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Providing more through less: current methods of retraction in SIMIS and NOTES cholecystectomy

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Abstract
Background As the field of minimally invasive surgery continues to develop, surgeons are confronted with the challenge of performing conventional laparoscopic surgeries through fewer incisions while maintaining the same degree of safety and surgical efficiency. Most of these methods involve elimination of the ports previously designated for retraction. As a result, minimally invasive surgeons have been forced to develop minimally invasive and ingenious methods for providing adequate retraction for these procedures. Herein we present our experience using endoloops and internal retractors to provide retraction during Single Incision Minimally Invasive Surgery (SIMIS) and Natural Orifice Transluminal Endoscopic Surgery (NOTES) cholecystectomy. We also present a review of the alternative retraction methods currently being employed for these surgeries.
Methods SIMIS was performed on 20 patients and NOTES was performed on 5 patients at our institution. Endoloops or internal retractors were used to provide retraction for all SIMIS procedures. Internal retractors provided retraction for all NOTES procedures.
Results Successful cholecystectomy was accomplished in all cases. One SIMIS surgery required conversion to standard laparoscopy due to complex anatomy. There were no intraoperative complications. Although adequate retraction was accomplished in all cases, the internal retractors were found to provide superior and more versatile retraction compared to that of endoloops.
Conclusion Adequate retraction greatly simplifies SIMIS and NOTES surgery. Endograb internal retractors were easy to use and were found to provide optimal retraction and exposure during these procedures without complications.

Keywords Laparoscopic cholecystectomy · Retraction · Instruments

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In recent years, with increased importance being placed on the aesthetic outcomes of surgery, surgeons are confronted with the challenge of accomplishing the requisite tasks of the same surgical procedure through smaller incisions and fewer ports. As such, minimally invasive surgeons must find a way to provide more through less. As procedures become less invasive, adequate retraction must often be sacrificed as ports designated for retraction are invariably the first to go. Although not specifically delineated in the NOSCAR white paper as an obstacle to widespread application [1], adequate retraction undoubtedly serves as an obstacle when performing these surgeries, especially

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when the anatomy encountered in less than “textbook.” Aside from its inevitable prolongation of operative time, inadequate retraction can potentially convert a technically straightforward case into a complex ordeal. As such, surgeons have been attempting to create novel methods of accomplishing adequate retraction without leaving any visible evidence of it. In this article we review both the “conventional” and the experimental methods of retraction used in Natural Orifice Transluminal Endoscopic Surgery (NOTES) and Single Incision Minimally Invasive Surgery (SIMIS) and describe our experience with a new unpublished method: internal retractors.

Transabdominal stay sutures

One commonly employed method of retraction in NOTES and SIMIS surgery that has already been performed on human subjects is transabdominal stay sutures [2]. The sutures are placed through the fundus and infundibulum of the gallbladder using a straight keith needle and then externalized in a transabdominal fashion to allow continuous extracorporeal manipulation, leaving only a negligible mark where the needle passed through the skin. One limitation of the transabdominal stay suture method of retraction is restricted retraction capability. In order to avoid entering the thoracic cavity and potential pneumothorax, the straight needle and stay sutures must be inserted inferior to the rib cage resulting in anterior rather than complete anterior–superior retraction of the gallbladder fundus as performed in standard laparoscopy. Another drawback of this method is the potential for intraperitoneal bile leakage and possibly complete tearing of the gallbladder as the needle must pierce the gallbladder wall. In addition, because these stay sutures serve as a fixed anchoring system, repositioning during surgery is not possible.

Transabdominal endoloop

Transabdominal endoloops (Fig. 1), although never described in the literature, have been used at our institution to achieve gallbladder retraction during our early experience with SIMIS cholecystectomy. The endoloop (Ethicon Endo-Surgery, Cincinnati, OH) is introduced transabdominally into the peritoneal cavity through a 5-mm trocar and attached to the gallbladder fundus which is then retracted anteriorly to the abdominal wall. Although similar conceptually to transabdominal stay sutures, endoloops provide two distinct advantages. First, because the endoloop is used to grasp the gallbladder as opposed to piercing it, the potential for leakage and complete tearing of the

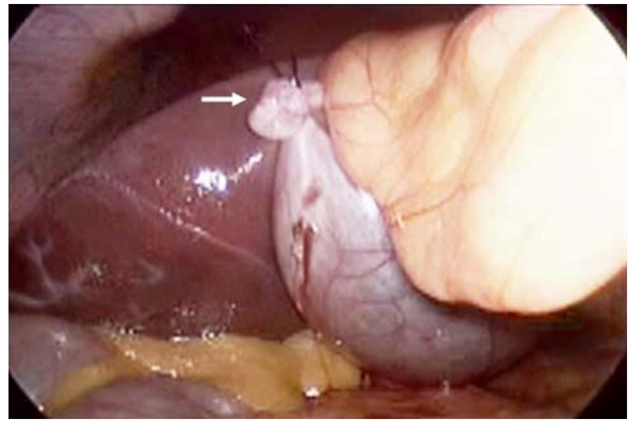

Fig. 1 Laparoscopic intraoperative image of endoloop retraction of gallbladder fundus. The *arrow* depicts the looped gallbladder fundus

gallbladder is minimized. Nevertheless, like stay sutures, because it must be introduced inferior to the rib cage, endoloops cannot achieve complete superiorly directed retraction. In addition, fastening of the endoloops may prove challenging in cases of scarred and distended gallbladders.

