskets to facilitate the extraction of stones of various sizes and shapes. The feasibility and ease of LTCE also depends on the anatomy of the cystic duct (duct diameter and the configuration of the CD/common hepatic duct junction) as well as the location, size and number of CBD stones[1].

Failure of the IOC catheter to negotiate the cystic duct is usually overcome by using a cholangiography clamp to retain the tip of the catheter in the duct. However, once an IOC showing CBD stones is obtained, further CD dissection can be carried out guided by the images and a more proximal incision is made nearer the CBD. This manoeuvre will often facilitate CD cannulation and allow transcystic passage of the catheter into the CBD.

The presence of CD stones may hinder cannulation. Special measures may be necessary; milking the CD using curved forceps, crushing stones through the CD wall or disimpacting and removing stones through a longitudinal incision of the CD towards

its junction with the CBD[10]. Occasional proximal CD stones causing Mirizzi type I anomalies may need to be fragmented using biopsy forceps or laser before CBD access is achieved. However, this would normally require choledochoscopy visualisation[11]. Some authors have used transcystic laser lithotripsy to fragment larger or impacted CBD stones in order to improve the rate of successful transcystic laparoscopic common bile duct exploration[12,13]. Others used disposable bronchoscopes, that are normally used for difficult tracheal intubation, for LTCE instead of a reusable sterilised choledochoscope[14]. However, the lack of expertise and/or availability of the small (2.8mm/3mm) choledochoscopes restrict the wider adoption of LTCE[6].

Dilatation of the CD in all cases has been advocated by some surgeons in order to increase the success rate of LTCE[15,16]. However, although cystic duct dilatation was not used in the current study, stones of up to 15 mm in diameter have been removed successfully using basket trawling alone together with one of the extraction techniques described above i.e longitudinal CD incision or mechanical fragmentation.

The BIC technique is easier than basket alone insertion and was reported in the preliminary study to increase the rate of LTCE from 55% to 70%[6], reducing the incidence of choledochotomy. The introduction of BIC increased the resolution of intraoperative suspicion of CBD stones, including equivocal cholangiographies having been used in 93% post-BIC compared to 46% of confirmed stones. This demonstrates that BIC facilitated the decision to employ basket trawling as it avoids certain operative complications (e.g false basket passage causing failure) and optimises the operative time. It reduces the reliance on choledochoscopy, reserving it for stones that are difficult to engage because of impaction or migration to the intrahepatic ducts. The utilisation of a choledochoscope is thus optimised and potential damage to this delicate instrument is minimised. This is of practical importance as the lack of equipment, most

importantly choledochoscopes, in many units is a major factor in the limited uptake of single session management of bile duct stones. The ease and increasing success of the BIC technique has been increasingly utilised in patients admitted emergently with acute pain, acute pancreatitis and jaundice. It proved to be an optimal way of managing patients with deranged liver function tests undergoing LC without the need for routine preoperative imaging. In this study the technique has been associated with a significant increase in the overall proportion of successful LTCE (from 54.9 to 73.1%, $p<0.001$), allowed the retrieval of larger stones and significantly reduced the need for transcystic biliary drainage, the operative time and retained stones. BIC was used as the only method of stone retrieval in 28.7% of all LTCE in the series.

The potential for successful LTCE may be determined by interpreting preoperative imaging of the bile ducts (MRCP) in patients with suspected choledocholithiasis. This can be of value in units where MRCP is routinely obtained. The presence of a few small distal CBD stones may encourage surgeons to attempt LTCE. However, most centers adopting pre-operative MRCP use preoperative ERCP for duct clearance rather than attempt to explore the duct at the same time as performing a cholecystectomy. Intraoperative imaging with IOC or laparoscopic ultrasound is usually limited to centres adopting single session laparoscopic management of CBD stones. Platt et al reported a case series in which the management of suspected choledocholithiasis without pre-operative bile duct imaging was advocated as an alternative treatment pathway applicable to both elective and emergency patients[17]. In the current study, preoperative imaging was not a routine part of the protocol and was only obtained in a small percentage of patients (6.9% MRCP, 5% CT and 2.1% ERCP) and IOC was the main CBD imaging modality. 23/26 of the patients who had preoperative MRCP and all 8 who had had failed ERCP, between two weeks and nine months prior to referral to the biliary unit, were found to have stones on IOC and

304 required LTCE. The availability and safety of the BIC technique in the group of patients
305 with preoperative or operative risk factors for CBD stones had a positive impact on their
306 management through reducing the need for preoperative cross sectional imaging while
307 allowing for operative exclusion of bile duct stones at the time of LC. When equivocal
308 cholangiographies are obtained, BIC also helps to resolve abnormalities simply and
309 quickly. There are few differences between the operative parameters of those with
310 stone-positive and stone-negative basket trawling. IOC abnormalities were found in
311 26% of those where BIC trawling was negative. However, negative trawling was
312 associated with significantly shorter operative time and significantly fewer
313 readmissions. This confirms the value of performing transcystic BIC trawling in patients
314 with suspected CBD stones even when no stones might be retrieved and where the
315 expertise for formal bile duct exploration is unavailable. Apart from detecting silent
316 stones, this practice will also occasionally help the retrieval of some CBD stones which
317 may not be identifiable on IOC, subsequently reducing the incidence of retained stones
318 (0.9% in the current study). Matsumura et al showed that, following what appeared to
319 be normal IOC, transcystic choledochoscopy detected cystic duct stones in 9.4% and
320 CBD stones in 12.5%[18].

