Antegrade balloon sphincteroplasty as an adjunct to laparoscopic common bile duct exploration for the acute care surgeon

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The incidence of choledocholithiasis has risen substantially in the last three decades, and its management creates logistical and therapeutic challenges for surgeons.[1–3] Increasingly, choledocholithiasis is managed by use of endoscopic retrograde cholangiopancreatography (ERCP) or laparoscopic common bile duct exploration (LCBDE).[4–7] Laparoscopic cholecystectomy with preoperative or postoperative ERCP is a multistep process, while LCBDE at the time of cholecystectomy can safely and definitively manage common duct stones under one anesthetic.[8–10] Despite the advantage of single-anesthetic choledocholithiasis management, ERCP before or after cholecystectomy has firmly supplanted LCBDE nationwide.[11] This trend has persisted despite multiple reports of the efficacy and safety of LCBDE and the associated decrease in hospital costs and length of stay (LOS).[11–13] One of the most significant factors in this shift from LCBDE is the associated learning curve of the techniques for common duct clearance and the real/perceived logistical hurdles at the time of laparoscopic cholecystectomy. To further complicate the issue, there are multiple management options that can be employed during LCBDE, such as forceful flushing with a cholangiogram catheter, nitinol wire basket stone retrieval with or without choledochoscopy, and laser lithotripsy. With an array of techniques and devices, the perceived learning curve, and the added time for the patient on the operating table, widespread resurgence of LCBDE in the routine management of common duct stones seems unrealistic. To gain traction, the LCBDE intervention must be efficient and simple. To that end, we have adopted a less commonly described, but straightforward technique of balloon dilation of the Sphincter of Oddi with standard over-the-wire noncompliant angioplasty balloon catheters. These balloon catheters have traditionally been marketed in the biliary space as a method to dilate the cystic duct for choledochoscopy insertion. However, in several small series, surgeons have used balloons to dilate the Sphincter of Oddi to facilitate stone passage into the duodenum.[14–16] To disseminate this technique among acute care surgeons, we provide a detailed description of approach and results of a simplified, stepwise LCBDE balloon sphincteroplasty.

DESCRIPTION OF OPERATIVE TECHNIQUE

The first step is obtaining 0.035″ wire access to the common bile duct. This is accomplished by placing a 12-gauge angiocatheter or introducer through the abdominal wall in a location that will provide a flat trajectory of the wire into the cystic ductotomy. Thoughtful placement of the angiocath in both proximity to, and at the correct angle of approach to the cystic ductotomy, allows for less tension on the wire once it is placed. The two-fold benefit is that good angiocath placement prevents a "spring back effect" in which the wire access is lost and coils intra-abdominally instead of advancing forward through the cystic duct and improves one-to-one manipulation of the wires/catheters in the CBD. For this reason, we tend to avoid relying on a previously inserted trocar as the portal of entry because the angle is often not ideal, and there is often leakage of insufflation when inserting smaller diameter devices. After thoughtful angiocatheter placement, a cholangiogram catheter is inserted through the introducer and into the cystic duct. Use of an inexpensive 6-Fr ureteral stent to perform the cholangiogram is advantageous because it both accommodates a guidewire and can be secured into position with a surgical clip applier without loss of luminal patency. We routinely trim the ureteral stent down to 35 to 45 cm of length to facilitate easier manipulation and to improve flow rates during flushing episodes. When intubating the cystic duct with the ureteral stent, initial use of the 0.035″ floppy tipped guidewire preinserted through the stent can help facilitate entry in a Seldinger fashion and also assist in maintaining patency of the stent when clipping it into position.

If the administration of glucagon and power flushing is unsuccessful in clearing a filling defect on intraoperative cholangiogram (IOC), the 0.035″ floppy tipped guidewire should be reinserted through the cholangiogram catheter and into the common bile duct (Fig. 1). We have found that performance of cholangiograms with this setup maximizes efficiency because we can quickly reinsert a wire without additional steps. Our standardized cholangiogram setup can be seen in Figure 2. It consists of a 6-Fr ureteral catheter, a Tuohy-Borst connector, extension tubing with a 3-way stopcock connected to two 60 cc syringes- one with saline and the other with a 50/50 saline-contrast mix. The back aperture of the Tuohy-Borst connector can be closed when performing a cholangiogram and then subsequently opened to accept a 0.035" guidewire as needed. To successfully thread the wire into the system, the ureteral catheter should be backed out of the Tuohy-Borst connector as demonstrated in Figure 3. The connector can also be closed down on the wire once it is in position (Fig. 3B). This configuration facilitates a "step-up approach" to laparoscopic common bile duct exploration and balloon sphincteroplasty with the next step immediately available to the operator using the same platform. Maximizing the likelihood for success with balloon sphincteroplasty not only includes a system through which to perform an IOC but also