R-Scope

The R-Scope (Olympus XGIF-2TQ240R, Olympus Corp., Tokyo, Japan) is a therapeutic endoscope equipped with two movable channels designed to enable both lifting and dissection of lesions. One channel is fitted with vertically moving grasping forceps to provide countertraction while the second uses a horizontally swinging electrocautery knife to dissect [3]. Using these two channels enables simultaneous retraction and dissection. Although initially used for endoscopic submucosal dissection of gastric lesions, Sumiyama et al. [4] report successful transgastric access to the gallbladder and cholecystectomy in four porcine models.

Magnetic anchoring and guidance system (MAGS)

Magnetic anchoring and guidance system (MAGS) (Fig. 2), developed by the group of Caddedu and Scott in 2001, employs intra-abdominal magnetically anchored instruments to perform trocar-sparing laparoscopic surgery. MAGS uses two internal neodymium–iron–boron magnetic platforms introduced into the abdomen through a 12-mm trocar. The internal platforms are magnetically anchored to external anchors on the patient’s skin and are capable of manipulating and stabilizing these platforms [5, 6]. In Cadeddu’s retraction system, two internal magnetic

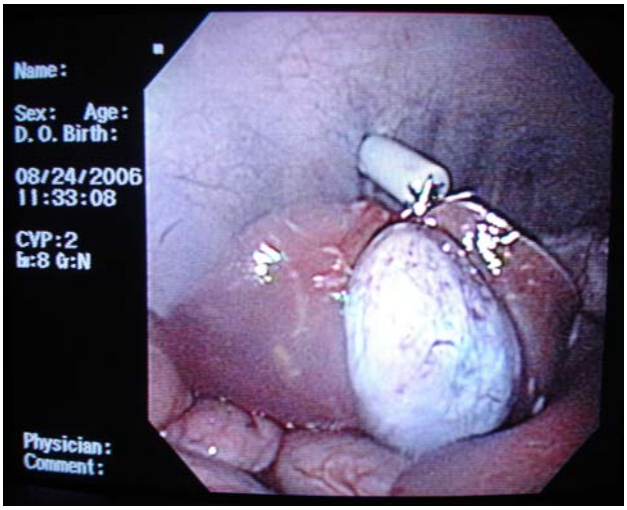

Fig. 2 MAGS system demonstrating retraction of the gallbladder using an internal magnet. Originally published in [6]

platforms are coupled to either a latex sling or a three-fingered paddle which allows nontraumatic elevation and retraction of organs like the liver and spleen. Ryou and Thompson [7] describe a modified MAGS retraction system whereby magnet-conjugated clips placed along the inferior edge of the liver are used to accomplish operative retraction. As yet, MAGS retraction has been used successfully in porcine models to perform transcolonic cholecystectomy and mesh implantation. In addition, MAGS instruments, cauterizers, and cameras have been used in single-port laparoscopic nephrectomies freeing up the single port to be used for direct retraction [8].

At this time, MAGS is still evolving and has been performed only on animal models. Aside from issues of cost and the necessary learning curve inherent in the introduction of new technology, a significant obstacle to widespread use of MAGS is the exponential decrease in magnetic coupling strength as a function of distance. At this time, magnetic retraction capability is impaired beyond a tissue thickness of 1.5 cm thereby restricting its use to thin or pediatric patients [5].

Internal retractors

The Endograb™ (Virtual Ports, Misgav, Israel) (Fig. 3) is an internally anchored retracting device that can be introduced into the abdomen at the outset of the operation through a 5-mm port. Once deployed, one of the two grasping ends is attached to the gallbladder while the other is anchored to the abdominal wall. The main advantage of this device is that it not only leaves no visible marks but it can be anchored superiorly just below the diaphragm,