321 Although postoperative hyperamylasemia or pancreatitis have been reported following
322 LTCE, their incidence is much lower than following ERCP, is almost certainly
323 technique-related and can thus be reduced with experience. Czerwonko et al[19] studied
324 447 LTCEs and highlighted the risk of postoperative pancreatitis. They reported post-
325 operative asymptomatic hyperamylasemia in 15.7% and symptomatic acute
326 pancreatitis in 4.5%. They suggested that preoperative jaundice was one of two
327 significant risk factors for pancreatitis. However, the incidence of acute pancreatitis in
328 the current study was only 1.8% (7/377) in the stone retrieval group and 0.28% (1/355)
329 in the group where no stones were removed. Asymptomatic hyperamylasemia was

documented in a similar percentage following LTCE and stone removal and this was only detected due to routine measurement of serum amylase for research purposes. The LTCE technique used by Czerwonko et al involved using Fogarty balloon papillary dilatation which is the likely cause of their high incidence of hyperamylasemia and pancreatitis.

Basket-alone (naked basket) transcystic exploration has been reported by an increasing number of centers, even where choledochoscopy was available [20-25]. On the other hand, the BIC technique has only been used by one group in a small series[26]. Chiarugi et al[3] performed blind basket exploration in 141 of 201 patients (70%) undergoing LTCE and reported successful clearance in 80%. Czerwonko et al.[8] attempted 500 LTCE and completed 469 (93.8%) using baskets alone. Although this is a high rate of success without choledochoscopy or choledochotomy, the study did not involve all comers with CBD stones; excluding hepatolithiasis, Mirizzi syndrome and severe acute cholangitis which would normally be caused by stones requiring choledochoscopy. The group also used pneumatic dilatation of the cystic duct and the papilla in some patients requiring a higher rate of postoperative ERCP (3.6%). Rhodes et al[27] reported 79 basket only LTCE. 8.8% had jaundice or cholangitis and stones were detected on 91% of IOCs. Duct clearance was successful in 76 patients (96.2%). In the current study, BIC patients had a higher incidence of jaundice (31%) or cholangitis (3%) and achieved a clearance rate of 98.4%. Sherif et al [28] carried out 126 basket only LTCE with an 88% success rate but also had many exclusion criteria including age above 70 years, acute cholecystitis, acute cholangitis, acute pancreatitis, CBD less than 8mm in diameter, liver cirrhosis, a history of hepatobiliary surgery and previous ERCP. A comparison between the operative and postoperative characteristics of these studies is shown in ***table 6***.

Whilst the skills, expertise, and logistic setup for choledochotomy exploration may not

be universally available, LTCE utilising BIC should be well within the capabilities of most surgeons dealing with biliary emergencies. BIC could also be attempted without IOC when operative risk factors for CBD stones are encountered as it neither adds to the operative time nor to the morbidity. Randomised trials may be required to demonstrate the benefits of the routine use of this practice, in units not carrying out IOC, for patients without CBD stone risk to study its potential for recovering silent stones, the incidence of which is reported to be up to 4-5% of patients without clinical or laboratory evidence of choledocholithiasis[29]. However, the limitations of the transcystic approach include such variables as cystic duct anatomy (duct diameter, configuration and angle of junction with the common hepatic duct) and the size, number and locations of the stones encountered. The BIC technique improves operative performance and outcomes, e.g ease of basket insertion, reproducibility of access into the CBD and the operative time and reduces the risk of operative complications such as CD perforation and false passage. It would not, however, prevent complications resulting from stone manipulation, particularly when multiple passages to extract numerous or impacted stones are required.

This study has some limitations. While consisting of a relatively considerable cohort spanning 28 years, this is a single centre series where subspecialist interest and expertise resulted from a practice with a high volume of emergency biliary cases and an unusually high proportion of patients with suspected bile duct stones. The experience, techniques and equipment have improved over time resulting in an inevitable adjustment of outcomes. However, all procedures were performed by one surgeon or by his trainees under on-table supervision, thus minimizing surgeon bias. The BIC technique replaces the need for spacialist insrtruments (choledochoscopy) or techniques (choledochotomy) in a significant proportion of patients found to have suspected or confirmed CBD stones on cholangiography, thus allowing centres lacking

specialisation to imnprove their results. The resulting optimisation of outcomes may also encourage other centres to adopt referrals and management protocols to establish specialist units.

Conclusion: The basket in catheter technique is a logical step in the management algorithm of CBD stones. It increases the success rate of basket-only transcystic stone extraction; reducing the reliance on choledochoscopy and saving unnecessary choledochotomies.

The technique can also be utilised to exclude suspected CBD stones in units without the expertise or specialised equipment for laparoscopic bile duct exploration. Such simple manipulations can resolve equivocal IOCs without the traditional disadvantages of negative CBD explorations. It can also be a useful training tool to help consolidate a skillset that is well within the ability of most surgeons dealing with biliary emergencies.

