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PERSPECTIVES

Hydrodissection in Laparoscopic Cholecystectomies for Gangrenous Gallbladders

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Abstract: To improve the quality of patient care for cholecystectomies for gangrenous gallbladders, multiple innovations have been introduced including laparoscopic and robotic surgery. However, laparoscopic cholecystectomies for gangrenous gallbladders performed by blunt dissection still represents one of the most technically challenging general surgery procedures, with a high rate of iatrogenic complications and suboptimal measures for key surgical parameters such as length of stay, operating time, and blood loss. For this reason, the novel use of surgical techniques such as hydrodissection, which involves the expulsion of normal saline streams at a predetermined pressure, for cholecystectomies for gangrenous gallbladders are of utmost importance. In this manuscript, we explore the application of hydrodissection in cholecystectomies for gangrenous gallbladders.

Keywords: laparoscopic, cholecystectomy, gallbladder, GB, hydrodissection, HD

Introduction

Since its introduction in 1998, the laparoscopic technique for cholecystectomies has become the standard of care.[1] Oftentimes, the severity of cholecystitis does not correlate with surgical difficulty. However, among cholecystectomies, the most challenging procedure is to treat gangrenous cholecystitis, with a high incidence of iatrogenic complications (ie, bleeding, bile duct injuries, and intestinal leaks) and many procedures being either partially completed or abandoned leading to bail-out procedures such as conversion to open cholecystectomies, subtotal cholecystectomies, and cholecystostomies as indicated by the 2018 Tokyo Guidelines.[2] Currently, standard laparoscopic cholecystectomies for gangrenous gallbladders (GB) entail blunt dissection. Blunt dissection aids in the removal of necrotic tissue and purulent material that surrounds the GB, ultimately clearing the visual field and allowing for the removal of the inflamed GB (Figure 1). However, blunt dissection is technically challenging as it is performed in hemorrhagic and inflamed fields, interspersed with dense adhesions, and can result in complications such as bleeding and injury of nearby structures.[1] These complications are often associated with increased mortality, morbidity, time spent operating, and length of stay in the hospital, resulting in financial burdens from malpractice ($250,000 to $1.2 million) and healthcare insurance expenses from the management of the complications ($100,000 to $1.5 million).[3]

An Innovative Use of the Hydrodissection Technique

Hydrodissection (HD), a common technique used in cataract surgery, spinal surgery, median nerve entrapment cases, and hepatic resection, can serve as a powerful adjunct to traditional laparoscopy and reduce the risk of the associated complications. Though HD has not shown benefit in routine, simple cholecystectomies,[4,5] our findings in a retrospective research study have demonstrated that HD is efficacious for the specific case of cholecystectomies treating gangrenous GBs.