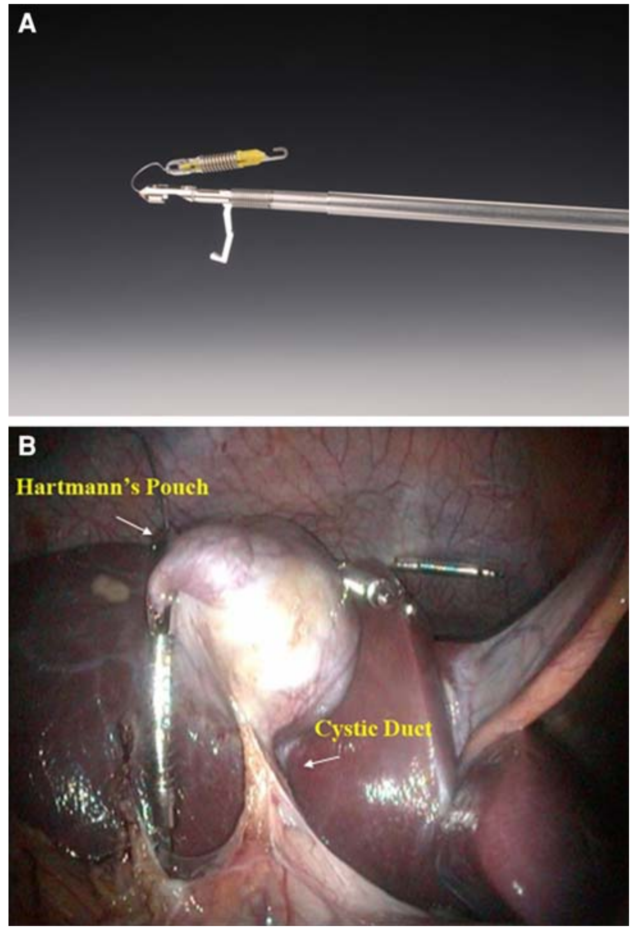

Fig. 3 **A** The Endograb™ held by the introducer with open jaws. **B** Complete anterior–superior retraction of gallbladder using Endograb™ retractors. The *arrows* depict the Hartmann's pouch of the gallbladder and the cystic duct, respectively

thereby allowing retraction equivalent to that achieved with a designated retracting instrument. This device can be adjusted repeatedly throughout the operation to allow for optimal retraction and is removed at the end of surgery.

Methods

In order to assess the safety and efficacy of the retraction methods to be used in SIMIS and NOTES surgery, the methods were first tested on porcine models. After receiving approval by the Hebrew University Animal Welfare Committee, SIMIS cholecystectomy was performed on five pigs using endoloops and stay sutures to provide retraction. SIMIS cholecystectomy was then performed on five additional pigs, this time using internal retractors to provide the necessary retraction. After a successful trial on porcine models, IRB approval was obtained to perform these procedures on human subjects. Twenty patients underwent SIMIS cholecystectomy using either endoloops or internal retractors to provide gallbladder retraction, and five underwent NOTES cholecystectomy using Endograbs.

Inclusion criteria for the procedure included symptomatic cholelithiasis, prior cholecystitis, or gallstone pancreatitis. General exclusion criteria for the both surgeries included a body mass index (BMI) greater than 35, acute cholecystitis, elevated liver enzymes, and ASA III-IV. Patients with prior upper abdominal surgery and virgins were excluded from NOTES procedures. (Note: SIMIS surgery was performed on one patient with a BMI of 36.1 and two patients were found intraoperatively to have acute cholecystitis.)

Operative technique

SIMIS with endoloop

Following a 15–18-mm umbilical skin incision, either a dual-seal 15-mm trocar or three low-profile 5-mm ports (Storz Endoscopy, Tuttlingen, Germany) were inserted into the abdomen. Through these ports either a flexible gastroscope (Storz Endoscopy) or a 5-mm 30° laparoscope (Storz Endoscopy) was introduced into the peritoneal cavity. Retraction was achieved by inserting a preformed tie (Endoloop, Ethicon Endo-Surgery, Cincinnati, OH) through one of the 5-mm ports and the dome of the gallbladder was looped. The end of the loop was then grasped using a suture passer which had been passed transabdominally into the right-upper quadrant just below the rib cage. The suture was pulled until the dome of the gallbladder reached the anterior abdominal wall, thereby achieving adequate retraction. The dissection was performed using laparoscopic articulating instruments (Novare Surgical, Cupertino, CA). Following the complete detachment from the liver bed, the gallbladder was removed using an endobag.

SIMIS with Endograb

The initial steps of the procedure describing the introduction of instruments into the peritoneal cavity are as above. The Endograb introducer was inserted through one of the 5-mm ports and the jaws of the device were used to grasp the dome of the gallbladder. The second pair of jaws located on the opposite end of the device was then fixed to the anterior peritoneal wall just below the dome of the diaphragm thereby achieving retraction equivalent to that achieved in the standard laparoscopic cholecystectomy. The remainder of the procedure is as above. The Endograb was removed from the peritoneal cavity using the Endograb introducer just prior to removal of the gallbladder.

