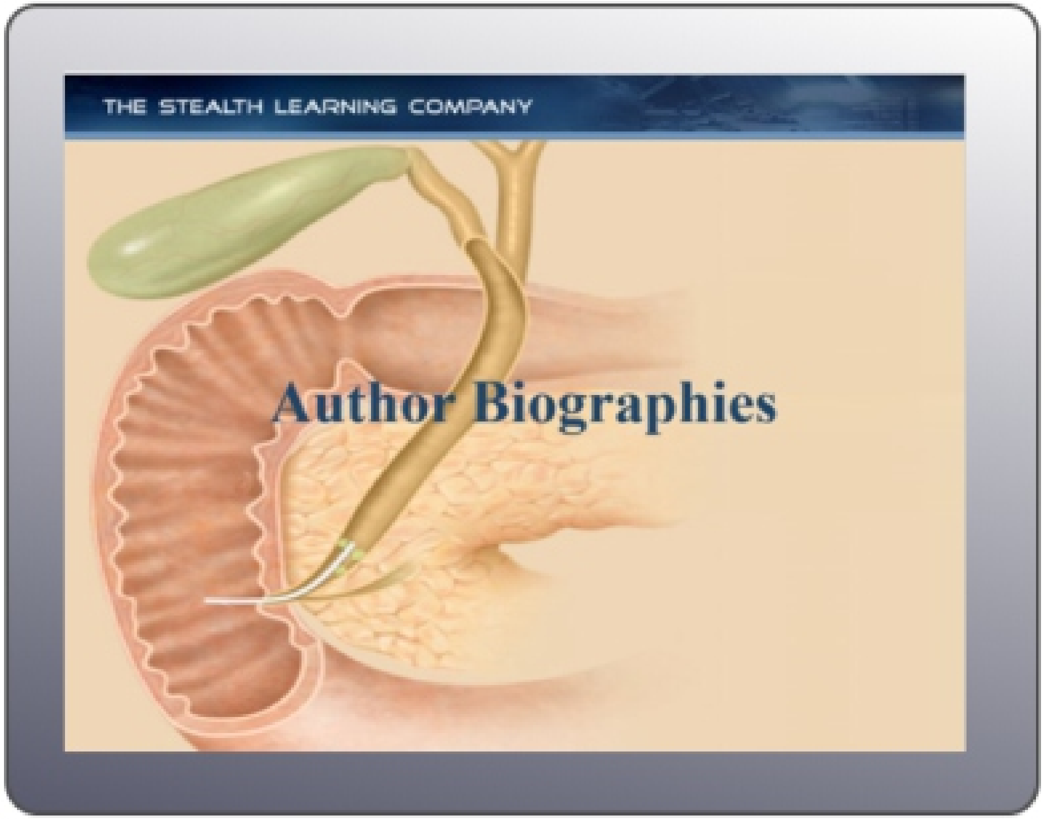
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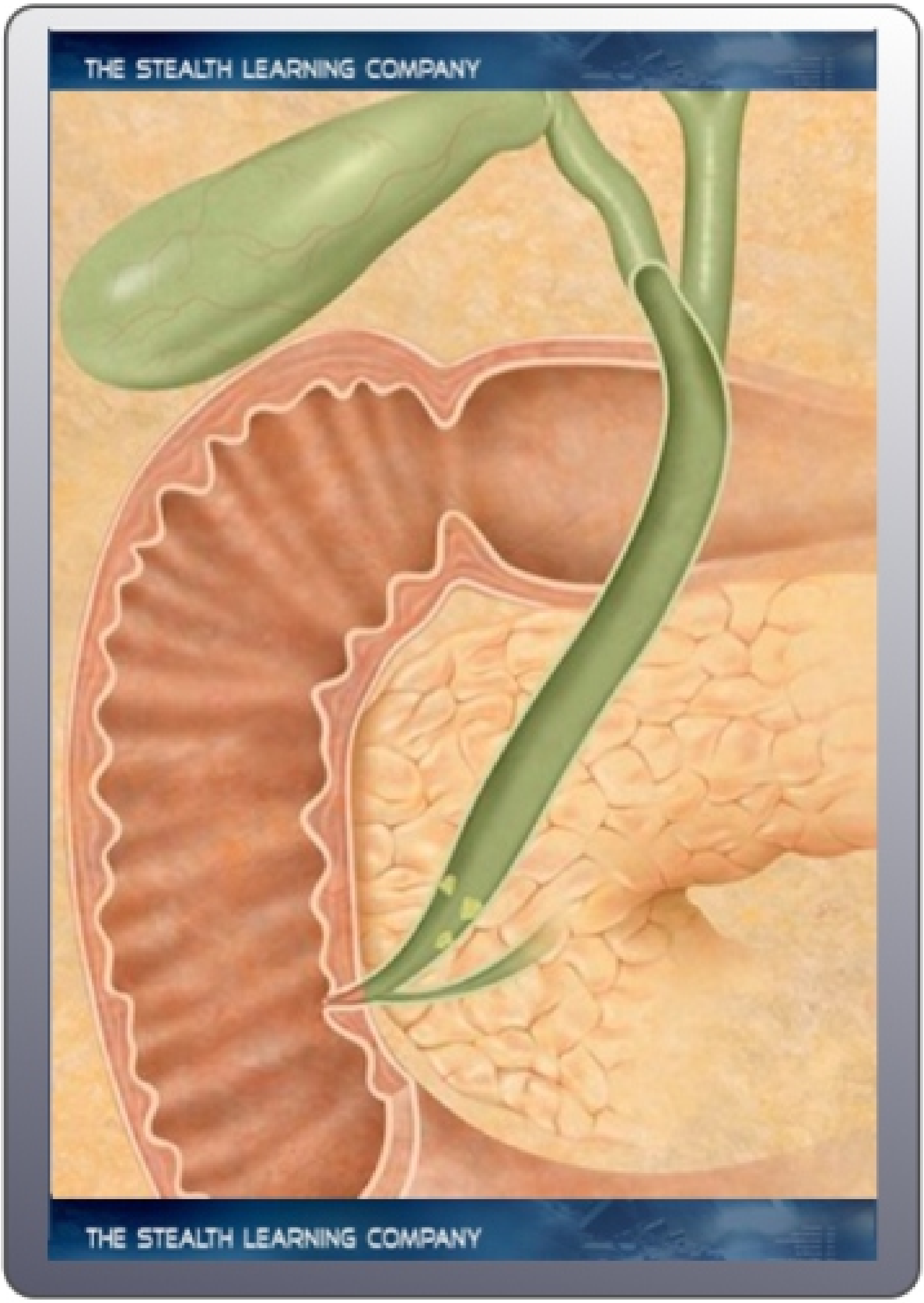
Author Biographies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CHAPTER 1

Author Biographies

James "Butch" Rosser, MD FACS
Editor in Chief/Co-Author
Clinical Professor of Surgery
University of Central Florida
School of Medicine
University of Buffalo
School of Medicine
CEO of Stealth Learning
Company

James C. "Butch" Rosser, Jr. MD FACS is a surgeon, educator, scientist, inventor, author, futurist, social advocate, television personality, playwright, video gamer, comic book collector, lover of cinema, and self-proclaimed terminal twelve-year-old. Dr. Rosser has described himself as the nexus where that which you think is frivolous meets that which you hold on high ground. He has given more than 350 invited lectures around the world, written over 60 peer reviewed articles, 16 chapters in books currently in print, and 11 digital books. Dr. Rosser has held academic appointments previously at Yale University School of Medicine, Albert Einstein College of Medicine and at the Morehouse School of Medicine. He is currently Clinical Professor of Surgery at the University of Central Florida and University of Buffalo Schools of Medicine. He is practicing general surgeon and Director of the Center for the Advanced Treatment of Heartburn at Grant Regional Health Center in Lancaster, Wisconsin.

Dr. Rosser has always projected a strong contribution in learning and training. He is author of the book, Playin' to Win: A Scientist, Surgeon and Parent Examines the Upside of Video Games. It has been heralded by Dr. Rod Paige, past US Secretary of Education as the bible of the Second American Revolution, an education revolution. His latest writing on the subject is scheduled to be published and is called Surgery, Drones, Planes and Video Games Enhancing STEM Education: The Birth of Stealth Learning. Poised to set a new bar for learning pedagogy revealing a formula for faster knowledge and skill transfer using pop culture icons like video games. He campaigns his brain-based learning techniques as the CEO of the Stealth Learning Company. Clients include GE, Starbucks, the Military, and many others.

Dr. Rosser has matured a very broad media profile. Over ten documentaries have been done on his projects on the Learning Channel and Discovery Channel, and he has been routinely featured on CNN, CBS, Fox and all the major networks. He has his own radio program on iHeart called "House Calls with Dr. Butch" and has been a regular on the Dr. Oz Show since 2010. In 2013, he garnered an Emmy nomination because of his contributions to the show. He has been called a "medical messenger" that translates complex technical and medicine issues simple for the public to understand.

Rosser has been on the cutting edge of telemedicine since the early nineties. In his capacity as the technical coordinator of the NASA/Yale Commercial Space Center, he executed many cutting edge telemedical applications. He designed and validated one of the first real time mobile telemedical delivery packages. He used that package to explore postoperative visits, wound care, and cardiology screenings among others. He was one of the early pioneers in telementoring and has guided surgical procedures from Mount Everest to the jungles of Ecuador to the Dominican Republic and many other locations around the world. He was honored as the keynote speaker for the 2012 American Telemedicine Association (ATA) conference and is the founding member of the ATA Telementoring Special Interest Group.

Dr. Rosser holds two patents and several products and appliances have been developed to his credit. He has received numerous recognitions and awards including keys to many cities, citations by several state legislatures, three Smithsonian awards for technical achievements in medicine, NAACP Living Legend Award in Medicine, and many others.

Eric S. Hungness, MD FACS
Co-Author

Professor of Surgery and Med/Ed North western U Feinberg School of Medicine. Stulberg Professor of Adv. Surgical Ed.

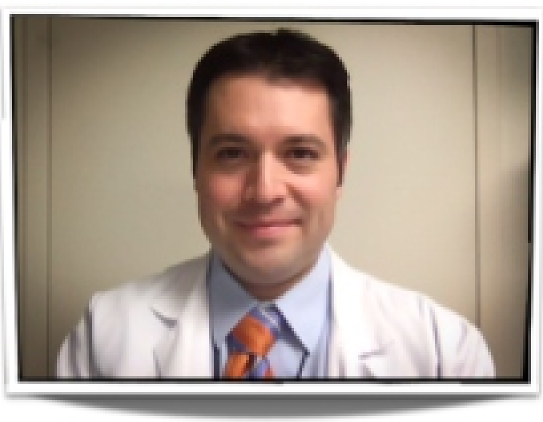
He is focusing on minimally invasive surgical skills acquisition and surgical innovation. His research team has contributed extensively on teaching laparoscopic common bile duct exploration to surgical residents and surgeons-in-practice through a simulation-based mastery learning curriculum.

Ezra Teitelbaum, MD MED
Co-Author

Assistant Professor of Surgery and Medical Education at Northwestern University in Chicago, Illinois.

Dr. Teitelbaum is a general and bariatric surgeon who completed medical school at the Mount Sinai School of Medicine and general surgery residency at Northwestern University, and received a master's degree in education from the University of Cincinnati. He completed a minimally invasive foregut surgery fellowship at Providence Portland Medical Center, with Drs. Lee Swanstrom and Steven DeMeester. His academic focus is on surgical education, specifically the development and implementation of simulator-based mastery learning curricula and the use of operative video review as a teaching and learning tool. He was involved in the development of a simulator-based curriculum for laparoscopic common bile duct exploration (LCBDE) at Northwestern and has taught LCBDE at multiple hands-on skills courses at surgical conferences including the American College of Surgeons Clinical Congress and the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) Annual Meeting.

B. Fernando Santos, MD
Co-Author



Assistant Professor of Surgery in the Department of Surgery, Dartmouth-Hitchcock Medical Center, Lebanon, NH.

B. Fernando Santos, MD is a staff surgeon at the VA Medical Center in White River Junction, VT. He completed a fellowship in Minimally Invasive Surgery at Dartmouth-Hitchcock Medical Center in 2014, after completing his General Surgery Residency at Northwestern University in Chicago. During residency, he spent two years in the research lab under the mentorship of Drs. Eric S. Hungness and Nathaniel J. Soper, MD. One of his original projects in the lab was to develop the initial prototype Northwestern laparoscopic common bile duct exploration simulator and rating scale for use in surgical education. He remains involved in the continuing development of the simulator and its use in various educational initiatives such as teaching courses for LCBDE at national meetings. He has authored several book chapters on LCBDE including recent chapters in Current Surgical Therapy, and the SAGES Manual series, and along with Dr. Nathaniel Soper has edited a volume entitled "Choledocholithiasis: Comprehensive Surgical Management." He is an active member of the Society of American Gastrointestinal & Endoscopic Surgeons (SAGES) and serves on the Safe Cholecystectomy Task Force.

Richard Vazquez, MD FACS
Co-Author

Assistant Clinical Professor of Surgery Emeritus at the Fein berg School of Medicine of Northwestern University.

Dr. Vazquez is a general surgeon and serial entrepreneur. He practiced general surgery at Northwestern Memorial Hospital in Chicago, Illinois for 38 years.

Dr. Vazquez is the creator of the SafeStart surgical safety and efficiency and software mobile application suite and is the CMO/CEO/founder of SafeStart Medical, Inc.

He frequently speaks on surgical safety. He holds certifications by the ARDMS (RVT, RPVI) for vascular ultrasound. He is a member at MATTER Chicago HIT incubator. He acted as the Director of Medical Affairs at Soft Tissue Sciences/PSD (PolyPro® Hydrocoat Hernia Mesh). Dr. Vazquez sits on the advisory boards of several HIT startups including TapCloud, LLC, Mondopoint, LLC. He is currently the Director of Innovation and Entrepreneurship, Medical Informatics at Northwestern University Feinberg School of Medicine.

Dr. Vazquez currently sits on the Safety/Quality/Outcomes Committee and Safe Cholecystectomy task force of Sages (Society of American Gastrointestinal and Endoscopic Surgeons) and is a member of ASHRM, the American Society of Professionals in Patient Safety, Institute for Healthcare Improvement, and National Quality Forum.

Ben Schwab, MD
Co-Author

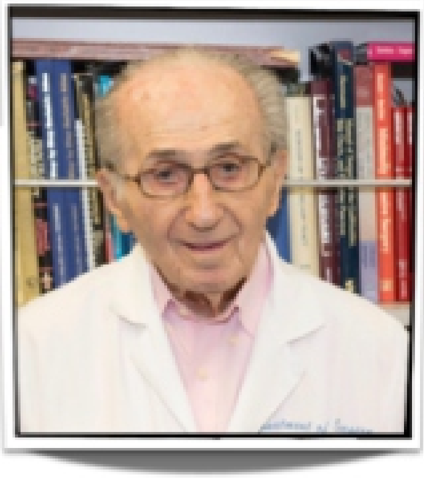
Chief Resident
General Surgery
Northwestern Memorial Hospital
Northwestern University
Chicago, Illinois.

Dr. Schwab obtained his Bachelor of Science in Biology from the University of North Dakota in Grand Forks, ND. After graduation, he joined the United States Peace Corps and was sent to work in the West African nation of Ghana. During his two years in Ghana, he spent time teaching high school students in various topic areas including biology, chemistry and mathematics. He also was active in the area of health education and was the primary organizer for an annual HIV/AIDS prevention bike ride that travelled to numerous rural communities providing education regarding HIV/AIDS.

After returning to the United States, Dr. Schwab earned his Doctorate of Chiropractic from the Palmer College of Chiropractic - West in San Jose, CA, where he graduated as the class valedictorian and earned numerous other awards including the Dean's Award and the Clinical Excellence Award. After graduation, he attended medical school at the State University of New York Downstate Medical Center in Brooklyn, NY. During his time at Downstate, Dr. Schwab participated in research in the field of traumatic brain injury and was active in a free student-run clinic in an underserved neighborhood of Brooklyn. He graduated with numerous academic honors, including the Class of 1998 Prize awarded to the class valedictorian and was nominated as a junior member of the Alpha Omega Alpha (AOA) Honor Medical Society.

Dr. Schwab is currently completing his general surgery residency at Northwestern Memorial Hospital in Chicago, IL. In addition to his clinical responsibilities, he has been active in research in the fields of surgical simulation and education in addition to clinical outcomes research in the area of laparoscopic common bile duct exploration. After graduation from residency, Dr. Schwab is planning to pursue additional fellowship training in the field of advanced gastrointestinal and minimally invasive surgery.

