INTRODUCTION

Endoscopic retrograde cholangiopancreatography (ERCP), typically combined with endoscopic sphincterotomy (EST), has become the gold standard treatment for the management of common bile duct stones. Approximately 15-20% of patients who undergo EST will not achieve complete stone removal, necessitating either advanced endoscopic or surgical procedures. Factors that may predict difficult stone extraction include large stones (>12mm), multiple stones, stones above a stricture, and/or a small or tapered common bile duct. This review will focus on the indications, success rate, and adverse events of Dilation Assisted Stone Extraction (DASE) for difficult biliary stones.

Dilation Assisted Stone Extraction

Dilation Assisted Stone Extraction (DASE) was first introduced in 2003 by Ersoz, Tekesin, Ozutemiz and Gunsar to aid in the extraction of large or complex biliary stones. Since its initial description, DASE has been referred to by many names and now possess numerous synonyms which represent the same procedure. Dilation assisted stone extraction is often referenced as either full or limited endoscopic sphincterotomy plus endoscopic papillary large balloon dilation (EST+EPLBD) or biliary endoscopic sphincterotomy with biliary orifice balloon dilation (BES+BBD), or some combination thereof. Regardless, the procedure is performed in four stages; deep cannulation of the bile duct, endoscopic sphincterotomy of the papillary orifice, and balloon dilation of the biliary tree before finally extracting biliary stones. (Figure 1) In its first description, endoscopic sphincterotomy was performed at the papillary orifice and extended to the transverse fold. Dilation to 12-20mm, based on stone size, is then performed with a large diameter balloon (over the guidewire, esophageal/pyloric type balloons) immediately following sphincterotomy. Of note, balloon inflation is maintained until 20-45 seconds after the gradual disappearance of the waist of the balloon is observed as this is thought to indicate a progressive dilation of the orifice.

Endoscopic Papillary Balloon Dilation

Endoscopic Papillary Balloon Dilation (EPBD), also referred to as endoscopic sphincteroplasty, was first described in the early 1980s and has been advocated as an alternative to endoscopic sphincterotomy. The procedure is accomplished through pneumatic balloon dilation of the biliary orifice. It was postulated that EPBD preserved the function of the biliary sphincter (as opposed to...
biliary sphincterotomy, which permanently cuts the entire sphincter muscle) and thus may convey some advantage in regards to short and long term sequelae over endoscopic sphincterotomy. However, EPBD alone often did not produce a wide enough dilation for the retrieval of large biliary stones frequently resulting in a need for mechanical lithotripsy or other advanced procedures. After the advent of DASE, and the addition of balloon dilation to biliary sphincterotomy, endoscopists began to utilize larger esophageal/pyloric type balloons and in modern era the procedure is often referenced as Endoscopic Papillary Large Balloon Dilation (EPLBD) with or without sphincterotomy.

Comparison of Techniques
EST VS DASE
Endoscopic sphincterotomy with subsequent balloon catheter stone extraction is widely accepted as the standard therapy for common bile duct stones. However, sphincterotomy alone is often not effective in the removal of large common bile duct stones (>12mm). In fact, in the sentinel study describing the DASE procedure was only implemented after sphincterotomy had failed and resulted in a 89-95% success rate depending the degree of dilation performed. In regards to small bile duct stones (<12mm), EST alone and DASE have a similar success and complication rates although there may be a lower rate of stone reoccurrence with DASE.

EST VS EPLBD
The use of endoscopic papillary large balloon dilation for the retrieval of large common bile duct stones has been heatedly debated throughout the literature and there are large differences in its utilization based on locoregional preferences. There are some studies, primarily performed in Asia, that suggest EPLBD is superior to or as effective as DASE or EST with similar complication rates. However, it has been postulated that this may be related to population-based characteristics and operator experience with EST. A randomized, controlled, multicenter study from the United States comparing EPLBD to EST demonstrated significantly higher rates of pancreatitis (15.4% vs 0.8%) and subsequent death (6.8% vs 0%). In this study patients who received EPLBD underwent more invasive procedures, had longer hospital stays, and more time off from normal activities. This study was terminated early given the adverse outcomes in the EPLBD group. The remainder of this article will focus on DASE as it is the most commonly utilized advanced procedure for large common bile duct stones within the United States and Europe.