DISCLOSURES

Drs. Ahmad H. M. Nassar, Haitham Qandeel, Khurram S Khan, Hwei J Ng, Ms Subreen Hasanat and Ms Haneen Ashour have no conflicts of interest or financial ties to disclose.

REFFERENCES

[1] Feng Q, Huang Y, Wang K, Yuan R, Xiong X, Wu L. Laparoscopic Transcystic Common Bile Duct Exploration: Advantages over Laparoscopic Choledochotomy. *PLoS One. 2016*; 11, p. e0162885, doi: 10.1371/journal.pone.0162885.

[2] Pang L, Zhang Y, Wang Y, and Kong J. Transcystic versus traditional laparoscopic common bile duct exploration: its advantages and a meta-analysis.," *Surg. Endosc. 2018;32:4363-4367* doi: 10.1007/s00464-018-6286-x.

[3] Chiarugi M, Galatito C, Decanini L, Puglisi A, et al. Laparoscopic transcystic exploration for single-stage management of common duct stones and acute cholecystitis. *Surg. Endosc. 2012; 26:*124–129. doi: 10.1007/s00464-011-1837-4.

[4] Soltan HM, Ammar MS, El Balshy MA, Mahmoud ESA. Laparoscopic cystic duct exploration. *Menoufia Med. J.* 2019; 32(3): 1132-1135 doi: 10.4103/mmj.mmj_668_16.

[5] Hanif F, Ahmed Z, Samie MA , Nassar AHM. Laparoscopic transcystic bile duct exploration: the treatment of first choice for common bile duct stones. *Surg. Endosc. 2010;24(7)*:1552–1556. doi: 10.1007/s00464-009-0809-4.

[6] Qandeel H, Zino S, Z. Hanif Z, Nassar MK, Nassar AHM. Basket-in-catheter access for transcystic laparoscopic bile duct exploration: technique and results. *Surg. Endosc.*2016;30(5): 1958–1964. doi: 10.1007/s00464-015-4421-5.

[7] Zhu JG, Guo W, Han W, Zhang ZT. Laparoscopic Transcystic Common Bile Duct Exploration in the Elderly is as Effective and Safe as in Younger Patients *J. Laparoendosc. Adv. Surg. Tech. A*. 2017; 27 (1) 48–52. doi: 10.1089/lap.2016.0116.

[8] Czerwonko ME, Pekolj J, Uad P, Mazza O, *et al.* Laparoscopic Transcystic Common Bile Duct Exploration in the Emergency Is as Effective and Safe as in Elective Setting. *J. Gastrointest. Surg.* 2019; 23(9):1848–1855. doi: 10.1007/s11605-018-4029-x.

[9] Nassar, A.H.M., Ng, H.J., Wysocki, A.P. *et al.* Achieving the critical view of safety in the difficult laparoscopic cholecystectomy: a prospective study of predictors of failure.*Surg Endosc* (2020). https://doi.org/10.1007/s00464-020-08093-3

[10] Mahmud S, Hamza Y, Nassar AHM. The Significance of Cystic Duct Stones Encountered During Laparoscopic Cholecystectomy. Surg Endosc 2001, 15; 460-2

[11] Nassar AHM, Nassar MK, Gil IC *et al.* One-session laparoscopic management of Mirizzi syndrome: feasible and safe in specialist units. *Surg Endosc* 2020. https://doi.org/10.1007/s00464-020-07765-4

[12] Lei J, Wang J, Li Q, Wu, P *et al.* Laparoscopic Transcystic Common Bile Duct Exploration: T-Shaped Incision of Cystic Duct with FREDDY Laser Lithotripsy. *J. Laparoendosc. Adv. Surg. Tech. A* 2016; 26 (8): 646–651. doi: 10.1089/lap.2016.0004.

[13] Jones T, Al Musawi J, Navaratne L, Martinez-Isla A, Holmium laser lithotripsy improves the rate of successful transcystic laparoscopic common bile duct exploration. *Langenbeck's Arch. Surg.* 2019;404 (8): 985–992. doi: 10.1007/s00423-019-01845-3.

[14] Aawsaj Y, Ibrahim I, Gilliam A. Technique for laparoscopic common bile duct exploration using disposable bronchoscope. *Ann. R. Coll. Surg. Engl.*2019; 101(1):69–70. doi: 10.1308/rcsann.2018.0125.

[15] Yang XB, Xu AS, Li JG, Xu YP *et al.* Dilation of the cystic duct confluence in laparoscopic common bile duct exploration and stone extraction in patients with secondary choledocholithiasis. *BMC Surg.* 2020; 20 50. doi: 10.1186/s12893-020-00705-y.

[16] Di Mauro D, Ricciardi E, Siragusa L, Manzelli A. Outcome of Laparoscopic Common Bile Duct Exploration After Failed Endoscopic Retrograde Cholangiopancreatography: A Comparative Study. *J. Laparoendosc. Adv. Surg. Tech. A* 2019; 29 (11):1391–1396. doi: 10.1089/lap.2019.0383.