George Berci, MD FACS FRS Ed (Hon)
Co-Author



Prof. Chair in Surgery of Cedars Sinai Medical Center
Clinical Professor of Surgery of UCLA and USC
Director of Surgical En doscopy and Surgical Research At Cedars of Lebanon Hospital

In war ravaged communist-controlled Hungary, Dr. Berci went to Medical School, did a surgical residency, wrote his first research papers and escaped during the 1956 Hungarian revolution to Melbourne, Australia. In Melbourne, he had an outstanding academic surgical career. He then came to the United States and performed a 1-year fellowship at the University of Seattle, and in 1970 then accepted the position of Director of Surgical Endoscopy and Surgical Research at Cedars of Lebanon Hospital and later CSMC under the chairmanship and mentorship of the great Leon Morgenstern. He was named Clinical Professor of Surgery at UCLA and later at USC (when he said he thought the word Emeritus looked a lot like dead!)

Dr. Berci has received many awards and recognitions. Some are listed below:

- The Glissan Prize (Australia), SAGES named their lifetime achievement award for him.
- The American College of Surgeons gave him their prestigious Jacobson Innovation Award.
- Karl Storz Endoscopy Endowed a Chair in Surgery in his Honor
- He was given an honorary PhD in Hungary: Doctor Honoris Cause Semmelweis Univ Hungary
- In 2017, Cedars-Sinai Medical Center gave him their Lifetime Achievement Award
- Delivered hundreds of lectures nationally and in more than 20 countries
- Published 12 books, 61 Chapters and produced 238 publications in peer reviewed journals
- Still works full time in teaching and research.

Robert D. Fanelli, MD, MHA, FACS, FASGE
Co-Author

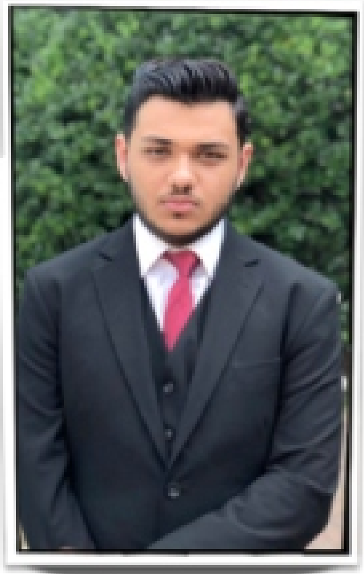
Chief, Minimally Invasive Surgery,
Chief, Surgical Endoscopy,
The Guthrie Clinic.

He is an American surgeon specializing in Minimally Invasive General Surgery and Therapeutic GI and Biliopancreatic Endoscopy. Dr. Fanelli serves as the Chief of Minimally Invasive Surgery and Chief of Surgical Endoscopy for The Guthrie Clinic, a five hospital Integrated Delivery Network with 1,000 providers throughout Northeastern Pennsylvania and the Southern Tier of New York. Based in Sayre, PA, Fanelli is a core faculty member for the Guthrie / Robert Packer Hospital Residency Program in General Surgery, chairs the Clinical Competency Committee for the residency, and is the inaugural Chair of the Guthrie Minimally Invasive Surgery and Therapeutic Endoscopy Fellowship planned for launch. Dr. Fanelli is a Clinical Professor in Surgery at the Geisinger Commonwealth School of Medicine, for which Guthrie serves as a major clinical campus, and at the Albany Medical College. Formerly, he was a Clinical Professor in Surgery at the SUNY Upstate Medical University. During his twenty-year tenure as Director of Surgical Endoscopy at Berkshire Medical Center, he built the area's first skills and simulation lab, and served as Instructor, Assistant Professor, and Associate Professor in Surgery at the University of Massachusetts Medical School. Dr. Fanelli was volunteer faculty in Pre-Medical Studies at Williams College, and now serves as clinical preceptor and project group leader for graduate students in the Meinig School of Biomedical Engineering at Cornell University.

Dr. Fanelli completed general surgery training in the Michigan State University Integrated Residency Program in 1991. He then completed an Advanced Surgical Endoscopy fellowship with Dr. Jeffrey Ponsky at the Mount Sinai Medical Center / Case Western Reserve University in 1992, specifically seeking to add ERCP to his broad endoscopic skill set. In preparation for his current role developing a mixed-specialty therapeutic endoscopy team, he completed additional fellowship training in 2012 in EUS through the Division of Gastroenterology and Hepatology at Strong Memorial Hospital / University of Rochester. He holds dual appointments in surgery and gastroenterology at The Guthrie Clinic. His practice is focused on foregut, colorectal, biliary, and hernia surgery, and he performs basic and advanced endoscopy with an emphasis on ERCP and EUS.

Dr. Fanelli is a Director for the American Board of Surgery where he serves on the General Surgery Residency Committee, the Certifying Examination Committee, the Chairs Committee, the Gastrointestinal Surgery Advisory Council, and is Chair of the General Surgery Advisory Council. He is a Director for the Society of American Gastrointestinal and Endoscopic Surgeons, has served as a member and has chaired numerous SAGES committees, was the 2016 Annual Meeting Program Chair, and currently serves as Chair for the SAGES Program Committee. Dr. Fanelli is most recognized at SAGES for his work in Guidelines, for helping to launch the Safety in Cholecystectomy Task Force, and for working toward integrating efforts with other professional societies on key initiatives. He is active also in the American College of Surgeons, The American Society for Gastrointestinal Endoscopy, and several other professional societies. Dr. Fanelli has produced more than 400 book chapters, manuscripts, oral and poster presentations, and has served as faculty in numerous wet and dry lab instructional courses. Dr. Fanelli has had a lifelong interest in medical technology and product development. He is a serial entrepreneur who has been a founding member of three successful startups, a consultant for technology firms and investment banks, and has developed numerous devices used in clinical medicine, including the Fanelli Cholangiography Catheter Set, and the Fanelli Laparoscopic Endobiliary Stent Kit.

Harris Alam
Programmer



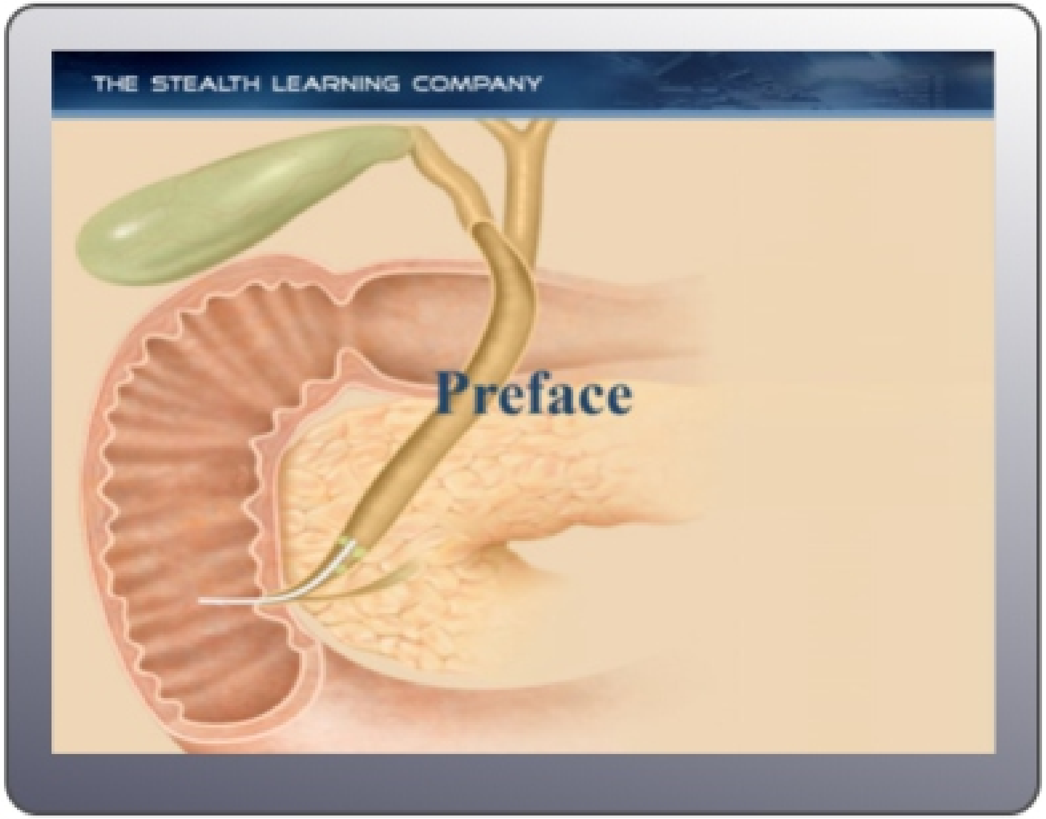
BS Candidate
University of Central
Florida

Harris is currently a student at the University of Central Florida pursuing his undergraduate degree and hoping to graduate with a Bachelor's of Science in Biomedical Sciences. He was born and raised in Kissimmee, Florida. Harris has spent most of his adolescence involved in medical activities frequently, volunteering at Celebration Hospital and accompanying Dr. Rosser on various other projects. He was the high school representative for SAGES 2017 (Society of American Gastrointestinal and Endoscopic Surgeons). Harris also helps to run and host Top Gun Surgeons and Mini Med School at SAGES and SLS (Society of Laparoscopic Surgeons). Most recently, he has helped to develop an engaging curriculum that incorporates stealth learning with common core standards, helping to develop the DroneSTEM program in Cape May, New Jersey. Harris hopes to attend medical school in the next few years and eventually take on a surgical residency following the footsteps of the other authors.

Jenaya Goldwag, MD
Editor

Surgical Resident
Dartmouth Hitchcock
Medical Center

Dr. Goldwag grew up in Santa Cruz, California and moved to Connecticut in high school where she also did her undergraduate training at the University of Connecticut. Her curiosity about the human body developed during college when, as a dual degree student in both art and biology, she had her first exposure to human anatomy. In her first painting class she was taught the basic muscles of the leg in order to ensure her figure painting's proportions and contours were correct and believable. Ever since then, Dr. Goldwag became more interested in anatomy and how beautifully the human body is designed. This ultimately led her to pursue a career in surgery because it allowed her to use her hands to help to fix diseases of anatomy. She earned her MD at the University of Connecticut School of medicine and now is a second-year surgical resident at Dartmouth Hitchcock.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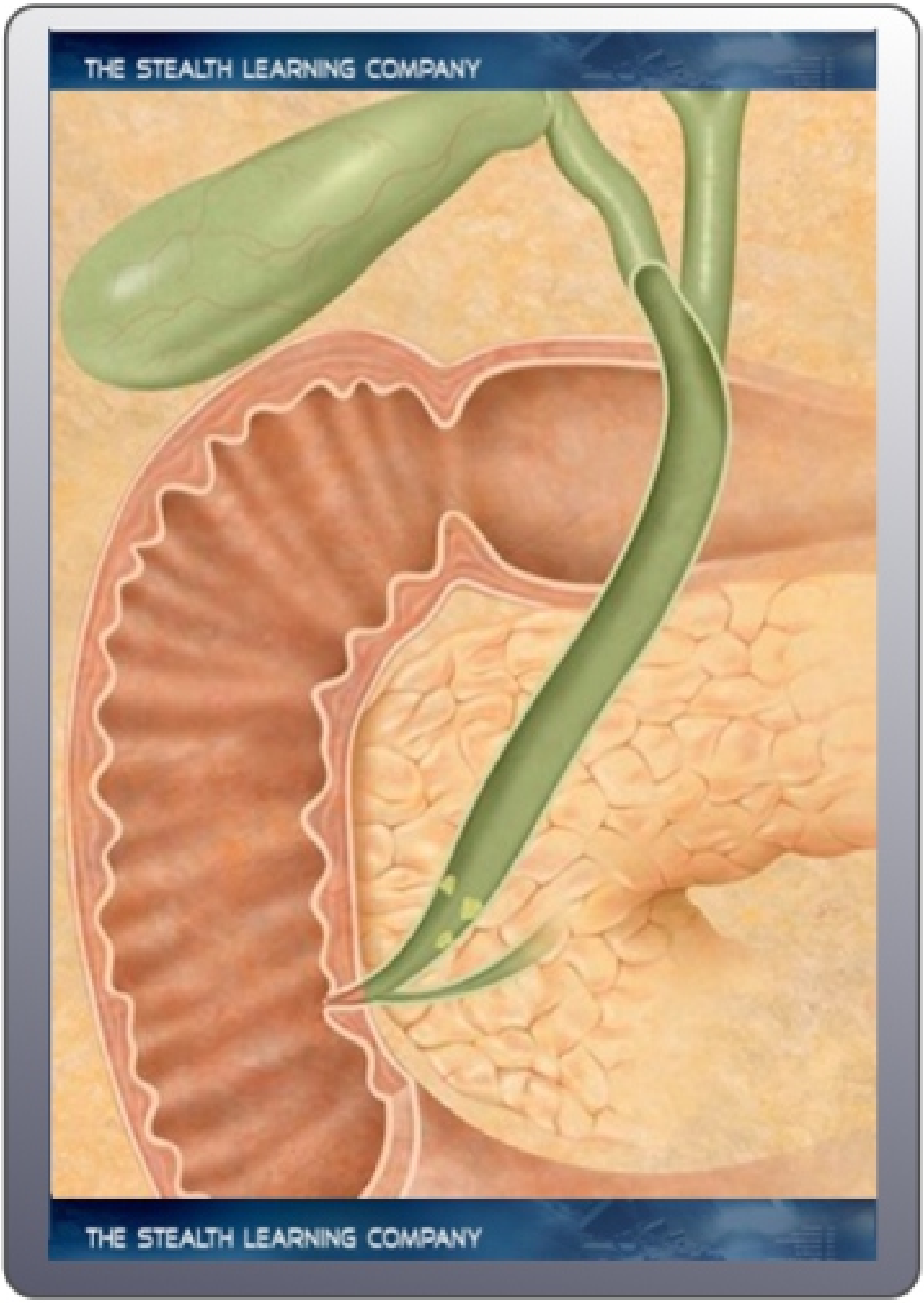
Preface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CHAPTER 2

Preface

The continuous grind of lifelong learning and skill acquisition for physicians is a never-ending process. A process that is made more difficult because of the negative return on these efforts secondary to current stress of productivity, decreased reimbursement and malpractice concerns. It presents a very disturbing dilemma for today's minimally invasive surgeon. Unfortunately, the first question about new procedure adoption is often not about the appropriateness of the procedure, patient benefit or even financial cost effectiveness. A prime example of this dilemma is Transcystic Laparoscopic Common Bile Duct Exploration (TLCBDE). By all objective consideration, this procedure should have widespread competent availability to the public. However, its current lack of adoption escapes rational explanation. When the literature is considered, there is no question that in skilled hands, it is a procedure that has a risk/cost/benefit ratio clearly in the favor of the patient and any healthcare system. However, the acquisition and implementation of TLCBDE expertise at the local level has not been accomplished.

Biliary Tract

Northwestern LCBDE Simulator

There are several barriers that provide inertia for any empowerment efforts. First, there is a misconception that this procedure

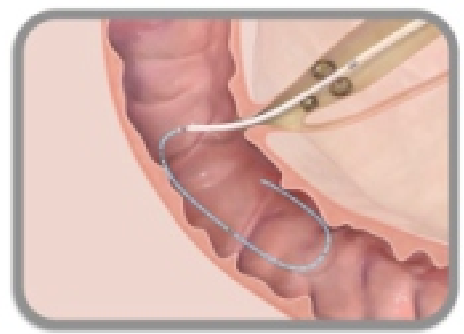
Dr. Berci with Personal Shielding

has one of the steepest skill and dexterity curves of any minimally invasive procedure. This is not true. There are sophisticated maneuvers that are executed with proprietary equipment, but this is well within the capability of the average competent minimally invasive surgeon.

To address these challenges to adoption, a training system that transfers and objectively evaluates the successful establishment of the knowledge and skill for TLCBDE is needed. Please note that I specifically stated a system is needed. No one training asset by itself will move the needle on adoption. This training asset is just one element of a multi-component system that effectively establishes competence and expands it to scale. It is based on the validated training program developed by Eric Hungness, MD and his team at Northwestern University School of Medicine. This iBook presents content in a multimedia, immersive, and interactive environment that addresses cognitive procedural requirements for TLCBDE. It provides consistent presentation of relevant content anytime, anywhere. It teams with the Northwestern standardized TLCBDE technique, validated laboratory practical using the Northwestern TLCBDE simulator executed with the Top Gun training method, and the STEALTH Telementoring System (STS) to offer an innovative training effort. As you will see, now is the time to increase adoption for Transcystic Laparoscopic Common Bile Duct Exploration and this iBook is the guide for a complete cutting-edge training system.

I would like to thank all the authors, programmers, and editors who participated in this project. Also, I would like to thank Cook Medical for their continuous efforts to assist surgeons in the pursuit of widespread adoption of this procedure. Special thanks to Wayne Radford, who was my wingman throughout this effort and his encouragement and assistance helped me to not let this project die. In closing, I would like to thank my lovely wife Dana and my five children Kevin, Duane, Nicole, Tianna and Taylor for understanding and sacrificing their personal time with me so I could contribute to helping patients stricken with common bile duct stones.