Indications, Success Rates, and Potential Adverse Events of Dilation Assisted Stone Extraction (DASE)
Indications
(periampullary diverticula, large stones)
The indications for the use of DASE have expanded since its initial description as a rescue procedure.
following failed EST. Often the endoscopist must determine the degree of difficulty anticipated with the extraction of the stone(s) based on their size, shape, and location. However, there is some evidence that DASE has a higher success rate than EST combined with balloon extraction alone when utilized on stones are greater than 12mm, with higher success rates seen with DASE in progressively larger stones. Authors also found a higher rate of failure, requiring multiple ERCP procedures, once stones were greater than 20mm in diameter. Furthermore, it has been suggested that patients with a single stone may have a higher success rate than those with a greater stone burden.

Adverse Events
The most common adverse events of DASE are pancreatitis, bleeding, and perforation. There have been several well-designed retrospective studies which have described rates of pancreatitis ranging from 0-5.9% and bleeding of 0-2.9%. There have been several well-designed retrospective studies which have described rates of pancreatitis ranging from 0-5.9% and bleeding of 0-2.9%. One retrospective study had a particularly high overall complication rate with pancreatitis occurring in 8.9% of patients and bleeding in 9.2%. However, the majority of DASE cases in this study were performed after failed EST stone extraction which may have influenced the overall complication rate. It has been postulated that sphincterotomy size and balloon dilation diameter/duration may have some effect on bleeding and perforation risk. Sphincterotomy size often varies considerably between studies and operators, and is subjectively measured by the endoscopists. However, when described as “full length”, complication rates have been similar to those with partial sphincterotomy.

Success Rates
There is considerable variation between the definition of success seen within the literature on DASE. Some authors report overall stone clearance rates while others rely upon stone clearance on initial ERCP. Factors including differences in sphincterotomy/dilation size, operator experience, and average stone size are often present which may have impact on the overall stone clearance rate and make it difficult to compare studies. However, reported success rates on the initial ERCP of patients undergoing DASE have ranged from 72-98% with the majority of studies reporting >85% success. Furthermore, a comparison of DASE vs EST alone found that DASE had a higher rate of stone clearance on the first attempt with reduced overall procedure time and a lower need for mechanical lithotripsy. In one retrospective review, it was found that DASE success rates were greatest when stones were >15mm in size but these

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utilizing 15mm.\textsuperscript{23} Theoretically, larger dilation diameters should carry more risk of perforation. However, a retrospective review of 101 patients who underwent DASE with balloon dilation to 12-20mm had a similar complication rate to other studies.\textsuperscript{24} In regards to balloon dilation times, a prospective randomized trial comparing dilation durations of 30 and 60 seconds found no difference in overall stone clearance or complications including pancreatitis, perforation, and bleeding.\textsuperscript{25} Overall, perforation appears to be relatively rare following DASE with rates of 0-1.4%.\textsuperscript{9,17}

It is important to consider the complication rate of DASE within the context of endoscopic sphincterotomy as this is an integral part of the procedure. When comparing sphincterotomy alone to DASE, one prospective study of 121 patients found no difference in rates of pancreatitis, stone/basket impaction, bleeding or perforation.\textsuperscript{9} Furthermore, there is some data that suggests a lower rate of bleeding and recurrence of common bile duct stones in patients who underwent DASE compared EST alone.\textsuperscript{6}

**Altered Anatomy**

There have been relatively few studies describing DASE use in patients with Billroth II anatomy however, two retrospective studies describe 100% successful stone extraction in a combined 37 patients without any procedural related complications.\textsuperscript{26,27} DASE has also been utilized in patients with Roux-en-Y anatomy and, while technically difficult, has had a high success rate although case numbers are low.\textsuperscript{28}

**CONCLUSION**

DASE is a safe and effective advanced endoscopic procedure for the extraction of difficult biliary stones. Dilation diameter and duration of dilation time varies considerably between operators and should be dependent on stone and bile duct size. Furthermore, operator experience must be considered when choosing sphincterotomy and dilation size. The complication rate of DASE appears to be similar to that of endoscopic sphincterotomy while successful stone extraction appears to be greater than EST alone in stones greater than 12mm.

**References**

11. Lai KH, Chan HH, Tsai TJ, Cheng JS, Hsu PI. Reappraisal of endoscopic papillary balloon dilation for the management of common bile duct stones. World J Gastrointest Endosc. 2015;7(2):77-86. doi:10.4253/wjge.v7.i2.77