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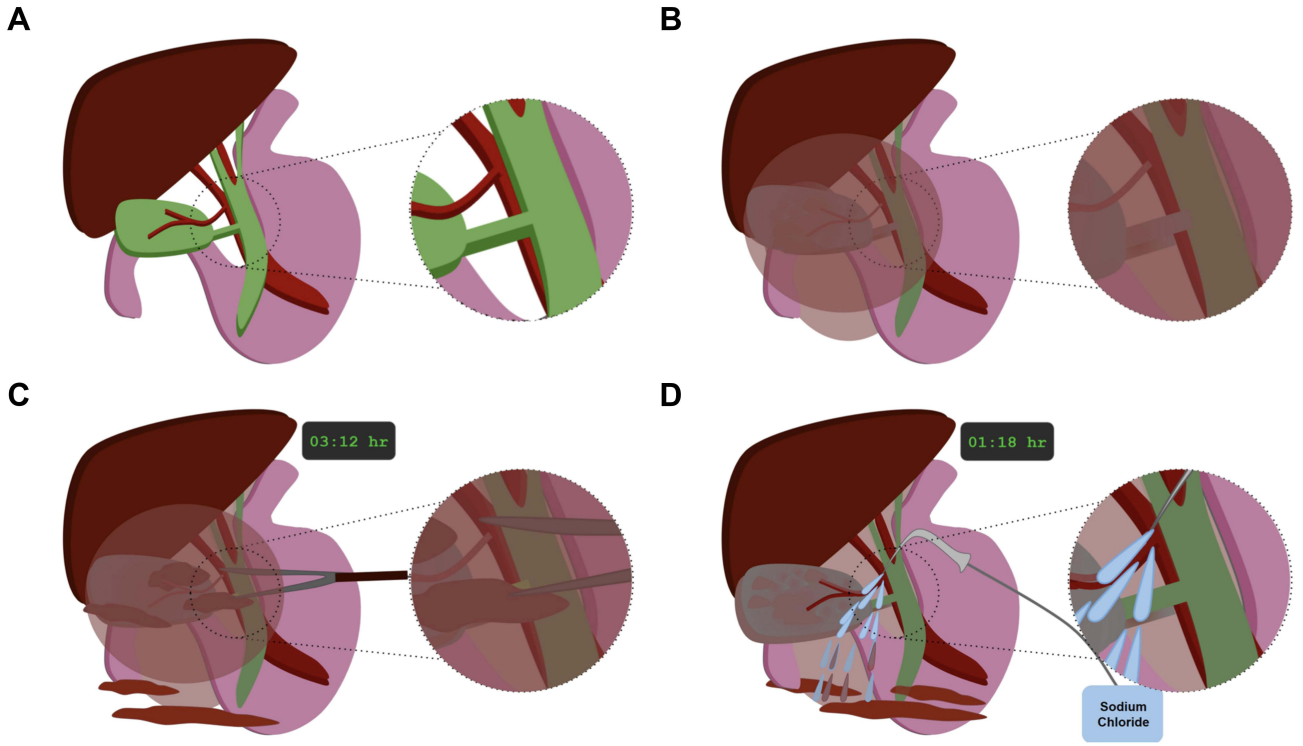

Figure 1 Examining cholecystectomy techniques. (**A**) Non-gangrenous gallbladder. Illustration of the critical view of safety, with the cystic artery and duct serving as anatomical landmarks. (**B**) Gangrenous gallbladder. Depiction of an obscured surgical field and critical view of safety due to an inflammatory and hemorrhagic landscape. (**C**) Cholecystectomy of a gangrenous gallbladder with blunt dissection. Blunt dissection of a gangrenous gallbladder, with an obsurced critical view of safety, using Maryland laparoscopic forceps for dissection. The digital clock details the average operating time using blunt dissection. (**D**) Cholecystectomy of a gangrenous gallbladder using hydrodissection. Cholecystectomy performed with hydrodissection, where saline is used to clean the debris and reveal the critical view of safety. The digital clock indicates a decreased operating time for hydrodissection when compared to blunt dissection.

HD involves the use of a modified, FDA-approved laparoscopic irrigation tool that releases jet-streams of normal saline at a predetermined pressure ranging from 14.5 to 1160 psi.[6] These pressures are strong enough to remove the necrotic and inflamed tissue without disrupting the collagen matrix, thus enabling the dissection of the cystic duct, cystic artery, and GB from surrounding organs including the liver, omentum, stomach, and intestine (Figure 1).

For this procedure, the Stryker irrigation system was incorporated during a standard laparoscopic surgery to remove the GB, dissecting the proximal one-third of the GB and Calot's Triangle from the liver and the adjacent structures. In the irrigation system, the catheter terminal tip was occluded, thus generating higher pressures (150 to 200 psi) of jetstream through the unoccluded side-holes.

HD is able to clean the highly vascular and purulent surgical field, thus improving visualization of the GB. This allows for exposure of the critical view of safety which helps prevent complications such as bile duct injury and deep-seated infections, and improves surgical measures (ie, conversion to open procedure, operating time, anesthesia time, hospital stay, and the number of complications associated with long surgeries) irrespective of body mass index and other comorbidities.