LCBDE Image Showing Guidewire Being Used



James "Butch" Rosser, MD FACS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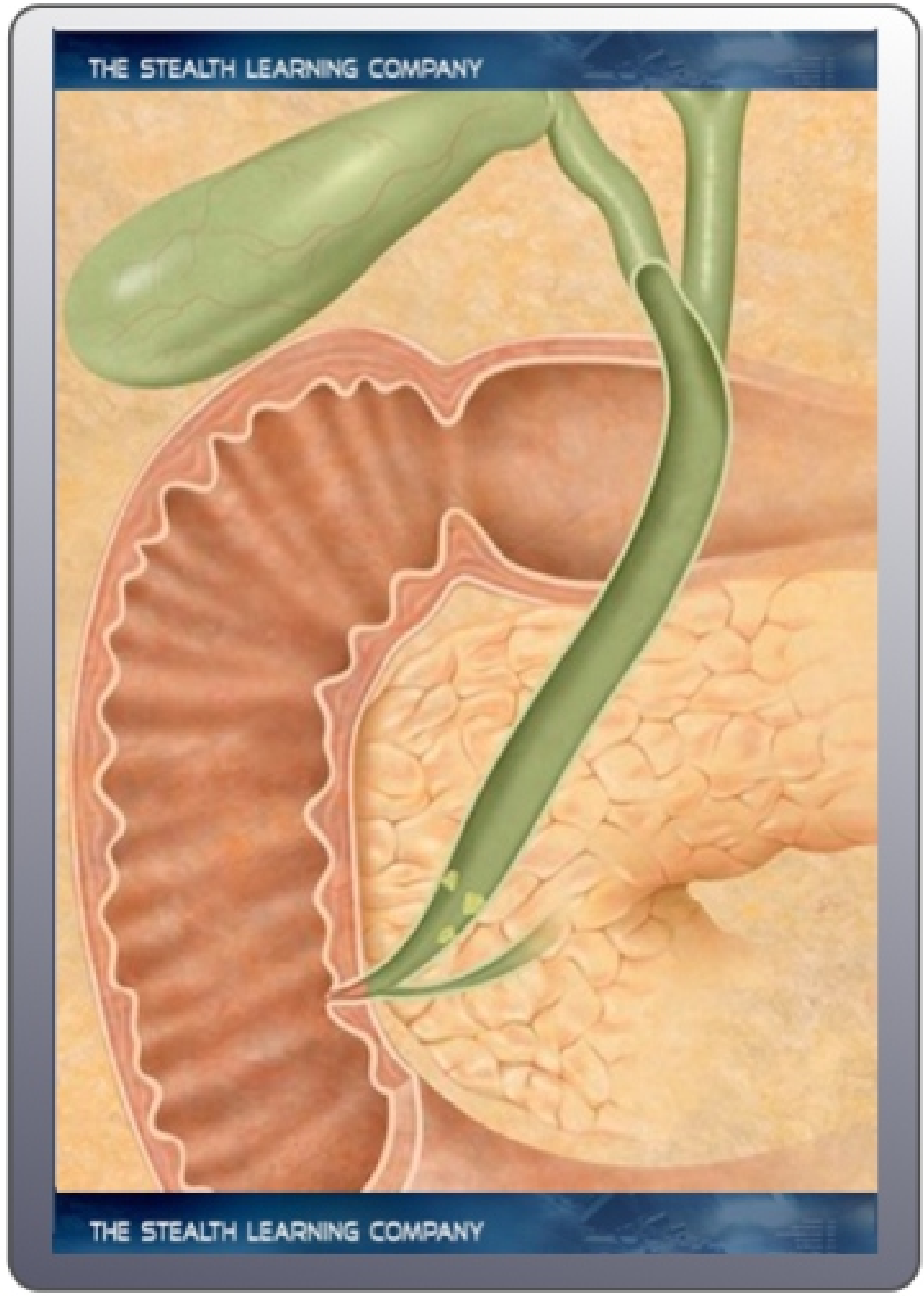
Why Start Now?
Eric S. Hungness, MD FACS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CHAPTER 3

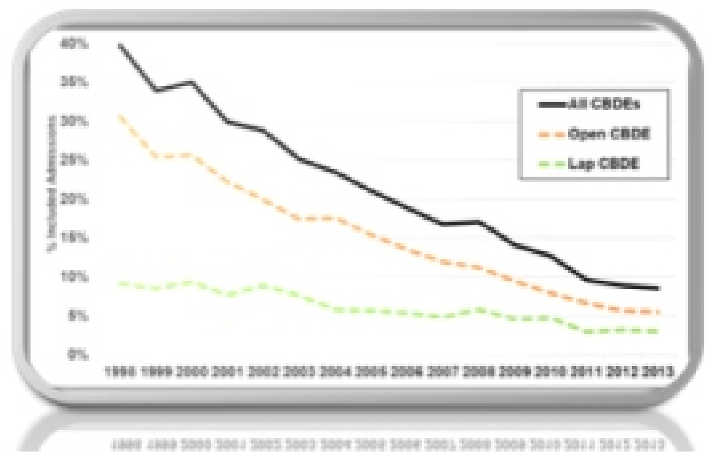
Why Start Now?

For many years surgeons have had the capability to perform laparoscopic common bile duct exploration. Equipment and techniques, particularly for the transcystic approach, have been on the scene for over 20 years. Why did the approach not ascend to mainstream then, and why is the time for widespread adoption now?

Introduction

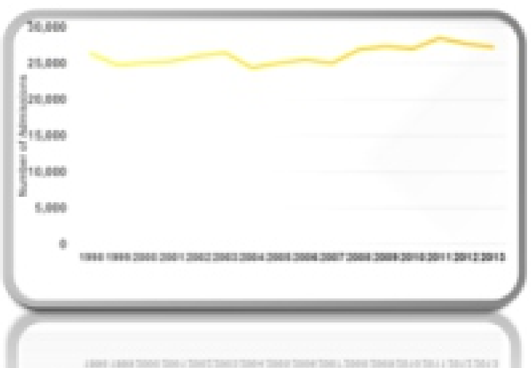
Welcome to this iBook covering transcystic laparoscopic common bile exploration (TLCBDE). I would like to share with you the rationale on why the time is right for surgeons to employ this established straightforward procedure in the care of their patients. Choledocholithiasis remains a quite common disease process that most general surgeons face between 10-18% of the time when performing cholecystectomy. It can lead to significant morbidity for patients including jaundice, pain, cholangitis, pancreatitis, and liver failure. Prior to laparoscopy, patients had open cholecystectomies, and most common bile duct stones were able to be removed with choledochotomy and T-tube placement. In the age of laparoscopy, common bile duct stones can be removed either laparoscopically or endoscopically with Endoscopic Retrograde Cholangiopancreatography (ERCP). A recent study from our group demonstrated that the annual admissions have remained steady over the past several decades at approximately 25,000 cases per year. Despite this, the number of surgical bile duct explorations continues to decline, with

Trends in CBD Exploration



currently less than 10% of stones being removed surgically and less than 5% laparoscopically. ERCP is the most common way bile duct stones are removed either pre or post laparoscopic cholecystectomy. This is despite the fact that although ERCP has good success when performed by well-trained gastroenterologists, ERCP adds an additional procedure requiring anesthesia. This can carry a risk of serious morbidity, which has been reported in up to 15% of all cases. Post ERCP pancreatitis, perforation, hemorrhage, and cardiovascular complications can happen leading to mortality rates of up to 1%. Also, many ERCPs have been determined to be unnecessary.

Annual Nationwide Admissions



Furthermore, there are numerous well-designed studies that demonstrate similar stone clearance, similar morbidity and mortality, shorter length of stay, and decreased number of procedures for laparoscopic common bile duct exploration compared with ERCP. Laparoscopic common bile duct exploration is a single stage treatment performed at the time of cholecystectomy which makes it more cost effective. Dr. Teitelbaum's chapter, Chapter 4 (A Great Clinical Tract Record), will discuss this in more detail. There is also data to show that the laparoscopic approach is better than the open approach. This recently published prospective randomized trial of over 250 patients showed similar success rates of duct clearance of over 94%. The laparoscopic approach however was associated with reduced estimated blood loss and length of stay. The overall morbidity trended toward significant and the OR times were similar. This has led to an official SAGES publication which concluded that "transcystic laparoscopic common bile duct exploration is a safe procedure and that should be within the realm of most general surgeons who frequently perform cholecystectomy."

Barriers Real and Unreal

The question is how surgeons can learn how to do laparoscopic common bile duct exploration when training programs are graduating chief surgical residents that perform less than one laparoscopic common bile duct exploration on average throughout their residency. See one, do one, teach one is not an effective approach to overcome the barriers of adoption to this procedure. Dr. Ponsky emphasized in 2010 that we need to identify an effective means to train surgeons in the techniques of bile duct exploration. There is a perceived barrier for many surgeons who feel that laparoscopic common bile exploration is too difficult to learn, and may not be worth the effort. In reality, the transcystic approach to laparoscopic common bile duct exploration is a straightforward procedure that builds upon the skills of laparoscopy, endoscopy, and Seldinger technique that the vast majority of general surgeons possess. The approach can be very straight forward. After accessing the duct with a flexible wire, the cystic duct is dilated. Next, a choledochoscope can be passed into the duct to identify and capture the stone in the bile duct. After the stone or stones are extracted, a completion cholangiogram confirms duct clearance. Since the cystic duct has been dilated, clips often will not securely close the duct. Therefore, loop ligation is advocated. The recent availability of high definition digital imaging systems has also greatly improved visualization when performing choledochoscopy.

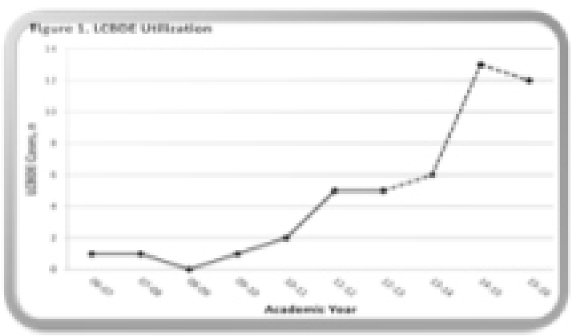
Northwestern LCBDE Simulator

The Training Solution

Based on this, a novel simulator and simulation-based *mastery* learning curriculum was developed and successfully implemented at Northwestern to teach senior residents laparoscopic common bile duct exploration.

This simulator is capable of showing laparoscopic and choledochoscopic views, as well as a simulated real-time fluoroscopy. The training curriculum is based on the premise that all surgeons can obtain proficiency in laparoscopic common bile duct exploration after adequate deliberate practice, coaching, and testing. This initiative has resulted in a significantly increased utilization of laparoscopic common bile duct exploration at Northwestern. Most graduating chief residents are now performing four to five cases throughout their training. We recently looked at the impact of this training at Northwestern. The use of laparoscopic common bile duct exploration at the time of cholecystectomy reduced the hospital cost at over $2,000 per case with a decreased length of stay from 4.3 to 2.5 days compared to when ERCP was used to clear the duct. Other centers have also formally incorporated laparoscopic common bile duct simulation into their training programs. Results show that residents and practicing surgeons benefit from the training with improvement in completion times and written test scores. Practicing surgeons also had higher comfort levels and incorporated laparoscopic common bile duct exploration into their clinical practice one year post training. It is also important for general surgeons to know that the extra time in the operating room is reasonably compensated for in terms of work RVUs (Relative value units). The addition of an intraoperative cholangiogram increases the work RVU from 10.5 to 11.5, while adding laparoscopic common bile duct exploration adds an additional 6.5 work RVUs.

Utilization of LCBDE at NMH



Conclusion

In summary, laparoscopic common bile duct exploration is a well-established procedure with good high-quality evidence supporting its safe, routine use. The transcystic approach is technically straightforward, and improved training can lead to higher adoption and increased value to patients, surgeons, and the healthcare community as a whole. I can confidently say that for laparoscopic common bile duct exploration, the time is now.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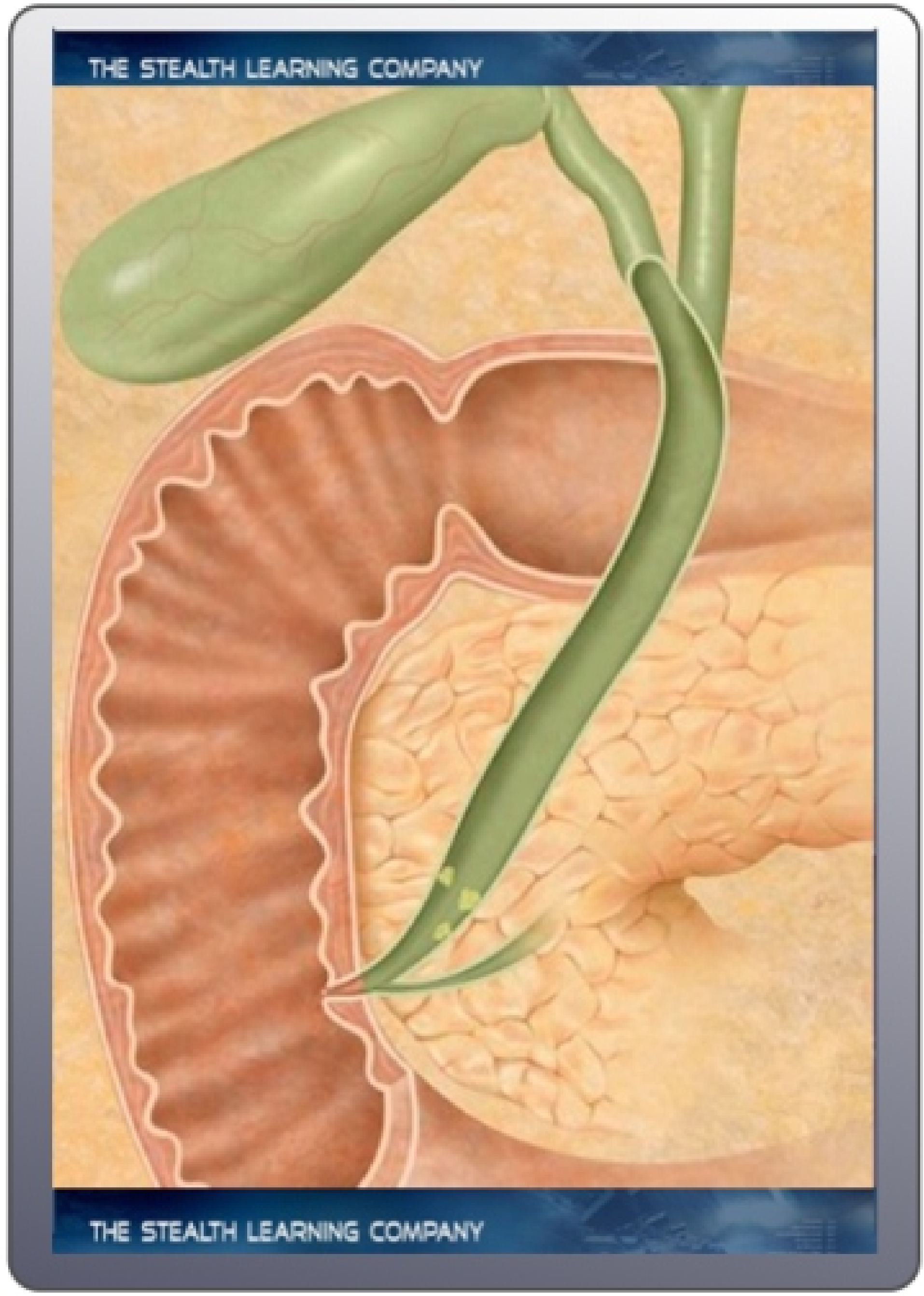
A Great Clinical Track Record
Ezra Teitelbaum, MD MED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CHAPTER 4

A Great Clinical Track Record

Introduction

Transcystic laparoscopic common bile duct exploration (TLCBDE) is a procedure with a great clinical track record. First, we will define some terms and give a brief background before delving into some of the data behind the use of TLCBDE. Choledocholithiasis is a common condition occurring in 3 to 18% of patients undergoing cholecystectomy for symptomatic gallstone disease. Common duct stones are extremely morbid in terms of both their symptom burden and sequela, which can include cholangitis and gallstone pancreatitis. In the open surgical era, most common duct stones were treated with a common bile duct exploration performed at the time of open cholecystectomy. This changed with the rapid adoption of laparoscopic cholecystectomy in the early 1990s. Surgeons in this era were concentrating on performing lap cholecystectomy safely and avoiding common bile duct injury. Treatment of common duct stones was largely relegated to a two-stage approach with ERCP used to clear the common duct, and lap cholecystectomy to prevent disease recurrence. Unfortunately, this underutilization persists today as only 3% of patients with choledocholithiasis are treated with laparoscopic common bile duct exploration (LCBDE).