457 [17] Platt T, Smith K, Nixon M, Sinha S, Srinivas G, Andrews S. Success of
458 intraoperative imaging and management of suspected choledocholithiasis
459 without pre-operative bile duct imaging - A case series. *Ann. Med. Surg.*2018
460 36: 173–177. doi: 10.1016/j.amsu.2018.10.036.

461 [18] Matsumura T, Komatsu S, Komaya K, Fukami Y *et al.* Dual common bile duct
462 examination with transcystic choledochoscopy and cholangiography in
463 laparoscopic cholecystectomy for suspected choledocholithiasis: a prospective
464 study *Surg. Endosc.*2020; doi: 10.1007/s00464-020-07779-y.

465 [19] Czerwonko ME, Pekolj J, Uad P, Mazza O *et al.* Acute Pancreatitis After
466 Laparoscopic Transcystic Common Bile Duct Exploration: An Analysis of
467 Predisposing Factors in 447 Patients. World J Surg. 2018;42(10):3134-3142.
468 doi: 10.1007/s00268-018-4611-0.

469 [20] Rajan KV, Kate V, Ananthakrishnan N, Elangovan S. Role of operative flexible
470 choledochoscopy in calculous biliary tract disease. *Trop. Gastroenterol. 200;*
471 *21(2): 80-83.*

472 [21] Pálf A, Bende S, Bartoki A, Szabo F *et al.* Laparoscopic transcystic biliary
473 calculus extraction with Dormia basket. *Magy. Seb. 2002*; 55(1):40–43.

474 [22] Topal B, Aerts R, Penninckx F. Laparoscopic common bile duct stone clearance
475 with flexible choledochoscopy. *Surg. Endosc 2007; 21(12)*: 2317–2321. doi:
476 10.1007/s00464-007-9577-1.

477 [23] Jameel M, Darmas B, Baker AL. Trend towards primary closure following
478 laparoscopic exploration of the common bile duct. *Ann. R. Coll. Surg. Engl.*
479 2008; 90(1) 29–35. doi: 10.1308/003588408X242295.

480 [24] Puhalla H, Flint N, O'Rourke N. Surgery for common bile duct stones--a lost
481 surgical skill; still worthwhile in the minimally invasive century?. *Langenbeck's*

Arch. Surg. 2015; 400(1): 119–127. doi: 10.1007/s00423-014-1254-y.

[25] Salama AF, Abd Ellatif ME, Abd Elaziz H, Magdy AS *et al.*, Preliminary experience with laparoscopic common bile duct exploration. *BMC Surg. 2017; 17(1)*,32. doi: 10.1186/s12893-017-0225-y.

[26]. ElGhamry E E, ElSheikh M, Abdelhady H, Hablus MA, Abdelhamid AF, Soliman H, Nassar A. An auspicious experience with laparoscopic common bile duct exploration. Egypt J Surg 2019; 38(3): 459-470

[27] Rhodes M, Nathanson L O'Rourke N, Fielding G. Laparoscopic exploration of the common bile duct: lessons learned from 129 consecutive cases. *Br. J. Surg. 1995;* 82(5) 666–668. doi: 10.1002/bjs.1800820533.

[28] Sherif TM , Sarhan AEA, Abdel-Elaziz A. Total laparoscopic versus endolaparoscopic common bile duct stone extraction and cholecystectomy. *Egypt. J. Surg. 2016;35(4) 311-320*, doi: 10.4103/1110-1121.194727.

[29] Kelley WEJ, Sheridan VC. Laparoscopic choledochoscopy with a small-caliber endoscope. A safe and effective technique for laparoscopic common bile duct exploration. *Surg. Endosc.* 1995; 9(3): 293–296. doi: 10.1007/BF00187771.

Table 1: Demographics, clinical presentations and preoperative imaging of patients undergoing basket-only trawling of the bile duct with or without stone retrieval

Characteristics	Basket Trawling Stone Retrieval n= 377 (%)	Basket Trawling No Stones n= 355 (%)
Age Median/years (range)	55 (16 – 90)	50 (13 – 87)
Female	272 (72.1)	88 (24.8)
Emergency Admission	234 (62)	220 (62)
Clinical Presentation		
Acute biliary pain	174 (46.1)	171 (40.2)
Pancreatitis	47 (12.4)	46 (13)
Cholecystitis	38 (10.1)	41 (11.5)
Jaundice	122 (32.3)	77 (21.7)
Ultrasound scan:		
Multiple stones	358 (95)	305 (85.9)
Bile duct dilatation	87 (23.1)	55 (15.5)
MRCP	26 (6.9)	9 (2.5)
CT Scan	20 (5.3)	18 (5.1)
ERCP pre-operatively	8 (2.1)	2 (0.6)

Table 2: Operative and postoperative data in patients undergoing LTCE or basket trawling for suspected stones.