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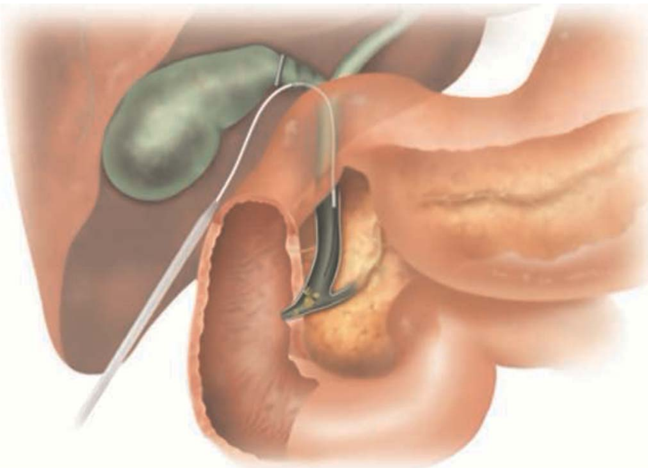

Figure 1. Insertion of 6-Fr ureteral stent and 0.035″ guidewire through a cystic ductotomy using a 12-gauge angiocath as a transabdominal introducer.

consideration of operating room ergonomics. When completing the IOC, the monitors in the operating rooms should be configured to display both the fluoroscopy and laparoscopy images simultaneously. While seemingly a minor point, optimization of the OR layout allows for more favorable working conditions and efficiency. Successful management of the wire and catheters is best facilitated by a team of three people. It is helpful to have one person maintain forward tension on the catheter while the primary surgeon manages the flushing and catheter manipulation, and a third person manages the wires and equipment on the back table. Wet surgical towels are the perfect implement to hold guidewires and extra catheter length in place like a paper weight once they are in position.

Using fluoroscopy, the 0.035" guidewire should be advanced into the duodenum (Fig. 4). This will decrease the likelihood of losing wire access (due to spring back) when manipulating both the wire and balloon catheter. A balloon catheter is then selected by taking the size of the common bile duct into consideration. The sphincter should not be dilated greater than the size of the pathologically dilated common bile duct.[4,5] The balloon inflation profile diameters typically range from 6 mm to 10 mm. Both the length of the balloon and the length of the entire catheter also have to be considered. Seventy-five centimeters is typically the standard *total* length of the balloon catheters. When trying to transverse the cystic-common duct junction, the 40-mm *balloon* length is often the most accommodating. After the appropriate balloon dilator has been chosen, the cholangiogram catheter is removed while maintaining wire position and the balloon catheter is then advanced over the wire into the duodenum (Figs. 4B and C). In general, a 5-Fr angioplasty catheter will fit through the 12-gauge angiocatheter that traverses the abdominal wall. The balloons have radiopaque markers at the proximal and distal extents of the balloon that assist with positioning, although inflating the balloon with a 50/50 mix of contrast and saline can make the extent of the balloon readily apparent on fluoroscopy. We use a standard rotational inflation device with a manometer to ensure inflation to the manufacturer's specifications (information regarding nominal and burst pressure for the balloon is included on the packaging). We have found it best to inflate the balloon fully in the duodenum first (Fig. 4D), and then retract it back gently until it is hubbed against the sphincter (Fig. 4E). This simple maneuver allows for both visual and tactile feedback of the location of the sphincter for positioning purposes. While this step may seem burdensome, manipulation of the common duct and wires within it can slightly distort anatomy and hinder precise placement of the balloon across the sphincter, resulting in inadvertent inflation of the balloon in the lumen of the CBD or the duodenum without actual sphincteroplasty. After the location of the sphincter is clearly understood, the balloon should be partially deflated and retracted until it straddles the sphincter (Fig. 4F). Once in position, the balloon is once again slowly inflated with the contrast-saline mix. A “waist” in the balloon profile should be seen at the location of the sphincter (Fig. 4G). The balloon is then inflated to the appropriate pressure and profile in this position for 3 minutes to 5 minutes (Fig. 4H). If no waist is demonstrated on fluoroscopy as the balloon comes up to profile, then it has likely either migrated back into the common duct or been propelled forward in the duodenum during inflation.