LCBDE can be performed using one of two approaches. In the transcystic approach, instruments are inserted through the same cystic ductotomy that is used for the initial cholangiogram. In the transcholedochal approach, a longitudinal incision is made in the common duct itself in order to access the stones. A separate chapter in this iBook will discuss an algorithm choosing between these approaches based on patient-specific factors. This chapter will discuss the reported outcomes of TLCBDE, with a focus on comparisons between ERCP and a transcholedochal approach.

Operative Safety

There should be no mistake made that although it is performed in a minimally invasive fashion, TLCBDE is major surgery with the potential for serious perioperative morbidity.

Much of this is due to the fact that patients presenting with choledocholithiasis are often elderly and frail. They can display altered physiology as a result of their disease process. That being said, perioperative mortality is low with meta-analyses of randomized trials and an analysis of outcomes from the NSQIP database showing rates ranging from 0.3 to 0.8%. This is equivalent to the mortality of patients treated with a two-stage approach of ERCP and lap cholecystectomy.

Morbidity is not infrequent in these patients with a rate of approximately 14% for both LCBDE and ERCP in a meta-analysis of randomized trials and a Cochrane review. NSQIP, which only tracks a subset of serious complications, showed a morbidity rate of 4.5%. It should be noted that these meta-analyses and NSQIP outcomes do not distinguish between LCBDE performed via a transcystic or transcholedochal approach. While overall mortality and morbidity are likely similar, other studies have shown that biliary complications, such as bile leak, are more frequent with a transcholedochal approach, especially if a T-tube is used during closure of the choledochotomy.

Mortality vs. Morbidity

	Mortality (%)		Morbidity (%)	
	LCBDE	ERCP	LCBDE	ERCP
NSQIP data[1]	0.5	-	4.5	-
RCT meta-analysis[2]	0.3	0.9	13.9	14.6
Cochrane review[3]	0.8	1.2	15.6	12.9

Stone Clearance Efficacy

Success in clearing all stones from the common duct is high for LCBDE, with overall clearance rates of ap-

proximately 90%. A meta-analysis and Cochrane review both analyzing randomized trials found superior clearance rates with LCBDE than with ERCP. The meta-analysis by Singh and colleges showed a clearance rate of 88% for LCBDE and 82% for ERCP and the Cochrane review demonstrated 91% success for LCBDE and 86% for ERCP. A transcystic approach appears to be at least as effective, if not better, than a transcholedochal approach. A systemic review showed success rates rating 80 to 100% for a transcystic approach as opposed to 58 to 100% for a transcholedochal approach. However, it should be noted that in the majority of trials included in this analysis, the surgeon was free to choose between transcystic and transcholedochal approaches. Thus, it is likely that the patients who underwent a transcystic approach had fewer and smaller common duct stones.

Length of Stay and Cost

It has been clearly shown in multiple randomized trials that a single-stage approach to choledocholithiasis re-

sults in decreased hospital length of stay when compared with a two-stage approach using ERCP. This difference ranges between one and two days depending on the trial. In the Singh meta-analysis, LCBDE had a mean length of stay of 4.9 days

Length of Stay for Patients

LCBDE vs. ERCP	Length of Stay (days)	
	LCBDE	ERCP
RCT meta-analysis[2]	4.9*	6.5
NIS analysis[3]	3.0*	4.0

* LCBDE superior to ERCP with p-value < 0.05

TC vs. TCD LCBDE	Length of Stay (days)	
	TC-LCBDE	TCD-LCBDE
RCT systematic review[4]	1.2 – 5	2.6 - 11

compared with 6.5 for ERCP. An analysis of the national inpatient sample showed a length of stay of 3 days for LCBDE and 4 days for ERCP. Additionally, it appears that transcystic LCBDE results in shorter lengths of stay than a transcholedochal approach. A systemic review of randomized trials showed length of stay ranging from 1.2 to 5 days for patients undergoing a transcystic approach, as compared with 2.6 to 11 days for a transcholedochal approach. This difference is likely due to the fact that utilization of drains and T-tubes is typically not

Successful Stone Clearance Percentage

LCBDE vs. ERCP	Successful stone clearance (%)	
	LCBDE	ERCP
RCT meta-analysis[1]	88.1*	82.2
Cochrane review[2]	91.5*	86.6

* LCBDE superior to ERCP with p-value < 0.05

TC vs. TCD LCBDE	Successful stone clearance (%)	
	TC-LCBDE	TCD-LCBDE
RCT systematic review[3]	80 - 100	58 - 100

necessary with transcystic LCBDE. A limited number of studies have compared costs between treatment approaches to CBD stones, and it appears that LCBDE may accrue fewer total costs. This is likely due to a decreased length of stay and reduction in the number of procedures and anesthetics needed during the hospitalization. More data is needed with regards to cost-effectiveness to make an even stronger case for the utilization of LCBDE.

Summary

In summary, when the clinical algorithms and technical steps outlined in the subsequent chapters are followed, TLCBDE is a safe and effective procedure for treatment of choledocholithiasis. TLCBDE achieves stone clearance rates equal or superior to a two-stage approach utilizing ERCP. Additionally, TLCBDE results in shortened lengths of stay and lower hospital costs when compared with ERCP. Backed by level-1 data, TLCBDE is well positioned to be the treatment of choice for the majority of patients with common bile duct stones.


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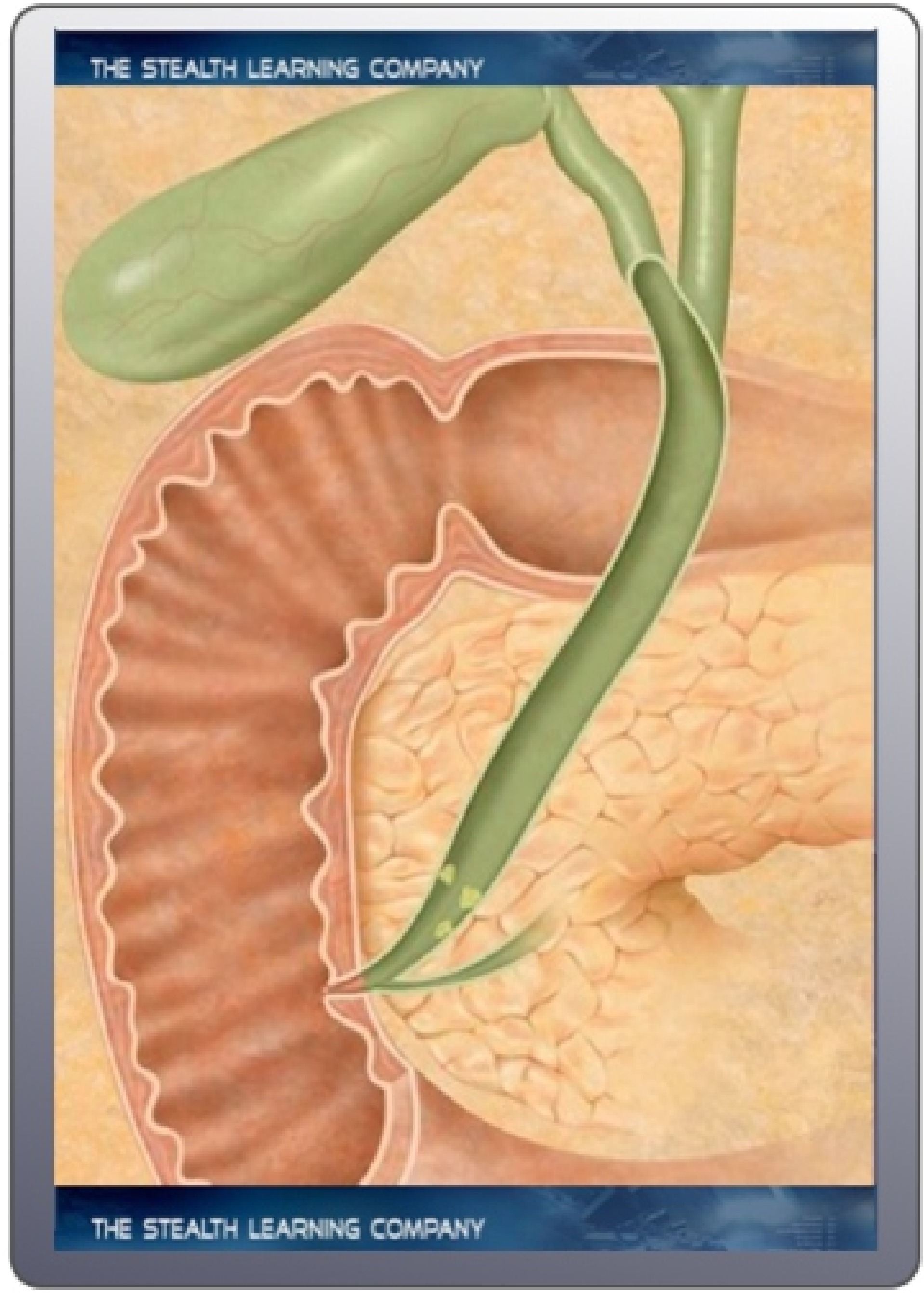
Instrument Size References
James "Butch" Rosser, MD FACS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Instrument Size References

Introduction

This section will feature charts that show the equipment sizes frequently used during cholangiography and TLCBDE. Once the surgeon has accessed the biliary tree with a guidewire, catheters, dilators, and scopes move along the wire into the common duct. It is important for the surgeon preparing for these procedures to understand the working channel sizes for each piece of equipment. For example, if a 9 French choledochoscope will be used, the surgeon needs to know that it will accept a 0.035-inch guidewire. The 0.035-inch wire is the standard in operating rooms because most central lines are used with this size.

Instrument Wire Guide Sizes

Diameter accepts (French)	Wire guides (inches)
4.0 French catheter	.021 or .025
5.0 French catheter	.035
5.0 French balloon catheter	.035
9.0 French choledochoscopes	.035
12.0 French (4 mm) introducers	.035

This chart shows the measurement relationships of inch, millimeter, French, and gauge. The diameter of needles is measured by gauge. Sheath and introducers are in millimeters. Guidewires are in inches or millimeters and catheters and choledochoscope are in French. It is helpful to note the relationship between millimeters and French. When you know the millimeter size, multiply it by 3 to get equivalent French sizes.

Measurement Comparison Chart

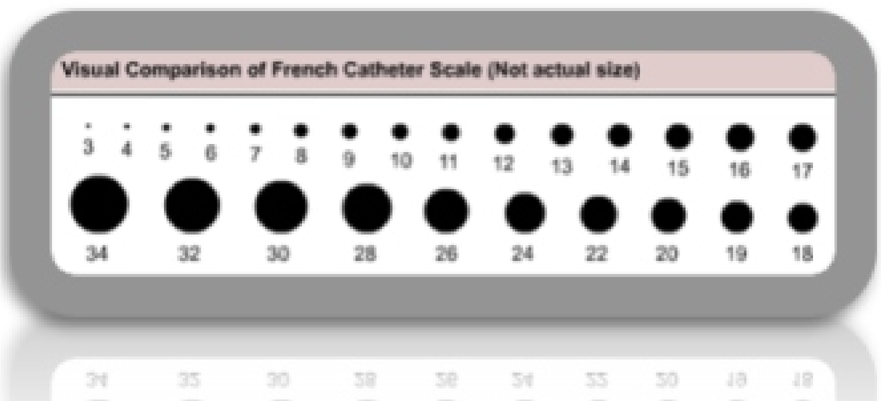
Diameter Measurement Comparisons

Inches	Millimeter	French	Gauge
0.039 in	1.00 mm	3.0 Fr	20 ga
0.053 in	1.35 mm	4.0 Fr	18 ga
0.066 in	1.67 mm	5.0 Fr	16 ga
0.079 in	2.00 mm	6.0 Fr	14 ga
0.092 in	2.30 mm	7.0 Fr	13 ga
0.105 in	2.70 mm	8.0 Fr	12 ga
0.118 in	3.00 mm	9.0 Fr	11 ga
0.131 in	3.30 mm	10.0 Fr	10 ga
0.144 in	3.70 mm	11.0 Fr	9 ga
0.158 in	4.00 mm	12.0 Fr	8 ga
0.170 in	4.30 mm	13.0 Fr	7 ga
0.184 in	4.70 mm	14.0 Fr	7 ga
0.197 in	5.00 mm	15.0 Fr	
0.210 in	5.30 mm	16.0 Fr	
0.223 in	5.70 mm	17.0 Fr	
0.236 in	6.00 mm	18.0 Fr	
0.249 in	6.30 mm	19.0 Fr	
0.263 in	6.70 mm	20.0 Fr	
0.288 in	7.30 mm	22.0 Fr	
0.315 in	8.00 mm	23.0 Fr	
0.341 in	8.70 mm	26.0 Fr	
0.367 in	9.30 mm	28.0 Fr	
0.393 in	10.00 mm	30.0 Fr	
0.419 in	10.70 mm	32.0 Fr	
0.445 in	11.30 mm	34.0 Fr	

Millimeters/Inches/French Conversion Chart

When you know	Multiply by	To find
Milimeters	3	French
Milimeters	.04	Inches
Fr.	.33	Milimeters
Fr.	.0133	Inches
Inches	25.4	Milimeters
Inches	75	French

Visual Size Comparison Chart



1. Which basket will fit in a 1.2 mm choledo-scope?

- **A.** 4.0 Fr
- **B.** 5.0 Fr
- **C.** 3.5 Fr

Check Answer

2. Which choledochoscope will fit into a 9 Fr diameter cystic Duct?

- **A.** 5 mm
- **B.** 2.7 mm
- **C.** 3.3 mm

Check Answer

3. Which basket will fit in a choledocho-scope with a 1.6 mm channel?

- **A.** 4.5 Fr
- **B.** 7 Fr
- **C.** 9 Fr

Check Answer

4. Which instruments will fit into a 4mm sheath needle?

- **A.** 12.0 Fr Catheter
- **B.** 5.0 Fr Catheter
- **C.** 12.9 Fr Choledochoscope

Check Answer

5. Which instrument will fit into a 16-guage sheath needle?

- **A.** 4.8 Fr Catheter
- **B.** 7.5 Fr Catheter
- **C.** 9.0 Fr Catheter

Check Answer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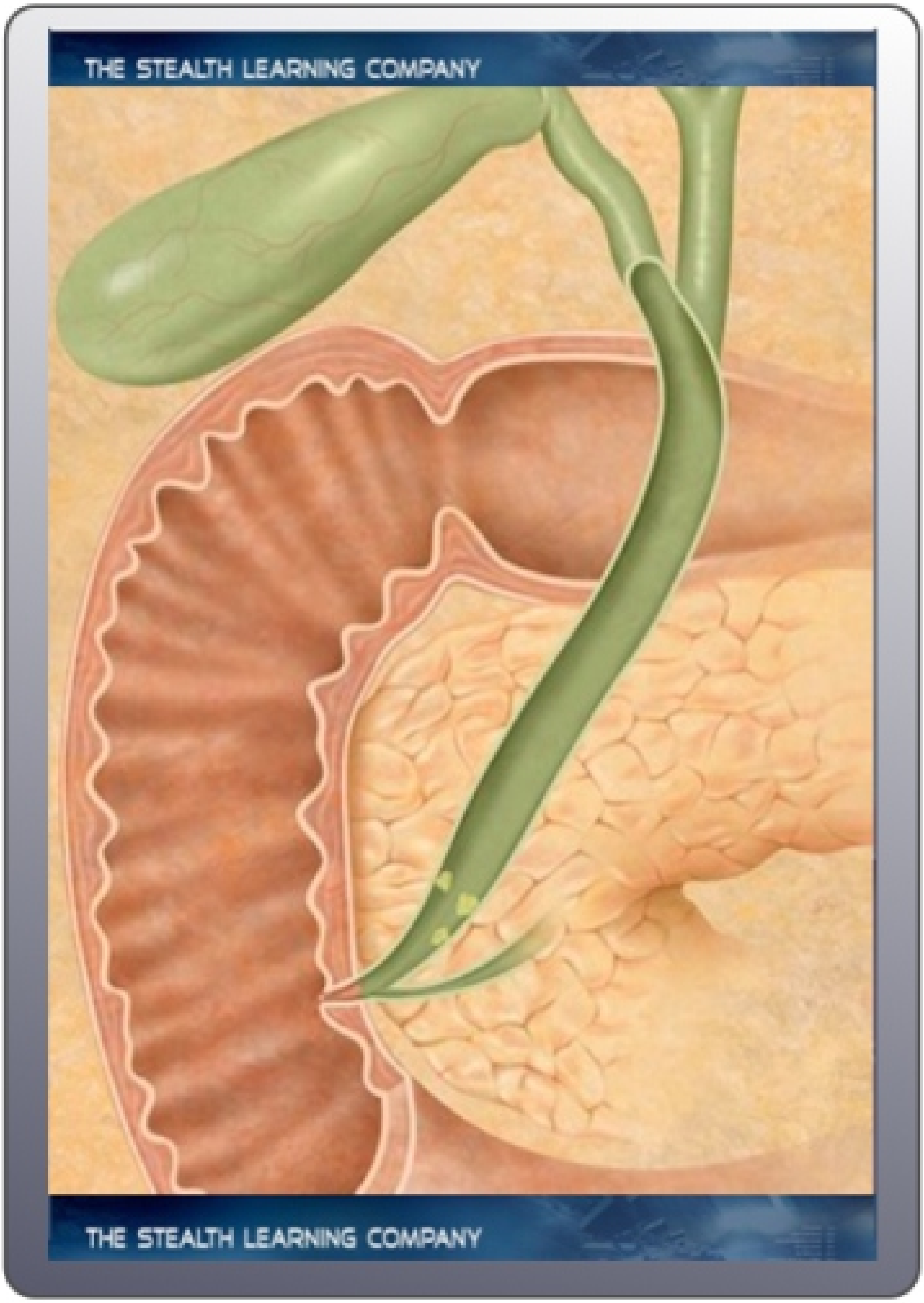
You Are Only As Good As Your Tools
James "Butch" Rosser, MD FACS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You Are Only As Good As Your Tools

Choledochoscope

One of the most important instruments for the completion of a common bile duct exploration (CBDE) is the choledochoscope. It is used to visualize the lumen of the biliary tree and retrieve stones. The particular model featured is the KARL STORZ flexible video choledochoscope. There are some important features that need to be reviewed. There are two buttons on the head of the instrument that are used during the

set-up process prior to the procedure. They are not usually manipulated after that time. There is a lever that can be identified on the ventral surface of the instrument. It activates movement of the distal tip. It has two movement options, forward and back. This causes deflection of the scope tip in an anterior and posterior direction. Additionally, the instrument has two ports. One port is the working channel and is used to insert a guidewire or stone basket. Another port is for irrigation, an important asset for successful exploration of the common bile duct. After insertion of the choledochoscope, you have to maintain continuous irrigation of saline to secure proper visualization of the lumen of the biliary tree. The movement of the scope tip is a feature that should not be underappreciated. Remember, the actuation lever is at the proximal head of the instrument and its movement causes angulation of the tip of the choledochoscope. If you are to navigate the scope without injury through the common bile duct, this range of motion is mandatory.