Operative Data	Basket Trawling: Stone n= 377 (%)	Basket Trawling: No Stones n= 355 (%)	P value	OR (95% CI)
Cholangiography abnormality	346 (92.0 %)	92 (25.9 %)	**< 0.001**	32.737 (21.144, 50.686)
Glucagon utilisation	246 (65.3 %)	10 (2.8 %)	**< 0.001**	64.881 (33.443,125.872)
Number of Stones Removed	2 (1-30)	N/A		
Size of largest stone (mm)	6 (3-15)	N/A		
Length of Surgery , Median (mins)	75 (40 - 265)	55 (28 – 175)	**< 0.001**	
Open conversion	2 (0.5 %)	0		
Total Hospital Stay (days)	5 (1-49)	5 (1-46)	0.063	
Re-admission	21 (5.57 %)	2 (0.6 %)	**< 0.001**	11.183 (2.617, 4.786)
Re-operation (for bile leakage)	1 (0.26 %)	1 (0.3 %)	1.000	0.919 (0.057,14.756)
30 days mortality	0	0		

512 *Table 3: Post-operative complications in patients who had basket only trawling with*

513 *or withour stone retireval*

Complications	Basket Trawling: Stone Retrieval n= 37/377 (9.8%)	Basket Trawling: No Stones n= 14/355 (3.9%)
Jaundice (negative imaging), resolved spontaneously or with glucagon	6 (1.6 %)	1 (0.3 %)
Retained stones: needed ERCP **Resolved with Glucagon**	6 (1.3 %) 1 (0.3 %)	1 (0.3%) 0
Bile leakage Resolved conservatively **ERCP and relaparoscopy** **Percutaneous drainage**	3 (0.8 %) 1 (0.3 %) 1(0.3%)	0 1 (0.3 %) 0
Pancreatitis	7 (1.8 %)	2 (0.56 %)
Sepsis (abdominal, liver abscess)	0	2 (0.56%)
Difficulty removing tube drain (left another 2 weeks)	2 (0.5 %)	0
Biliary drain related pain / dehydration: resolved without intervention	2 (0.5 %)	0
Chest infection	1 (0.3 %)	2 (0.56 %)
Chest pain / MI / PE / TIA	2 (0.5 %)	3 (0.8 %)
Wound infection / Haematoma	3 (0.8 %)	2 (0.56 %)
Urinary retention / infection	2 (0.5 %)	0

514
515
516

517 *Table 4 : Preoperative and operative characteristics of patients undergoing basket only*
518 *LTCE without (pre April 2009) and with the BIC technique. LTCE; laparoscopic*
519 *transcystic exploration, BIC; basket in catheter, IQR; interquartile range, CI;*
520 *confidence interval, TC; transcystic.*
521

Characteristics	No BIC LTCE 1992-April 2009 n= 122 (%)	BIC LTCE May 2009-March 2020 n= 255 (%)	P value	OR (95% CI)
Median Age (years) (IQR)	57 (42 – 67)	54 (39 – 66)	0.277	
SEX Male Female	24 (19.7) 98 (80.3)	81 (31.8) 174 (68.2)	**0.014**	0.526 (0.313, 0.883)
Emergency Admission	54 (44.3)	180 (70.6)	**<0.001**	0.331 (0.212, 0.518)
Clinical Presentation:				
Chronic pain	60 (49.2)	72 (28.2)	**<0.001**	2.460 (1.572,3.848)
Acute biliary pain	30 (24.6)	144 (56.5)	**<0.001**	0.251 (0.155,0.407)
Acute pancreatitis	12 (9.8)	35 (13.7)	0.321	0.686 (0.342,1.373)
Jaundice (including cholangitis)	23 (18.9)	91 (35.7)	**0.001**	0.419 (0.249,0.705)
Ultrasound:				
Multiple stones **Bile duct dilatation/stone**	118 (96.7) 30 (24.6)	240 (94.1) 57 (22.4)	0.326 0.695	1.844 (0.599,5.678) 1.133 (0.683,1.880)
At operation:				
Cystic duct wide	32 (26.2)	52 (20.4)	0.234	1.388 (0.837,2.301)
Cystic duct stones	50 (41.0)	86 (33.7)	0.172	1.365 (0.875,2.128)
LC Difficulty Grading:				
Grade I - II	68 (55.7)	149 (58.4)	0.657	0.896 (0.580,1.385)
Grade III - V	54 (44.3)	106 (41.6)		
All LTCE/total	268/488 (54.9)	620/848 (73.1)	**<0.001**	0.448 (0.354,0.566)
CBD stones number (IQR)	1 (1 – 2)	1 (1 – 2)	0.211	
CBD stones size (mm) (IQR)	5 (4 – 6)	6 (5 – 7)	**<0.001**	
TC biliary drain	29 (23.8)	7 (2.7)	**<0.001**	11.048 (4.679,26.084)
Operative time (minutes) (IQR)	85 (66 – 100)	70 (60 – 89)	**<0.001**	

522

523 Table 5 : Postoperative outcomes of patients undergoing basket only LTCE without
524 (pre April 2009) and with the BIC technique

Characteristics	No BIC LTCE 1992- April 09 n= 122 (%)	BIC LTCE May 09- March 20 n= 255 (%)	P value	OR (95% CI)
Open conversion	2* (1.6)	0	0.104	
Reoperation	0	1 (0.4)	1.000	
Complications	13 (10.6)	24 (9.4)	1.000	0.954 (0.451, 2.017)
Readmissions	2 (1.6)	19 (7.5)	**0.028**	0.207 (0.047, 0.904)
Median hospital stay (days) (IQR)	5 (2 – 7)	6 (3 – 9)	**0.017**	
Median number of episodes (IQR)	1 (1 – 1)	1 (1 – 1)	0.535	
Median presentation to resolution (weeks) (IQR)	1 (1 – 3)	1 (1 – 2.3)	0.507	
* including first case in series converted due to failed TCE.				