After successful dilation, often with elimination of the initial “waist” at the sphincter, the balloon should be deflated once again and retracted to the cystic-common duct junction under fluoroscopy (Fig. 4I). Once in this more proximal position, it is now *partially* inflated to occlude the proximal portion of the common duct. This incomplete inflation creates a partial seal that excludes the common hepatic duct while still traversing the cystic duct-common bile duct junction and facilitating pressurization of the distal CBD where the debris resides. Additional power flushing and completion cholangiogram is performed through the wire lumen of the balloon catheter after the wire is removed (Fig. 4J). Preventing debris from flushing into the proximal hepatic ducts is an additional benefit of leveraging the balloon catheter as a proximal duct occlusion device during the flushing phase. Careful examination of the completion cholangiogram is essential to ensure no proximal reflux of stones. If the LCBDE is not successful, our practice is to proceed with cholecystectomy and often secure the cystic duct stump with an endoloop and clips in preparation for postoperative ERCP.

PATIENT EXPERIENCE AND OUTCOMES

We have used this stepwise balloon sphincteroplasty technique in 15 patients ranging from 19–88 years of age (Table 1). Operative indications included cholecystitis (n = 8), gallstone

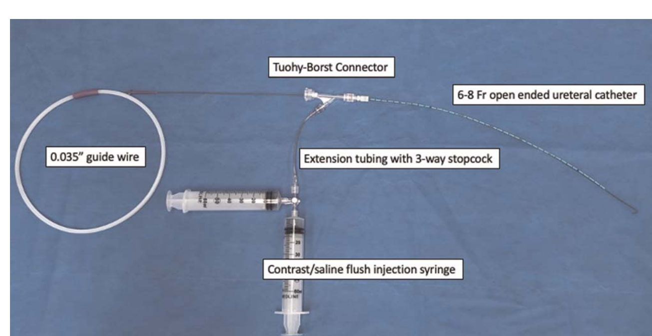

Figure 2. Standard setup for cholangiogram and subsequent LCBDE.

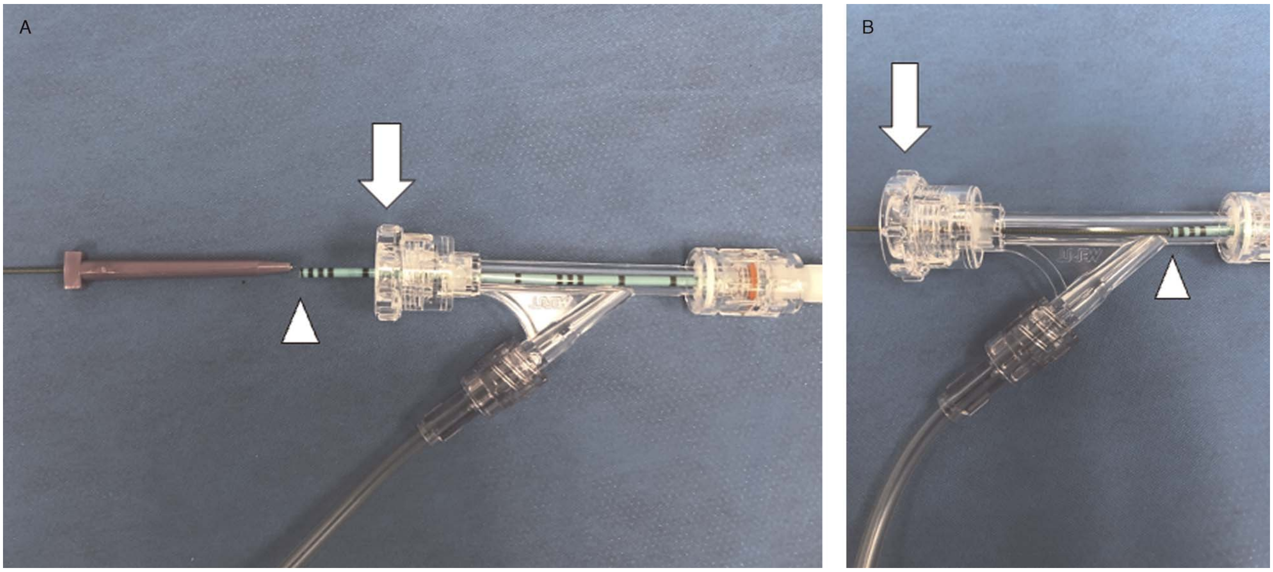

Figure 3. (*A*) Backward advancement of ureteral stent (*arrowhead*) through the Tuohy-Borst aperture valve (*arrow*) facilitates insertion of the 0.035″ guidewire. (*B*) Tuohy-Borst connector with back aperture closed down over wire (*arrow*). Note stent has been readvanced back into the flush chamber of the connector (*arrowhead*).