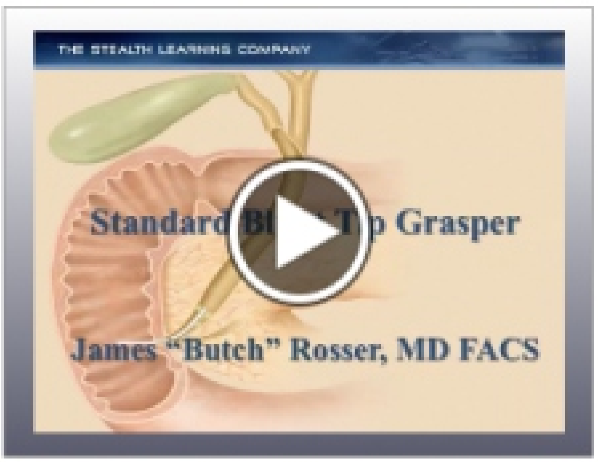
Maryland Grasper

The next item to be showcased is a manipulation and grasping

instrument called the Maryland Grasper. There are some function items that you must be aware of when using this instrument. It has a ring manipulation mechanism that allows you to grasp, dissect, and pick up. The opening and closing of the rings actuates the opening and closing of the jaws to complete selected tasks. There is a knob that allows you to rotate the jaws of the instrument to assist in proper positioning to achieve designated tasks. Also, there is a portal for cleaning. When you turn your attention to the tip of the instrument you can see the action of the jaws. You should note their opening and closing as well as rotation with manipulation of the rotation knob.

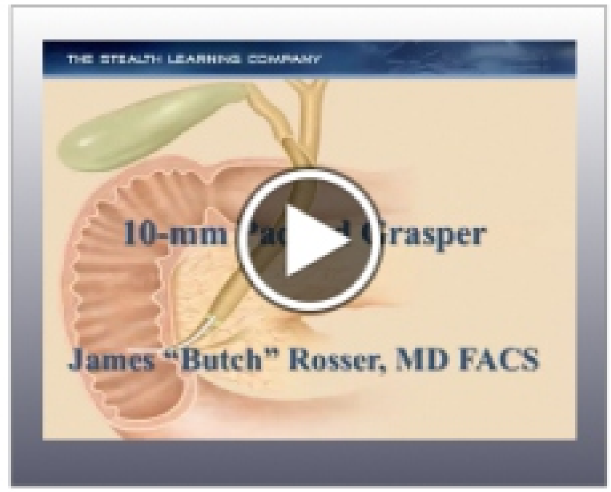
Standard Blunt Tip Grasper

Another choice of instruments necessary for Transcystic Common Bile Duct Exploration (TLCBDE) is the Blunt Tip Grasper. It uses a ringed mechanism of action that is similar to the Maryland. Opening and closing the rings on the handles correspond with the opening and closing of the jaws at the distal tip. There is also a rotation knob that allows expanded jaw positioning. Finally, there is a cleaning portal. The major difference between this instrument and a Maryland is the shortened jaws. It is frequently used to aggressively grasp structures. Additionally, this grasper can be used to handle tissue, catheters, and guidewires. Please remember not to use this instrument to grasp and manipulate the choledochoscope because it can cause damage.



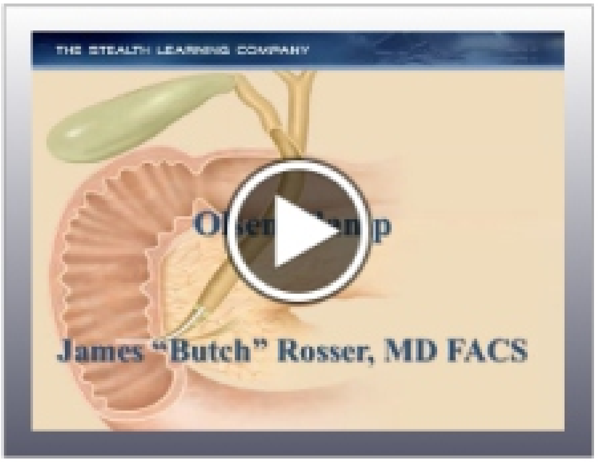
10-mm Padded Grasper

The 10-mm Padded Grasper is another very important instrument for the TLCBDE procedure. The instrument showcased is produced by KARL STORZ. As far as how the jaws are manipulated with ringed handles, it has a similar mechanism of action to previous instruments. This instrument can operate either in a free movement role or locked into place with a ratchet mechanism. It is suggested that the free movement role is used during the procedure. Remember, you are also able to rotate the instrument. Observe the tip of the instrument and the padding on the jaws of this grasper. It has a specialized function, atraumatic manipulation of the choledochoscope. Finally, there is a port for cleaning.



Olsen Clamp

The Olsen Clamp is a 5 mm instrument produced by KARL STORZ. It assists in the efficient placement of cholangiogram catheters into the cystic duct to accomplish intraoperative cholangiograms. It can also permit access for instruments into the biliary tree. Once again, the standard ringed handle mechanism is used. Move the handles in order to open and close the jaws. Remember, you must open the jaws fully to observe the cholangiogram catheter exiting the distal channel. The catheter is placed in the cystic duct and the jaws using the ratchet mechanism are closed to prevent contrast backwash. The importance of this instrument for the efficient completion of TLCBDE cannot be overappreciated. A point of interest is that there are a number of different cholangiography catheters that will work through it, and it works both with and without a guidewire in the lumen of the catheter. Inspect the distal tip of the instrument. See the jaws open and close, and again remember it does have a ratcheting mechanism. In order to use this instrument, insert your cholangiography catheter through the opening at its proximal end. Sometimes it takes a little bit of work if the guidewire is not in position. Advance the tip of the catheter until it exits the distal end. The jaws fully opened facilitate proper visualization of the catheter and assists in placement accuracy. Be very careful not to close the jaws too tightly because it can occlude your catheter and prevent contrast from going into the biliary tree.



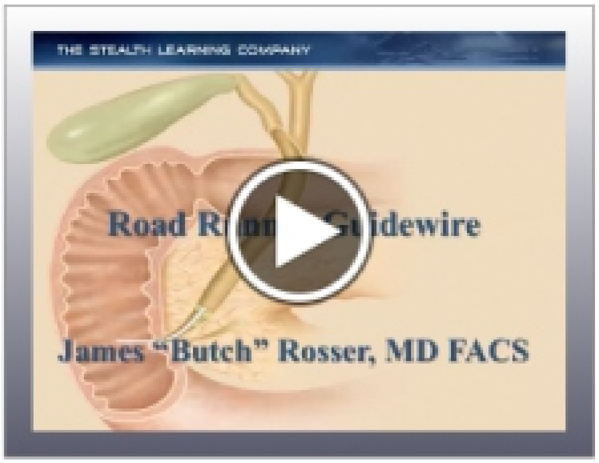
Clip Applier

A laparoscopic clip applier should be always available when performing a TLCBDE. A 5 mm model is a popular choice. The appliance uses a lever action to deploy and compress a clip. There is also a rotation knob that permits you to change the angle of final clip placement. The clip applier can be used as an alternative to the Olsen clamp to secure the cholangiogram catheter in the biliary tree. After the catheter has been placed in the cystic duct free hand, the lever is actuated to deploy and partially compress the clip. This will secure the catheter in place and assist in decreasing leakage of contrast material. Be sure to irrigate the catheter while performing this maneuver otherwise it may

become completely occluded. Also, take care in selecting the brand of clip applier, as not all of them permit partial compression. After the cholangiogram is finished, a Maryland or blunt tip instrument can be used to remove the clip.

Road Runner Guidewire

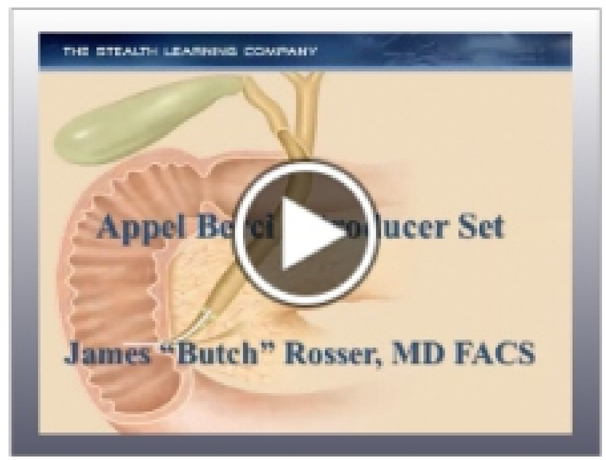
If you are to perform a TLCBDE, access to the biliary tree is mandatory. This can be done free hand, but in many clinical situations this task is best accomplished by using a biliary guidewire. One of the best is the Cook Medical Road Runner Guidewire. It has a 0.035 inch diameter and the length is 145 cm. The flexible tip and hydrophilic coating assists in manipulating curves in the biliary tree as you are cannulating the cystic duct and traversing the common bile duct.



Similar to the Fanelli cholangiogram catheter, this device has a 3-way stopcock and the center channel is a working port that permits placement of the guidewire. Fluoroscopy can be conducted with the guidewire in place. This greatly facilitates the TLCBDE procedure. The guidewire is placed through the center port. Be careful when performing the initial insertion of the guidewire and it will pass without difficulty. Monitor the exiting of the guidewire at the tip of the cholangiography catheter. If you are using the Olsen clamp, make sure that the jaws are not closed too tightly. This can occlude the catheter and prevent deployment of the guidewire.

Appel Berci Introducer Set

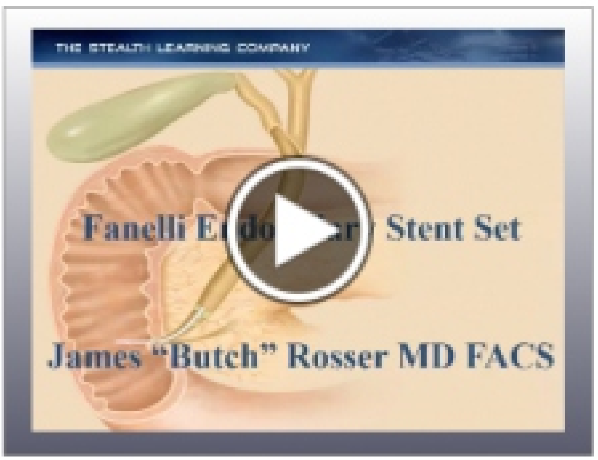
One of the challenges of performing a TLCBDE is having enough access ports for the required instrumentation. The Cook Medical Appel Berci Introducer Set addresses this issue. It has extended length to bring instrumentation closer to the point of entry into the biliary tree. This increases accuracy of placement of the balloon dilation catheter and choledochoscope. You can pass this appliance into the abdomen in two different ways. First, if you have deployed your guidewire through a previously placed midclavicular trocar, you can insert the intro-



ducer over the guidewire. Alternatively, it comes with its own access trocar kit that includes the introducer/ dilator, an 18-gauge needle and a 0.035-inch stainless steel guidewire. This gives you placement options based on your clinical judgement. There are two parts to the introducer. There is the outer blue trocar sheath and then there is the inner gray dilator that provides rigidity as the sheath is passed through the abdominal wall. Once you have inserted the sheath/dilator complex, remove the internal gray dilator and the sheath is left in place. Now, you can maneuver the sheath to introduce your balloon dilator and choledochoscope with greater accuracy into the biliary tree.

Fanelli Endobiliary Stent Set

Often, in spite of all efforts, a surgeon is not able to successfully clear the common bile duct. The Cook Medical Fanelli Endobiliary Stent Set addresses this issue. Furthermore, in the most novice of hands, it can facilitate the decompression of an obstructed common bile duct and make it easier for follow-up ERCP and spincterotomy for stone clearance. The stent is packaged in a kit that has a 0.035-inch guidewire along with the biliary stent assembly.



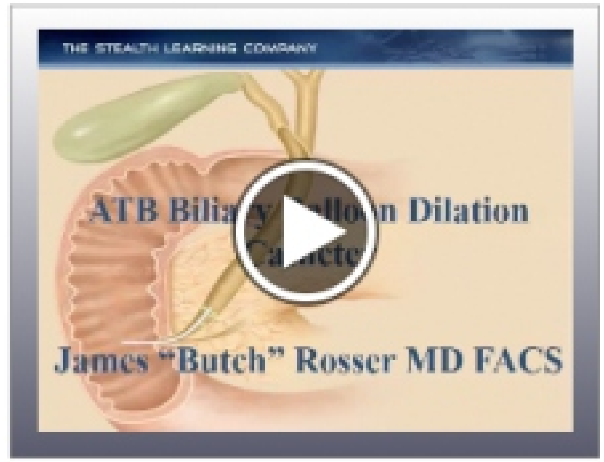
It is strongly suggested that the appliance is inspected before it is inserted into the biliary tree. First, look at the handle of the stent system. Identify the working channel that will receive the guidewire. Now, identify the blue capped port that is used to inject contrast for fluoroscopy. This is used to confirm proper placement of the stent prior to permanent deployment. Observe the distal portion of appliance and identify the white segment which is the Fanelli stent itself. The stent has four radiopaque markers, one proximal and one at the distal tip. These can be readily seen. There are also two others unseen that mark the location of the anchor flanges that hold the stent in place. They all serve to give the surgeon an accurate impression of the position of the stent under fluoroscopic examination. The distal two markers must be in the duodenum and proximal two in common bile duct. Remember, the anchoring flanges are responsible for holding the stent in place.

Now, you are ready to place the guidewire into the biliary tree. Once this is done, verify that the guidewire is in good position in the common bile duct via fluoroscopy. Next, place the Fanelli Stent System over the guidewire and insert it into the biliary tree. Frequently, before this can be done, it is necessary to enlarge the cystic duct. At this time use fluoroscopy to establish that the stent is in proper position. Remember, there should be two proximal radiopaque markers in the common bile duct and two in the duodenum.

Now, we are ready for final deployment of the stent. First, establish a firm grip on the handle of the appliance. Remember the stent is held in place by a two-part system. The first is the sleeve which fits over the stent. The second is a catheter that passes through the stent all the way to its distal end. Next, move the proximal edge of the black marking that represents the stent sleeve to the distal aspect of the hub of the appliance. Once the sleeve is pulled back, the stent is partially deployed. Now, remove the guidewire. You can do so safely at this point because you have verified the stent is positioned across the ampulla. Now, rotate the proximal catheter Luer lock hub counterclockwise. This will allow the extraction of the internal catheter and release the stent in its final position.

ATB Biliary Balloon Dilation Cath.