Evidence Supporting the Use of Hydrodissection

In our submitted data of 386 patients collected between 2018 and 2020, 24 patients were reported to have gangrenous GBs during the procedure. Patients were age and sex matched to create a control group. Using Mann–Whitney U testing and chi-square testing, we observed a statistically significant reduction in operating time and length of stay (LOS) with HD when compared to the standard technique. Other parameters such as conversion to open procedures and 30-day readmissions were trending towards statistical significance. Two patients in the comparison group required conversions to open procedures and no patients in the study group required a conversion to open procedure. Incidentally, no patients required subtotal cholecystectomies or cholecystostomies.

Discussion

In 2002, a porcine study showed feasibility of the HD technique, but a subsequent human study failed to show efficacy in the routine, simple cholecystectomy.[4,5] The HD group had cleaner operating fields resulting in quicker and cleaner dissections.[4] However, the routine, simple cholecystectomy dealt with healthy tissue, which is difficult to separate with HD, therefore the study did not show a statistically significant decrease in operating time. This highlights that HD benefits a niche group of patients who have gangrenous GBs, as HD more easily dissects the weakened and inflamed tissue of gangrenous GBs than the strong connective tissue of non-gangrenous GBs.

However, other studies did show potential in the use of HD for laparoscopic cholecystectomies. In one study using HD during laparoscopic cholecystectomies, 55 patients were separated into different groups based on the level of surgical difficulty determined by the Cuschieri Scale.[7] Results demonstrated better visualization of the anatomy of all patients; however, some patients still necessitated sharp dissection to complete the procedure.[7] Another study of 133 patients utilizing HD for laparoscopic cholecystectomies studied the procedure for use during prograde and retrograde dissection to help with liver cirrhosis.[8] This study reported decreases in blood loss, decreases in the incidence of GB damage, and quicker dissection times.[8] These studies support the efficacy of HD to treat laparoscopic cholecystectomies and highlight the need to further modify the technology. This study is focused on the application of HD for gangrenous GBs which constitutes the most complicated GB surgery and 10% to 25% of all GB surgeries. This is a novel indication of HD that is not discussed or studied in the previous literature.

Impact on Clinical Care

Given the frequency of bile duct injuries, estimated at 2500 patients per year in cholecystectomies, there is considerable risk for complications such as anastomotic strictures (10% to 20%), increased bleeding (3.64%), and cholangitis.[3] Vascular damage to the hepatic arteries and portal vein, the surrounding inflammation, and the need to convert to open surgery (3.91%) further complicates patient care.[1,3] However, through the precise delivery of normal saline to the gangrenous area, HD can decrease the risk of such complications and improve patient care.

Hydrodissection Landscape in the Future

To further support our preliminary findings, we are currently enrolling patients for a multi-institutional study of 1500 to 2000 patients.

With regards to scaling the technique, the creation of standard, case-specific guidelines for optimal parameters (eg, angle, velocity, and force) for the delivery of normal saline may prove to be a laborious process. Additionally, the cost of HD equipment, lack of reimbursement, and the training of multiple providers may limit widespread adoption of the HD technique.

Further, in under-resourced areas, acquisition of HD equipment may be delayed. However, with the routine application of the HD technique in ophthalmology (eg, cataract surgery) and physical medicine, incorporating HD into laparoscopic procedures is a realizable initiative. Additionally, with a more user-friendly device underway, awaiting FDA clearance, adoption of HD will be enhanced.

Given the poor outcomes and the complexity of gangrenous GB surgeries, HD is poised to become the mainstay technique in cholecystectomies treating gangrenous GBs.

Statement of Informed Consent

Deidentified data was used; no consent was necessary.

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Disclosure

Shahini Ananth and Kayla K Umemoto are co-first authors for this study. Dr. Dinesh Vyas discloses that he is CEO and President MV Surgical LLC, MV Surgical Medical Technologies Inc., MV Surgical Medical Devices Inc. and Stocks in

BlackSwan Inc. Additionally, he is an editor for *International Journal of General Medicine*. The authors report no other conflicts of interest in this work.

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