pancreatitis (n = 2), cholelithiasis (n = 3), and primary choledocholithiasis (n = 2). Ninety-four percent of the common bile ducts were successfully cleared without the need for a postoperative ERCP. The average LOS was 1.9 days. Average fluoroscopy time was 296 ± 81 seconds. Fluoroscopy time was unavailable in the electronic medical record for one patient. The average operative time was 159 ± 36 minutes (Table 2). There were no intraoperative or postoperative complications, including postprocedural pancreatitis. This data is consistent with the additional 15 pediatric patients who have undergone balloon sphincteroplasty at the same institution with a 100% clearance rate and no reported complications.[17]

DISCUSSION

In contrast to ERCP, LCBDE can treat choledocholithiasis during a single anesthetic event. While rendezvous procedures using ERCP in the operating room at the time of cholecystectomy is described, it is often not feasible as coordination between multiple teams is difficult, especially at night on a busy emergency general surgery service. Successful LCBDE allows for the surgical team to provide the complete spectrum of management for this disease process. Often, the result is decreased LOS and cost.[8,11–13,18] With the ability to both definitively diagnose and manage choledocholithiasis, LCBDE also can avoid additional expensive and time-consuming imaging studies. However, none of the potential benefits elucidated from LCBDE are possible without increasing LCBDE adoption and proficiency. A nationwide assessment of choledocholithiasis management by Wandling et al.[11] noted that rates of choledocholithiasis management by LCBDE fell from 5.3% in 1998 to 1.5% in 2013. Increasing adoption may be accelerated through straightforward techniques and ready access to the materials and

TABLE 1. Patient Characteristics and Outcomes

Age	Sex	Diagnosis	Successful LCBDE	Fluoroscopy Time (sec)	LOS (Days)	Operative Time (Min)
19	F	Gallstone pancreatitis	✓	188	2	153
23	F	Gallstone pancreatitis	✓	495	2	238
25	F	Cholecystitis	✓	243	1	141
35	M	Cholelithiasis	✓	327	1	186
52	M	Cholecystitis	✓	242	4	185
55	M	Cholelithiasis	✓	316	1	144
78	M	Cholecystitis	✓	Not available	2	168
88	F	Choledocholithiasis	✓	325	3	134
41	F	Cholecystitis	✓	213	3	166
64	F	Choledocholithiasis		377	2	113
62	F	Cholecystitis	✓	352	3	163
23	F	Cholelithiasis	✓	320	1	142
64	M	Cholecystitis Choledocholithiasis	✓	204	1	124
52	M	Cholecystitis Choledocholithiasis	✓	279	1	219
57	F	Cholecystitis	✓	268	1	112