Often, the cystic duct is not large enough to accommodate instrumentation and stone extraction for successful completion of a TLCBDE. The Cook Medical ATB Biliary Balloon Dilation Catheter (All Terrain Balloon) is used to enlarge the cystic duct. This is especially important when inserting the choledochoscope. The balloon can disrupt the spiral valves of Heister and decrease the difficulty of scope insertion. Proper insertion of the balloon starts with placement of the guidewire through your previously established abdominal access port into the cystic duct. Next, place the balloon catheter over the guidewire. Be prepared to secure the guidewire as it exits the proximal working channel.



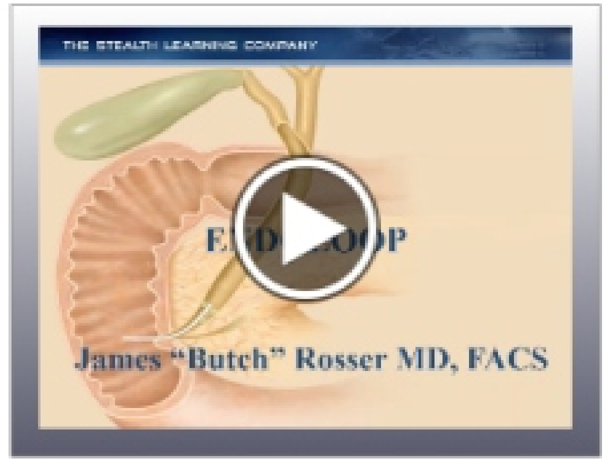
Once the balloon has been placed into the cystic duct, locate the balloon inflation channel of the appliance. The kit comes with its own 12 ml syringe which allows you to inflate the balloon. It is preferable to use liquid for inflation because it allows accurate monitoring of the inflation process. The length of the balloon catheter is approximately 40 cm. The length of the balloon is 4-cm, and when fully inflated it is 8 mm in diameter. Therefore, the size limit of stones that can be extracted during a TLCBDE is 8-9 mm. The device has two radiopaque markers that allow you to confirm placement of the balloon with fluoroscopy prior to inflation. The goal is to insert the balloon so that the proximal radiopaque marker is within the cystic duct and the distal radiopaque marker is just within the common bile duct before you inflate your balloon.

Now you are ready, for balloon inflation. It usually takes 5-7 cc to fully inflate. You do not need a pressure device to achieve proper inflation parameters. Once the balloon is fully inflated, turn the stopcock to the closed position. This will maintain the inflation tension of the balloon. Leave the inflated balloon in place and wait three to five minutes before deflating and removing. This will provide a proper sized pathway for the choledochoscope.

ENDOLOOP

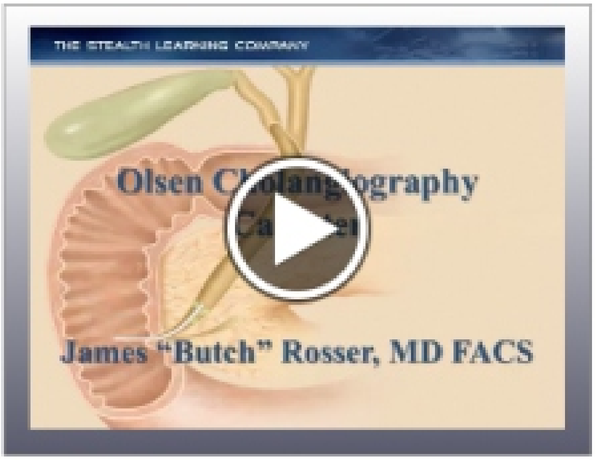
When all stones have been removed from the biliary tree, the final step is proper closure of the cystic duct. Typically, the cystic duct can be closed with a large clip. However, frequently, the cystic duct has to undergo dilation. If this is the case, an Endoloop is typically used. This will help to avoid the risk of a bile leak postoperatively. An Endoloop is a long plastic tube with a pre-tied looped suture. The loop exits the appliance at the distal tip. The Endoloop usually comes with its own introducer. The introducer can be placed through a 5-mm trocar. This prevents leakage of the pneumoperitoneum during placement.

The proper use is as follows: First, you have to backload the appliance into the introducer and then insert it through the trocar. Place the loop around the cystic duct. Next, use a blunt grasper to grab the cystic duct through the open looped suture. Once that has been accomplished, turn your attention to the proximal end of the appliance and locate a black fracture point marking line. Fracture the plastic rod and push the larger distal portion towards the cystic duct as you pull the smaller proximal portion towards you. This motion advances the knot toward the cystic duct. Frequently, two hands are required. The assistant is responsible for holding the cystic duct with the grasper. Continue this movement until the knot is brought down to the cystic duct until it is totally occluded. Next, cut the suture and remove the appliance from the abdomen.



Olsen Cholangiography Catheter

Different clinical circumstances and surgeon preference can sometimes call for appliances with specialized features. When the expense of an extra trocar is not wanted, the Olsen Cholangiography Catheter offers the option of having a sheath over a needle that allows introduction of the catheter through the abdominal wall. In addition, it has an internal stylet that provides extra rigidity that can be key to navigating a cystic duct with extensive valves of Heister. A three-way stopcock is provided to allow infusion with saline and contrast to perform cholangiograms. Finally, the catheter has an acorn tip that enhances securing of the catheter in the cystic duct when using a clip technique.

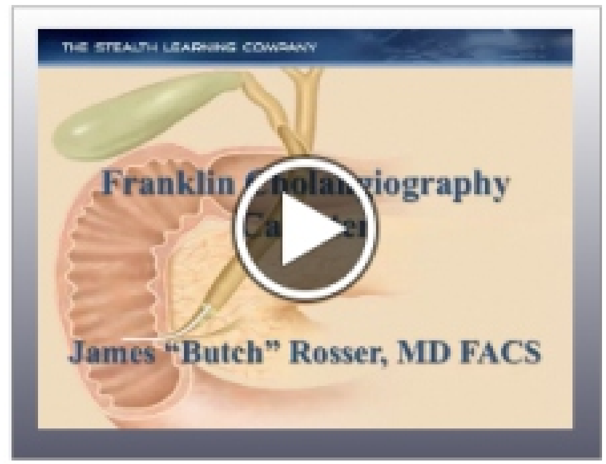


Mixter Cholangiography Catheter

Another option for routine cholangiography is the Mixter Cholangiography Catheter. It features an inner stylet and a streamlined tip. The need for a sheath is eliminated and introduction of the appliance into the abdomen can be accomplished with just a small skin incision. A three-way stopcock is included that allows infusion of saline and contrast. Remember, it does not have an acorn tip and therefore there is no added cystic duct security of the catheter when using a clip technique.

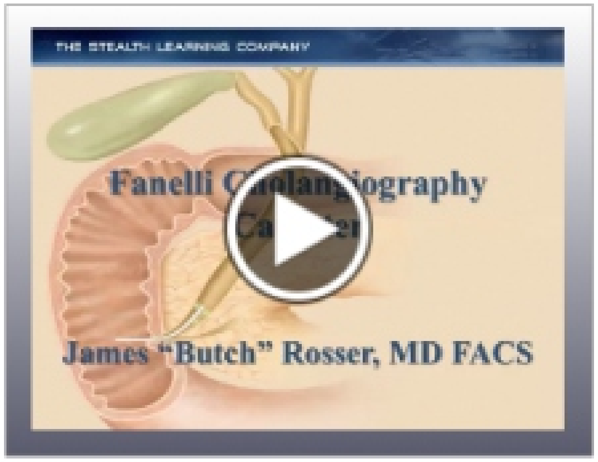
Franklin Cholangiography Catheter

Clinical circumstances and/or surgeon preference may at times dictate the necessity of having a cholangiogram catheter that permits guidewire assisted introduction into the cystic duct. The Franklin Cholangiography Catheter is 4 French and has a guidewire that facilitates introduction of the catheter into the cystic duct. Often, it is used to navigate a difficult duct and can be secured with a clip technique.



Fanelli Cholangiography Catheter

The Fanelli Cholangiography Catheter is 5 French and comes with a sheath over a needle and guidewire. It also has a multi-purpose adapter that allows for the placement of a guidewire to secure access to the biliary tree, infusion of saline and contrast, and placement of a basket to capture common bile duct stones using a fluoroscopic technique. All of these tasks can be done without using any other appliances or relinquishing biliary tract access. It is very efficient in certain circumstances in removing small to medium sized stones and facilitating the placement of biliary stents.



NCompass Nitinol Stone Extractor Basket

An appliance that is needed when utilizing a fluoroscopic technique to clear the common bile duct of stones is the NCompass Nitinol Stone Extractor, tipped basket. The basket is readily seen on fluoroscopy. It is offered as a separate accessory most often used with the Fanelli Cholangiogram Catheter. The basket fits through the multi-purpose adapter. However, it can be placed through any 5 French catheter.

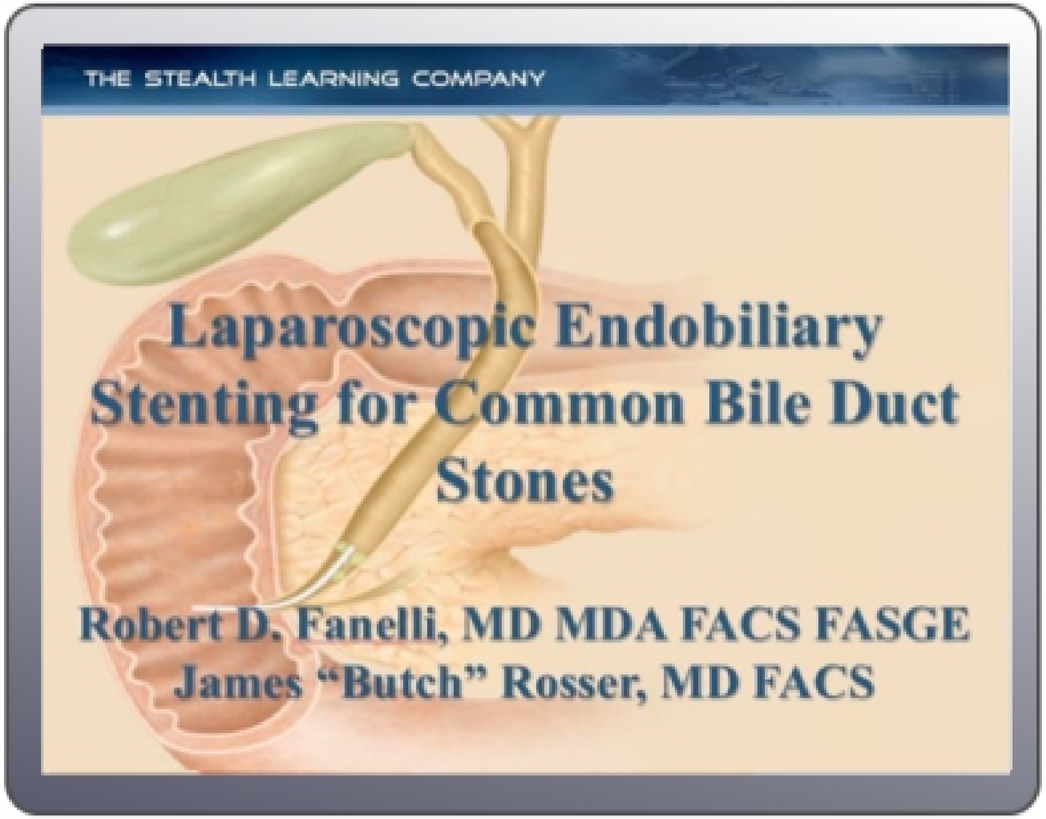
Common Bile Duct Exploration Set

There are several accessory appliances that can be used for the successful completion of common bile duct explorations. At times, it may become confusing, and often as time passes surgeons will develop product preferences. To simplify equipment selection during the learning curve, Cook Medical has put together a Common Bile Duct Exploration Set. It has all the basic appliances together that will address most needs with this procedure.

First, there is a three-way multipurpose adapter that allows infusion of saline or contrast as well as insertion of guidewires and baskets.

Next is the Roadrunner PC Wire Guide. It is used for gaining initial access to the biliary tree, and it frequently helps to direct the balloon catheter into the cystic duct. Also included is the Berci Introducer, it is very effective in establishing a secure pathway for instruments and appliances that need to be brought into the abdominal cavity during common bile duct explorations. Another important item included in the set is the Balloon Dilation Catheter. At times, the cystic duct will need to be dilated for the procedure to proceed, and this appliance is specifically made to achieve that goal. Lastly, there is a tipless retrieval basket. This appliance is strongly suggested for harvesting stones from the biliary tree when using the choledochoscope.

Chapter 7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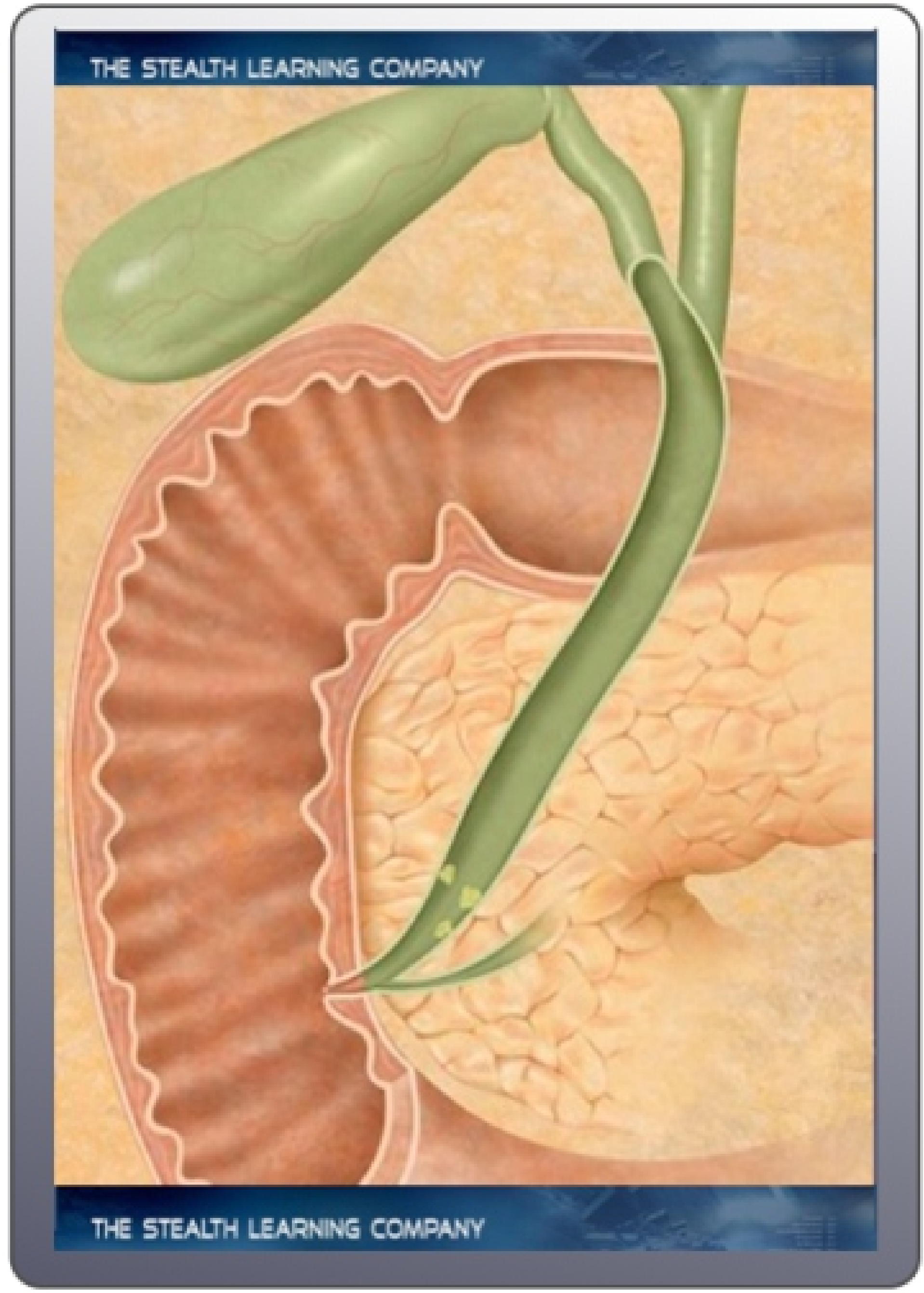
Laparoscopic Endobiliary Stenting for Common Bile Duct Stones
Robert D. Fanelli, MD MDA FACS FASGE
James "Butch" Rosser, MD FACS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CHAPTER 7

Laparoscopic Endobiliary Stenting for Common Bile Duct Stones

Introduction

There are times when the common bile duct can't be cleared. The Fanelli Endobiliary Stent can temporize the clinical situation and facilitate an excellent outcome. At this time, let's look at the anatomy of the Fanelli Stent and review how to use this innovative appliance (refer to video).