525

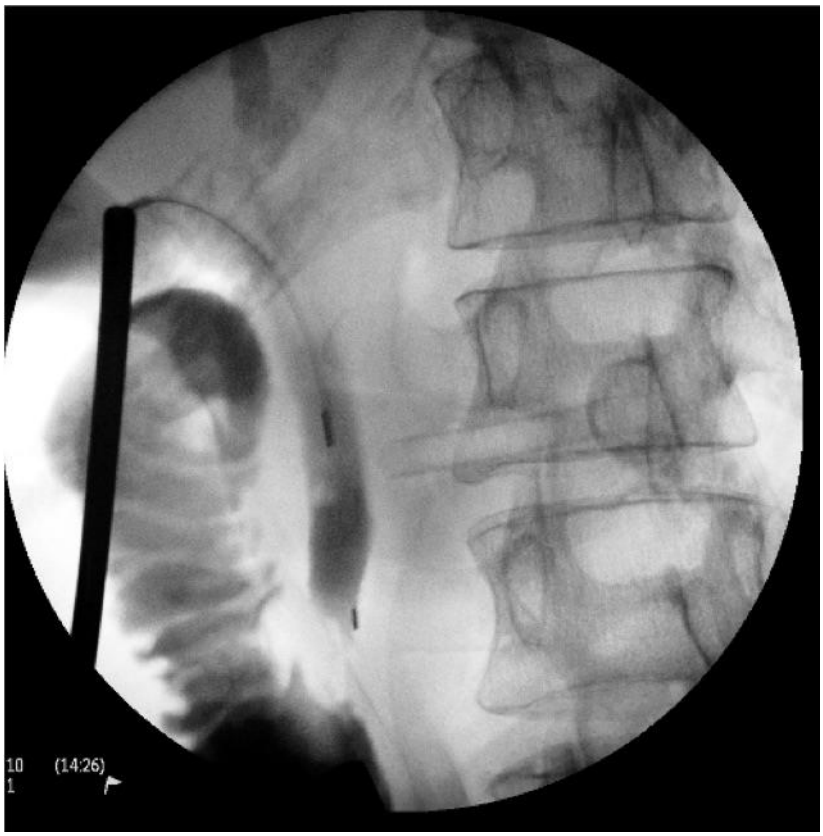
Table 6: C*omparison between the operative and postoperative characteristics in studies reporting basket only LTCE. *For comparison, conversion to choledochotomy, use of choledochoscope or negative explorations in these studies were excluded from the total number. ** Post-operative stay only. NA: data is not available.*

Study (year)	Basket only LTCE	Age/ years	Basket Technique	Number of stones extracted	Size of stones extracted	Operative time/ Minutes	Complications / morbidity	Bile leak	Retained / Recurrent stone	ERCP op	Hospital stay Days	Re-admission	Re-operation
This Study (2020)	377	Median 55 (Range 17-90)	BIC / Naked Basket-alone	Median 1 (Range 1- 30)	Median 6mm (Range 3 –15)	Median 75 (40– 265)	9.3%	1%	1.8% / 2.1% up to 24 years	2.1%	Median 5 (Range 1-49)	5.6%	0.26%
(Chiarugi et al., 2012)[3]	141*	Mean 65	Naked Basket-alone	NA	NA	Mean 157 (175 in emergent14 1 in elective)	< 22% (not enough data for precise percentage)	< 3% (not enough data for precise percentage)	4% (6/149)*/ 0% up to 2 years	8.5%	Mean 5.1** (5.2 in elective 4.9 in emergent)	5.5% (10% in emergent 4% in elective)	1%
(Czerwonko et al., 2019)[8]	461*	Mean 61.9 (SD = 17.8)	Basket-alone + Pneumatic Dilatation of the cystic duct and the papilla	NA	NA	Mean 115 (SD= 60)	4.6%	0.8%	1.4% / 3.6%	5%/ 3.6%)	Median 2** days (1-25)	1.8%	1 %
(Rhodes et al., 1995)[27]	79	Median 47 (Range 19 – 91)	Naked Basket-alone	Median 1 (Range 1-20)	3 – 11 mm	Median 55 (35-80)	5%	0%	3.8% / 0% up to 3 years	5%	Median 2 (Range 1-10)	1.3%	1.3%
(Sherif et al 2016)[28].	116*	Mean 44.8	Naked Basket-alone	NA	NA	Mean 71.8 (SD= 28.1)	28%	16.7%	4.3% (5/116)* / 0% up to 1 year	4.3%	Mean 4.5 (SD = 2.1)	NA	0%