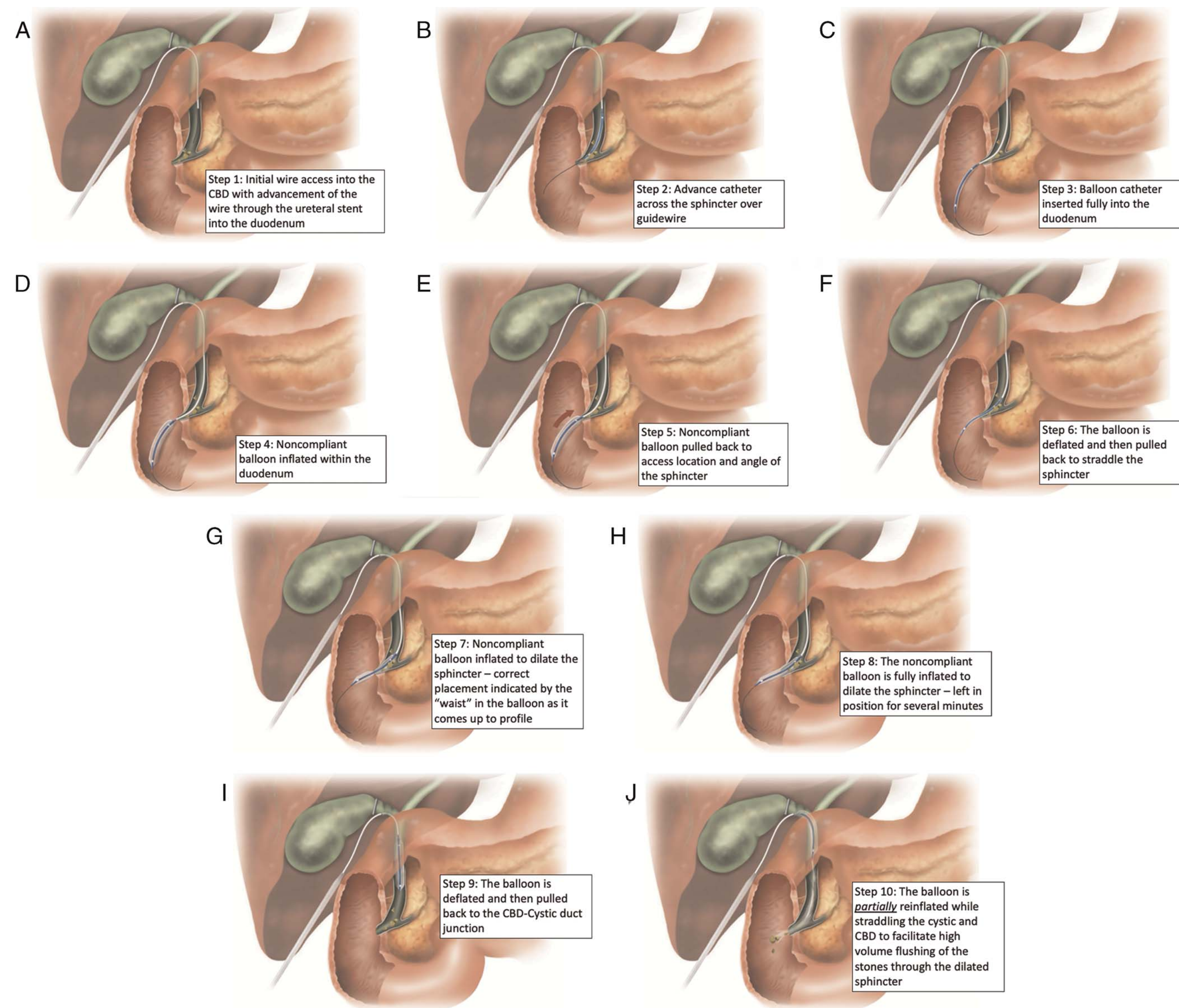

Figure 4. (*A–J*) Steps 1 through 10 of balloon sphincteroplasty technique.

equipment needed to complete the procedure. Transcystic balloon sphincteroplasty as described above only requires a few inexpensive items (Table 2) and leverages the basic wire/catheter skills possessed by virtually all acute care surgeons. Yet, as with any procedure, there is a learning curve and associated risks. The risks of transcystic balloon sphincteroplasty are similar to those assumed with other methods of stone retrieval/removal (e.g., ERCP, open common duct exploration, nitinol basket use with or without choledochoscopy). These risks include damage to the biliary tree or duodenal perforation, retained stones, and postintervention pancreatitis. The available series report a small number of complications.[14–16] Although our experience is nascent, we have not noted any intraoperative or postoperative complications using this technique, while maintaining a high rate of stone clearance on an emergency general surgery service with multiple attending surgeons.

TABLE 2. Averages of Patient Characteristics and Outcomes

	Average Standard Deviation
Age (y)	49.2 ± 21.0
Fluoroscopy Time (s)	296.4 ± 81.3
LOS (d)	1.9 ± 1.0
Operative time (min)	159.2 ± 36.3

Transcystic balloon sphincteroplasty as an adjunct to LCBDE is a safe and effective technique that is feasible in an emergency general surgery setting. Laparoscopic common bile duct exploration is within the skill set of acute care surgeons and could improve outcomes and decrease cost for patients presenting with choledocholithiasis.

AUTHORSHIP

Bosley-literature search, design, data collection, analysis, writing, critical revision.
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DISCLOSURE

The authors declare no conflicts of interest.

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