The following is a very common clinical situation. Once you have identified stones with a cholangiogram, you often must dilate the cystic duct for stent insertion. Refer to the details of balloon dilation covered in chapter 9, Step By Step Laboratory Protocol. In the clinical scenario presented, balloon dilation has occurred, and the catheter is still in place. Next, the tracer hybrid guidewire is inserted into the biliary tree. Under fluoroscopy, it is tracked into the common bile duct and threaded into the duodenum. The catheter is then removed and with assistance from the guidewire and the Fanelli Stent is then placed into the common bile duct and duodenum.

Now, identify the stent markers and determine its location. Marker one appears at the distal tip of the inner guide matching the position of the distal tip of the stent. Marker two appears on the inner guide at the position that matches the distal flange of the stent. Marker three denotes the proximal flange. Marker four is the largest marker. It represents the distal tip of the stent backstop. After the stent has been positioned across the ampulla, markers one and two should be within the duodenum. Markers three and four should be within the bile duct.

The next step is to retract the outer sheath. Once you retract the outer sheath, you may not be able to retrieve the stent using the delivery system. Slowly retract the outer sheath back towards both Luer connectors. Stop when it contacts the white connector. Remove the guidewire completely. Hold the purple connector securely without permitting it to move and unscrew the white Luer hub from the purple Luer connector. Draw the white hub away from the assembly. This will facilitate final deployment of the stent. After deployment, obtain a completion cholangiogram by injecting contrast through the stent backstop. Now, remove the stent backstop from the biliary tract. Once placement of the stent has occurred, you have secured drainage of the biliary tree, and established a safety net for your patient. (Fanelli Technique Critique- "Once I position the stent across the ampulla and just before I'm going to deploy, I remove the guidewire as the first step, then draw the outer sheath back, and then unscrew the Luer locks and withdraw the central cannula.")

Laparoscopic Endobiliary Stenting

Laparoscopic endobiliary stenting has many advantages. It eliminates the need for T-tubes, cystic duct catheters, external drains, and other maneuvers after laparoscopic common bile duct procedures. It also can eliminate the need for common duct explorations when occult common bile duct stones are identified. Laparoscopic endobiliary stenting can protect ductal closures and limit the risk of bile leaks. It also can prevent complications from retained common bile duct stones. Laparoscopic endobiliary stenting assures success of postoperative ERCP in most cases. Necessary equipment is relatively inexpensive and readily available as a self-contained kit. Furthermore, laparoscopic endobiliary stenting is suitable for use in surgery centers as well as critical access hospitals and general hospitals. Initially, it was used after laparoscopic cholecystectomy and common bile duct exploration, however now some surgeons use it as the primary means of addressing occult common bile duct stones.

ERCP: Not a Foolproof Safety Net

I know the previous suggested approach may be shocking to many surgeons. Surgeons like to be in control. However, the availability of this clinical resolution avenue must be considered in our current management algorithm because ERCP is not a foolproof safety net.

Let's look at the evolution of laparoscopic endobiliary stents. A review is presented looking at 1995 to present. First of all, most surgeons rely on postoperative ERCP to intervene when common bile duct stones are discovered. However, while awaiting postoperative ERCP, there are risks for

patients with retained common bile duct stones. They can be exposed to pancreatitis, cholangitis, and pain. Furthermore, these patients are often hospitalized pending ERCP scheduling. This adds increased cost to the management of common bile duct stones. In addition, postoperative ERCP results vary based on endoscopist volume.

High volume providers and centers can have a greater than 95% selective cannulation rate while low volume providers and centers can have less than a 60% selective cannulation rate. Other significant facts to be considered is that the average selective cannulation rates for community hospitals runs about 80-85%. ERCP complications are directly related to number of cannulation attempts. As many as 20% of patients referred for postoperative ERCP may require repeated ERCP attempts. This can necessitate further surgery, percutaneous transhepatic cholangiograms, or transfer to another facility. Laparoscopic endobiliary stenting significantly improves rates of selected cannulation, stone clearance, and overall results of postoperative ERCP for common bile duct stones.

Now, let's look at some of the results in low volume centers with endoscopists performing fewer than 100 ERCPs per year. In that clinical setting, selected cannulation during postoperative ERCP increased in the hands of these low volume providers and centers from 82% to 100% after laparoscopic endobiliary stenting. High volume centers and endoscopists performing more than 100 ERCPs per year saw their selected cannulation rate during postoperative ERCP increase from 92% to 100% after laparoscopic endobiliary stenting. If postoperative ERCP is your method of managing patients with common bile duct stones discovered at the time of laparoscopic cholecystectomy, laparoscopic endobiliary stenting significantly improves patient outcomes. Let's look at why cannulation is easier after laparoscopic stent placement. The clinical video featured shows a stent that was placed one week prior and the patient is undergoing a postoperative ERCP. You can see the stent is readily visible and it assists in the safe performance of a sphincterotomy. With a loop, the stent can easily be removed.

Clinical Experience

Now, let's review the clinical experience with the endobiliary stenting by Dr. Fanelli. In his initial experience, he used the endobiliary stent in 16 patients as an adjunct to laparoscopic common bile duct procedures. He found that it obviated the use of T-tubes and drains after the procedures and 100% of the cases had common bile duct stones cleared during surgery. The average hospitalization for these patients was 36

hours. There were no bile leaks, strictures, or any other common complications observed. Furthermore, there was no stent migration, dislodgement, or improper placement of the stent.

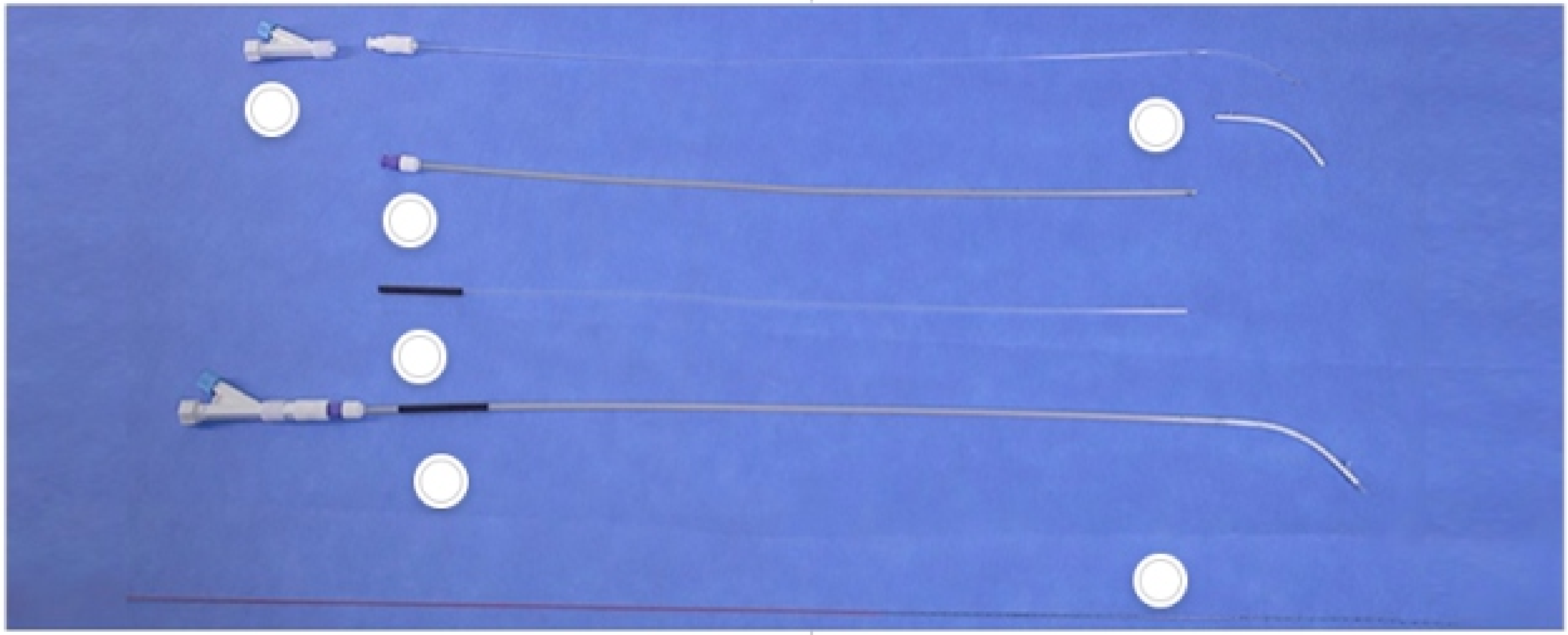
In another study by Dr. Fanelli, 372 laparoscopic cholecystectomies were done over a 36-month period. The surgeon used the Hasson cannula, three 5-mm upper abdominal ports, general anesthesia, carbon dioxide insufflation, and routine fluorocholangiography. Fluorocholangiography was accomplished in all patients. Common bile duct stones or suspicious fluorocholangiograms were identified in 48 for a 12.9% rate of occurrence. In this study, no attempt was made to clear the common duct of stones. All patients were treated with stents. Stent placement added 9 to 26 minutes to the laparoscopic cholecystectomy operative time. Cystic duct balloon dilation was only necessary in 29.2% of the patients, and laparoscopic suturing and advanced skills were not utilized. All 48 of the patients were treated for common bile duct stones with stenting only. The longest follow-up was 46 months in the initial series and there was an extension of follow-up to 80 months; 44% or 92% of these patients were treated on an outpatient basis. Only 8% of the patients were admitted overnight with the average length of stay being 30 hours. Two patients had postoperative nausea and vomiting, one surgery was completed too late for discharge, and the weather was too severe for safe discharge in another. These patients had outpatient ERCP within 1-4 weeks postoperatively. All had successful clearance of common bile duct stones, and there were no false-positive fluorocholagiograms. Hemorrhage, bile duct injury, duodenal perforation, suboptimal stent placement, stent migration, and other common complications did not occur. No ERCP stent related complications were encountered.

Summary

Laparoscopic endobiliary stenting improves the results of postoperative ERCP;
Based on Dr. Fanelli's and others experiences, it should be considered as a treatment of choice for common bile duct stones found at time of laparoscopic cholecystectomy. This is based on safety, efficiency, economy, and the preservation of minimally invasive surgical principles. Biliary stenting may become an emerging approach in light of recent reports that newly trained surgeons have little facility with safe performance of common bile duct explorations. Laparoscopic endobiliary stenting provides distinct advances over the many other options available. Whether you decide to use it alone or in adjunct with other common bile duct exploration procedures, it is a technique that is easy to master. Also, it requires no advanced suturing skills and should be a part of every surgeon's skill set.

Question 1 of 3

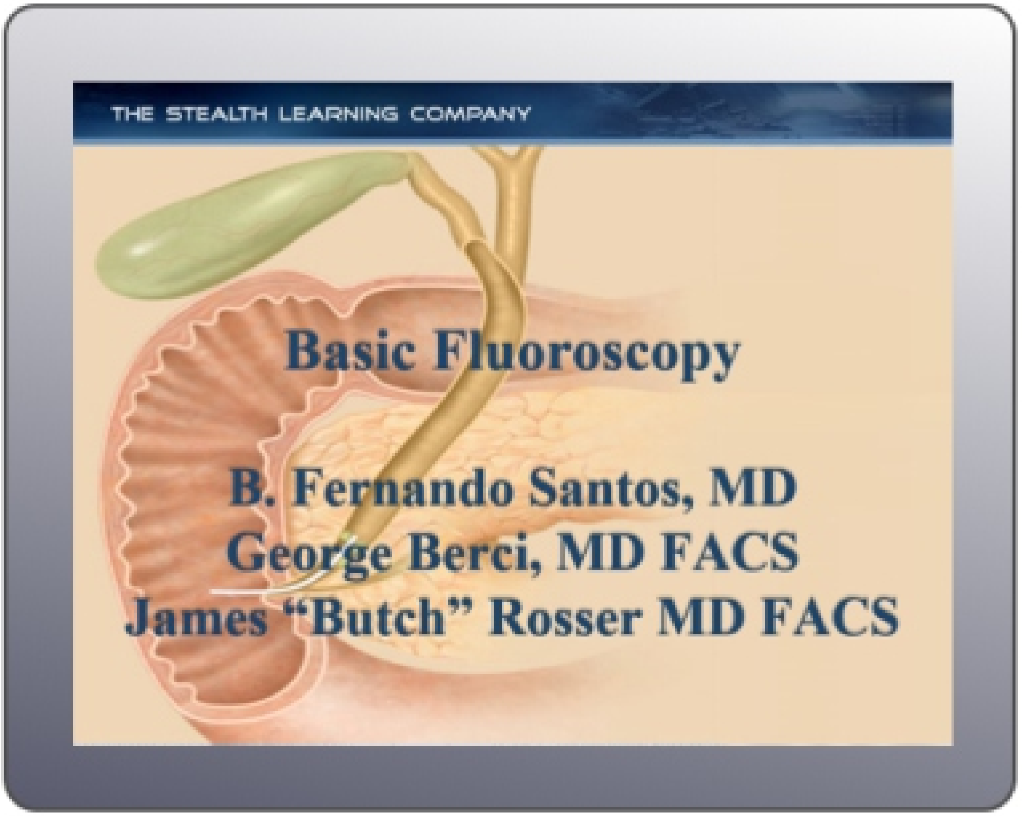
Drag and drop the answers.



Inner Carrier | Stent Backstop | Outer Sheath

Fanelli Endobili. Stent | Tracer Hybrid Wire Guide | Stent

Check Answer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Basic Fluoroscopy
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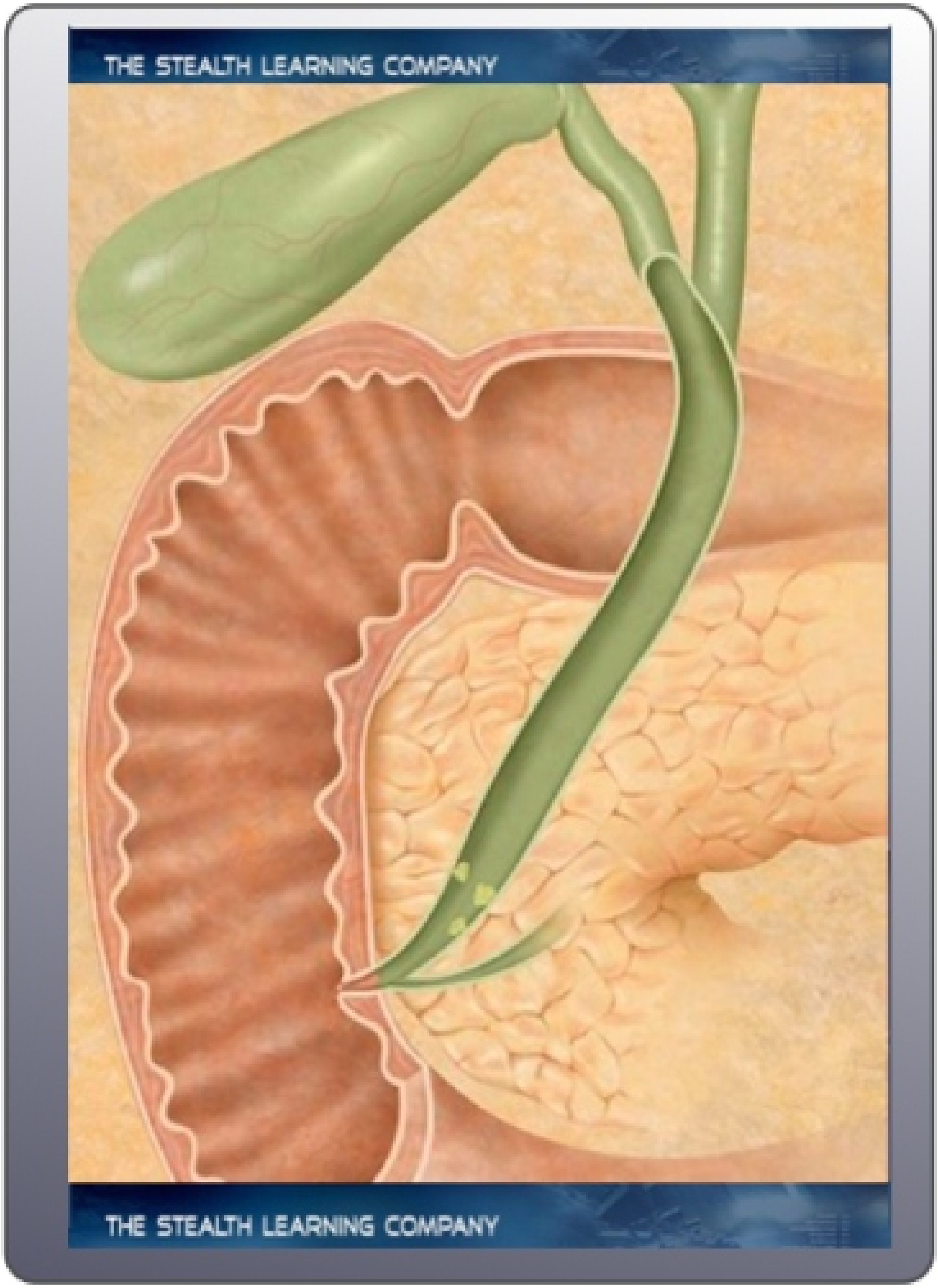
George Berci, MD FACS
James "Butch" Rosser MD FACS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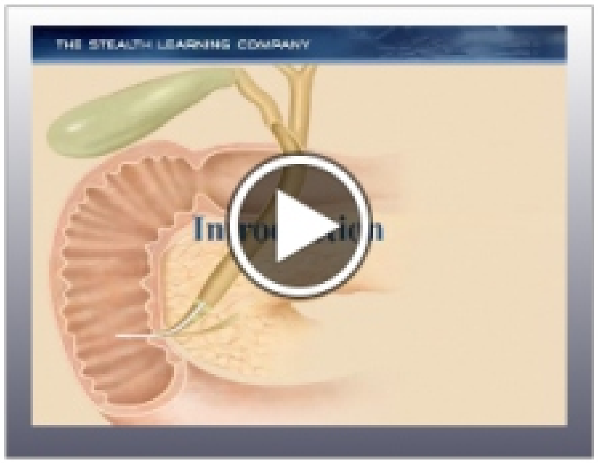
CHAPTER 8

Basic Fluoroscopy

Introduction

This chapter will cover the basics of fluoroscopy equipment, radiation safety, and how to protect the patient and yourself and provides an overview of fluoroscopy use in LCBDE. The discussion of radiation safety is intended to provide the learner with an overview of important concepts and should not replace formal radiation safety training requirements and policies set by your local institution.