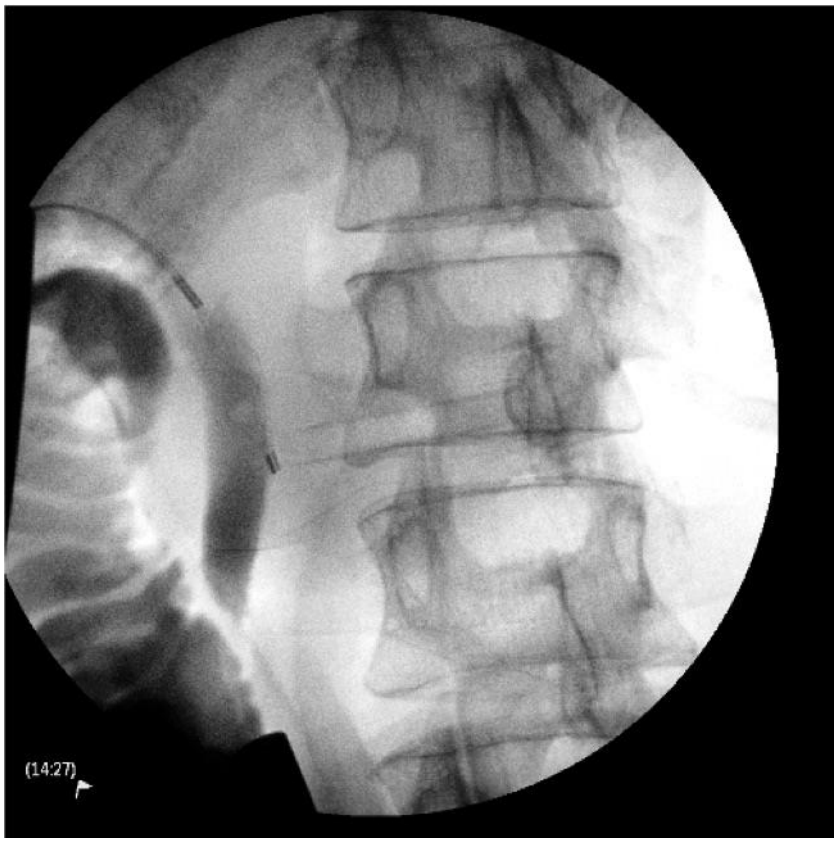
Legends for Figures:

Supplementary media file 1: *The potential difficulty in inserting "naked" disposable baskets into the cystic duct is resolved by using the BIC technique, allowing the basket to reach the common bile duct.*

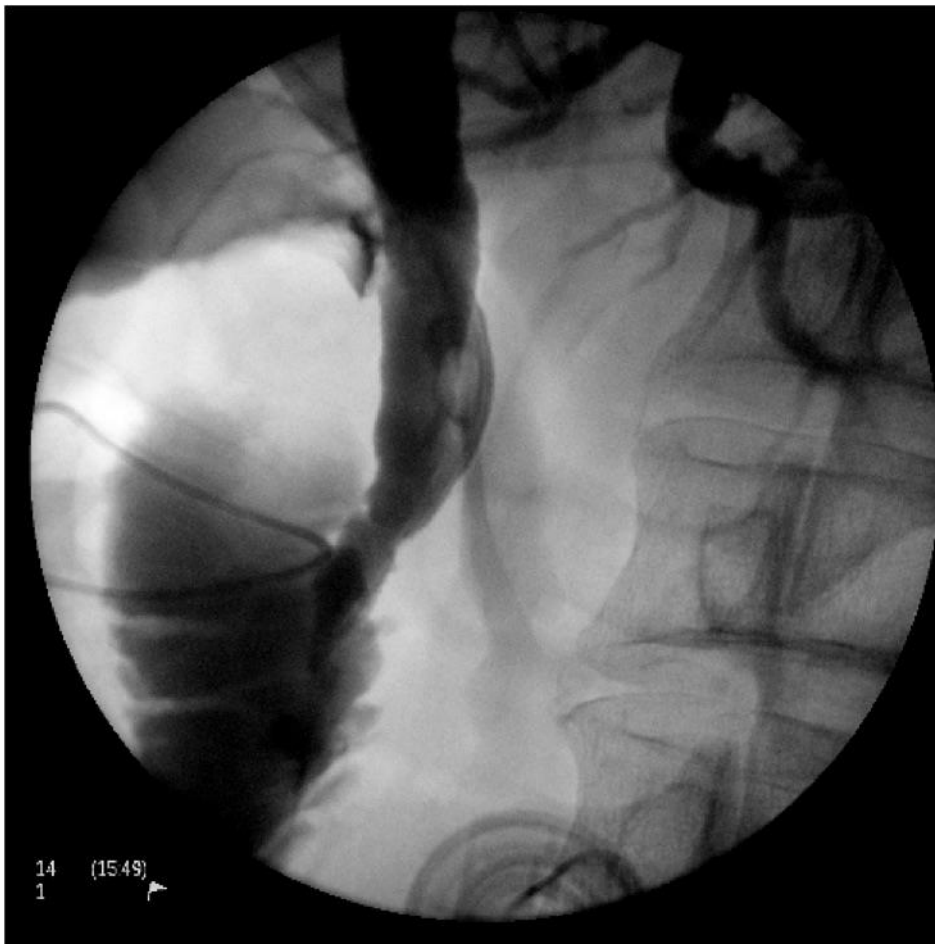
Supplementary media file 2: *The basket in catheter technique allows the trawling of the common bile duct and extraction of stones. A grasper is used to prevent stones from travelling into the common hepatic duct. As the basket emerges from the cystic duct opening the introducer tip is advanced to control the stones as they are removed.*