NOTES with Endograb

A 5-mm skin incision was made in the umbilicus through which a trocar and 30° laparoscope was introduced into the peritoneal cavity to visualize the introduction of the vaginal port. A 15-mm trocar (Applied Medical, Rancho Santa Margarita, CA) with dual seal was then inserted through the posterior fornix of the vagina and a single-channel gastroscope (Storz Endoscopy, Tuttlingen, Germany) was inserted through it into the peritoneal cavity. Using the gastroscope to visualize the operative field, two Endograbs were introduced into the peritoneal cavity to provide retraction. The first was used to retract the dome of the gallbladder to the anterior abdominal wall and second retracted the Hartmann's pouch to the upper-right quadrant thereby exposing the triangle of Callot for dissection. To reduce operating time, the dissection was performed using both the flexible endoscopic instruments passed through the working channel of the gastroscope and laparoscopic instruments passed through the 5-mm transumbilical port. The Hartmann's Endograb was repositioned as necessary to optimize retraction and dissection. The gallbladder was dissected free of the liver bed using a cauterizing hook. The Endograbs were then removed and the gallbladder was removed through the vaginal port.

Results

SIMIS (Tables 1 and 2)

SIMIS cholecystectomy was successfully performed in 19 of 20 patients. There was one early conversion to standard laparoscopy due to difficult anatomy and intrahepatic gallbladder. The dissection of the triangle of Callot was performed using the standard laparoscopic approach. There were no intraoperative complications. The average operative time was 136 min. The only morbidity was a cystic duct stump leak, which occurred in the converted patient and which was treated successfully with common bile duct stenting via ERCP.

Table 1 Patient demographics and surgical indications for SIMIS and NOTES cholecystectomies

Procedure	% Female	Avg. age	BMI	Indication
SIMIS (20)	90%	40.7	27	Biliary colic—75%
				Cholecystitis—20%
				Gallstone pancreatitis—5%
NOTES (5)	100%	31.8	24.3	Biliary colic—60%
				Gallstone pancreatitis—20%
				Gallbladder polyp—20%

Table 2 Retraction methods and surgical outcomes for SIMIS and NOTES cholecystectomies

Procedure	Method of retraction	OR time (min)	Complications	Morbidity
SIMIS (20)	Endograb—55% Endoloop—45%	137	None	1 cystic duct stump leak (repaired with ERCP stent)
NOTES (5)	Endograb—100%	129.8	None	None

The Endograb retractors achieved superior retraction compared to endoloops. These retractors successfully fixed the gallbladder to the anterior–superior peritoneal wall. There were no significant injuries to the peritoneal wall noted after removal of the Endograb. It is noteworthy that although average operative time for the procedure was 136 min, the range was from 78 to 230 min, which reflects the progression along the learning curve as we gained familiarity with the techniques and devices.

NOTES

NOTES cholecystectomy was successfully performed in all five patients. The average operative time was 129 min. The Endograb successfully provided retraction in all cases, enabling good visualization and safe dissection of the triangle of Callot. Repositioning of the Endograbs was easily performed as necessary and provided superior retraction and exposure of the triangle of Callot. There were no intraoperative or postoperative complications.

Discussion

There have been a number of creative alternative retraction methods described in the literature that allow retraction while obviating the necessity of an extra port. Some of these methods have been performed only on porcine models while others have already been successfully performed on human subjects. Nevertheless, it should be noted that for the most part, all of these methods have been performed under optimal surgical conditions where situations of less-than-optimal retraction can often be tolerated. However, in reality, each method has its disadvantages and not all of them can achieve the same degree of retraction, a point which becomes significant when less-than-ideal surgical anatomy is encountered. The ability of the Endograb to accomplish complete anterior–superior retraction of the gallbladder fundus is a distinct advantage over other methods. Because it is internally deployed it can be attached high up on the anterior abdominal wall just below the diaphragm without concern of entering the thoracic cavity. After being initially tested in porcine models, we have now performed 11 successful SIMIS cholecystectomies and 5 successful transvaginal NOTES cholecystectomies using this retraction device without complication. In the future, a 70-cm introducer will be available for positioning the Endograb transvaginally thereby obviating the need for transumbilical placement of the Endograb. These internal retractors are also currently being employed for colon retraction during colectomy and gastric retraction during sleeve gastrectomy.

We believe that internal retractors such as the Endograb not only yield the most aesthetic results but also are the most versatile method of retraction for the performance of SIMIS and NOTES procedures.

Disclosure Dr. Yoav Mintz is on the medical advisory board of Virtual Ports which is the company that manufactures Virtual Ports Endograb™. Drs. Avraham Schlager, Abed Khalaileh, Noam Shussman, Ram Elazary, Andrei Keidar, Alon J. Pikarsky, Avi Ben-Shushan, Oren Shibolet· Santiago Horgan, Mark Talamini, Gideon Zamir, and Avraham I. Rivkind have no conflicts of interest or financial ties to disclose.

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