Supplementary Figure 1A: *Transcystic exploration using BIC under X Ray control*



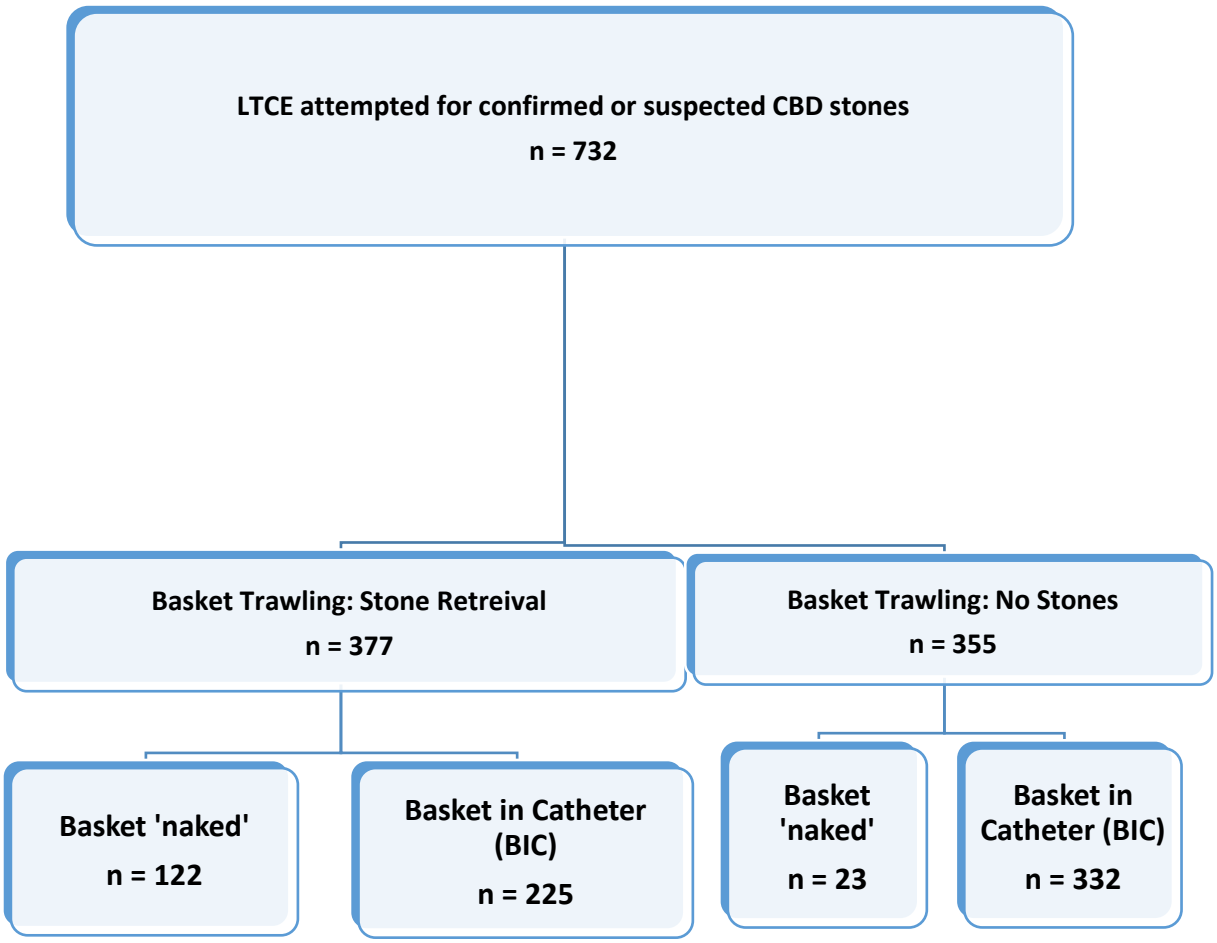
Supplementary Figure 1 B: *Transcystic exploration, stone engaged in basket under X Ray control prior to removal.*



Supplementary Figure 2: Cholangiography showing two stones in the intramural cystic duct. Low medial entery of the cystic duct indicates exploration under choledochoscopic vision rather than blind basket exploration.

Figure 3: *Laparoscopic transcystic approaches for confirmed or suspected bile duct stones. LTCE = laparoscopic trans-cystic bile duct exploration, CBD = Common bile duct.*

Figure 3


LTCE attempted for confirmed or suspected CBD stones
n = 732
Basket Trawling: Stone Retreival
n = 377
Basket Trawling: No Stones
n = 355
Basket 'naked'
n = 122
Basket in Catheter (BIC)
n = 225
Basket 'naked'
n = 23
Basket in Catheter (BIC)
n = 332