Radiation Safety

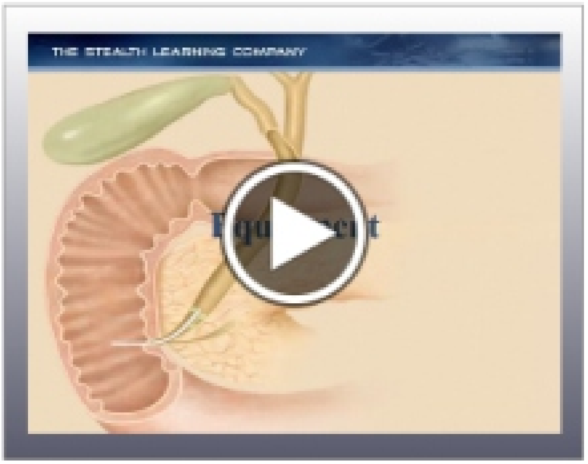
Fluoroscopy Use During Laparoscopic Common Bile Duct Exploration

Fluoroscopy is a key tool used during LCBDE. In the video, procedural steps in LCBDE, which may require fluoroscopy are presented, and the recommended modes are given for each. Initially, fluoroscopy comes into play during performance of cholangiograms. Once the surgeon decides to proceed with TLCBDE, live fluoroscopy is used to guidewire placement and balloon dilation. Once access to the biliary tree has been achieved, fluoroscopy may be used during stone extraction for guidance of instruments such as a stone extractor or to check the position of wires. When using the choledochoscope to inspect the intrahepatic ducts for stones, fluoroscopy may be used to confirm the anatomic location of the choledochoscope within the biliary tree. Fluoroscopy is also used to guide stent placement during TLCBDE and and to perform a completion cholangiogram. Un-

derstanding how to effectively and safely use fluoroscopy is critical to performing LCBDE.

Equipment

The basic equipment for fluoroscopy is shown in the video. Shown is a c-arm used for intraoperative imaging. It consists of an x–ray tube at the bottom from which x-ray beams are emitted towards the image intensifier seen above. The image intensifier detects the x-rays after they have passed through the patient and translates them to a visual representation seen on the image display. Typically, a foot pedal allows the operator to activate the x-ray beam in real-time as needed.



Radiation Safety

Radiation safety is of paramount importance to protect both the patient and the operator, from harm. Radiation exposure may cause detrimental effects which are direct tissue damage which in severe cases may result in tissue burns or radiation sickness. Stochastic effects, are also possible, which lead to long-term cancer risk and are generally related to the degree of cumulative radiation exposure. Strategies to minimize risks from radiation include proper positioning, minimizing radiation dose and fluoroscopy time, shielding, and maintaining a safe distance from the radiation source. It is important to position the c-arm and patient properly.

An illustration showing a typical c-arm configuration during cholangiography is shown in the supplied video. The x-ray tube is below the table and image intensifier above the patient. To minimize radiation dose to the patient's skin, the x-ray tube should be positioned as far away from the patient as possible with the image intensifier closer to the patient. This position also reduces scatter of radiation to the operator's face and upper torso after it enters the patient. The use of strategies for dose reduction are absolutely necessary for radiation safety.

Above all, the operator should try to minimize fluoroscopy use. Engage it only when necessary to complete a step, such as cannulating a wire past the papilla. For such real-time guidance, the operator should use the lowest pulse rate possible that allows acceptable resolution. "Cine" or cineangiography runs use much higher pulse rates and deliver higher corresponding radiation doses.

Radiation Burns

This should be limited to situations that require capture of diagnostic quality films, such as during an initial or completion cholangiogram. Collimation is an additional strategy to reduce dosing. This technique uses shutters on the x-ray tube to narrow the x-ray beam and can be adjusted to the minimum required field size. This practice reduces the overall radiation exposure to the patient and the operator. Magnification is sometimes used to more closely image a point of interest seen on the cholangiogram. However, this leads to higher radiation doses and should be avoided, or used only when necessary to investigate an unclear finding.

Personal Shielding

For routine cholangiography or when doing "cine" runs, consider using a mobile wall shield. Mobile shields provide another layer of protection. These can either be a waist-high shield or even better, a clear shield that protects the entire operator while allowing a view of the field. In the video, there is a photo that shows how a mobile clear shield can be used to protect operators during cholangiography.

Mobile Wall Shielding

Personal protective shielding is another cornerstone of good radiation safety practices. When doing TLCBDE, the operator should wear personal lead to facilitate necessary manipulations that may be difficult using a mobile wall shield alone. Personal protective equipment should, at a minimum, consist of a thyroid shield, and coverage of the trunk and proximal lower extremities. In addition, some operators use protective eye-glasses to reduce the long-term risk of cataract formation with radiation exposure. Distance from the x-ray tube is also an important factor to minimize radiation exposure. Notice that long IV tubing is useful during cholangiography to allow the surgeon to step at least 6 feet away from the c-arm minimizing radiation exposure even further.

Summary

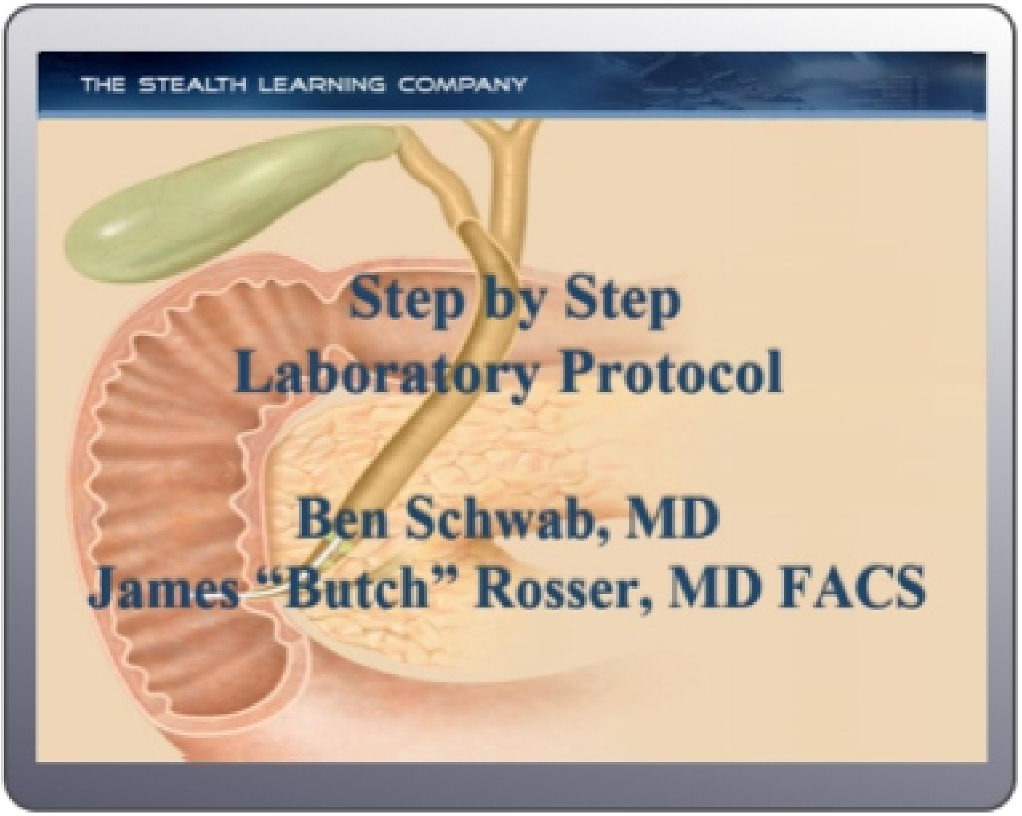
In summary, it is important to understand the basic aspects of fluoroscopy equipment and how to use fluoroscopy safely. Proper patient and C-arm positioning, dose reduction strategies, and radiation shielding are important considerations when performing LCBDE.

Question 1 of 5

1. Strategies to minimize risk from radiation exposure while using fluoroscopy include all of the following except:

- **A.** Positioning the c-arm and the patient properly
- **B.** Minimizing the dose required
- **C.** Shielding
- **D.** Increasing the pulse rate of the beam

Check Answer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Laboratory Protocol
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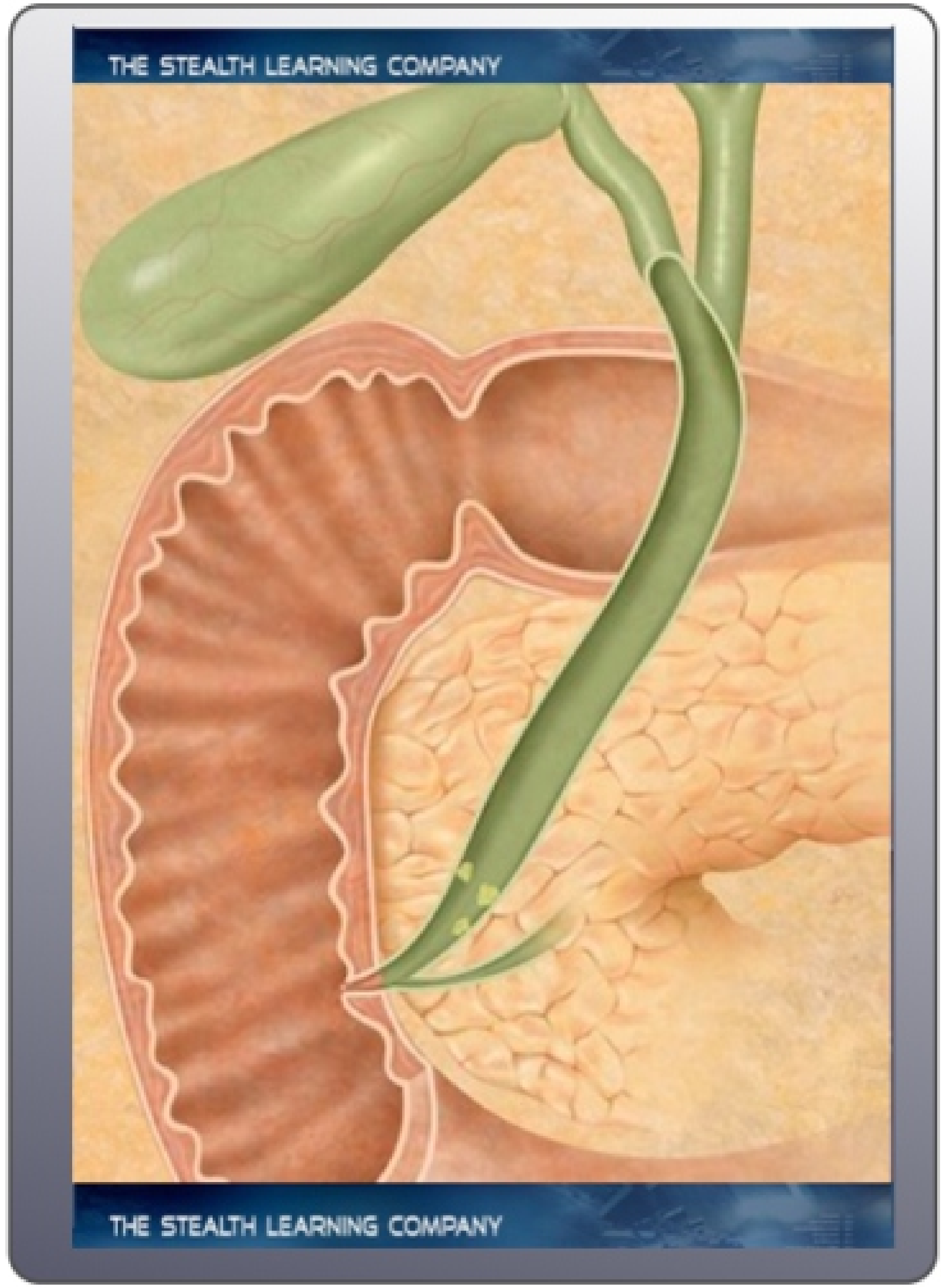
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CHAPTER 9

Transcycstic Common Bile Duct Exploration: Step By Step Laboratory Protocol

External Simulator Tour

The key to effectively learning the TLCBDE technique is the Northwestern CBDE simulator. The importance of knowing the features of this device is of upmost importance. The external features include a cephalad and caudal area. Next, there is a simulated abdominal wall with three inserted trocars. There is one on the right side of the simulated abdomen. It is a 5 mm trocar that represents the mid-axillary port site. It allows a grasper to control the dome of the gallbladder and establishes exposure for the procedure. To the left of that

trocar, there is another 5 mm trocar. It represents the midclavicular port. A large portion of the procedure will be accomplished using this location. Items include: obtaining a cholangiogram, establishing guidewire access, insertion of the choledochoscope, etc.

Finally, to the left of the midline, there is a 10 mm trocar that simulates the epigastric port. It is used to insert instruments that facilitate the insertion of devices into the biliary tract. It is 10 mm because some of the instruments needed are of that size. There is no umbilical port because the simulator uses an internal camera for the endoscopic view. (Location references are from the simulator and not the surgeon's vantage point.)

Internal Simulator Tour

The internal aspect of the simulator features a landscape that represents the undersurface of the liver and the hepatoduodenal ligament. The anatomical structures featured include the liver, gallbladder, cystic duct with a cystic ductotomy already made,

right and left hepatic ducts, common hepatic duct, and hepatic artery.

Fluoroscopic Simulator Tour

A critical feature of the Northwestern CBDE Simulator is the fluoroscopic component. It presents a high-fidelity representation of real-time imaging that is so prominent in the performance of this procedure. Anatomical landmarks featured include the cystic duct, right and left hepatic duct, common bile duct, duodenum, and, filling defects.

Step 1: Obtain Cholangiogram

The first step of the clinical procedure is to obtain a cholangiogram and accomplish a complete dissection of the hepatoduodenal ligament establishing the “critical view of safety.” This must reveal all important anatomical structures. Next, the surgeon has to perform a cystic ductotomy. In the simulator, please note that all of this has been done. Your first task is to load your cholangiogram catheter of choice into the Olsen clamp. Make sure you advance the catheter until about 1-2 cm of the catheter is outside of the distal tip of the instrument. Now, insert the clamp through the mid-clavicular port. If necessary, a Maryland dissector may be placed through the epigastric port to help direct the catheter.

Now, place the catheter at the entrance of the opening in the cystic duct and thread it into the duct. Advance the catheter approximately 0.5-1 cm into the duct and then close the Olsen clamp with one click. Be careful not to occlude the lumen of the catheter. Next, turn your attention to the three-way adapter with the connected contrast and saline syringes. This should be accomplished ahead of time and both lumens should be irrigated to avoid getting bubbles in the biliary tree. Air bubbles can lead to false positives on fluoroscopic evaluation.

Next, flush the biliary tract with a small amount of saline and then inject contrast while observing with fluoroscopy. The fluoroscopic view has the following anatomical landmarks 1) right and left hepatic ducts 2) common hepatic duct 3) cystic duct 4) common bile duct 5) and duodenum. The simulator will also feature a stone, most likely in the distal common bile duct.

Step 2: Establish Guidewire Access

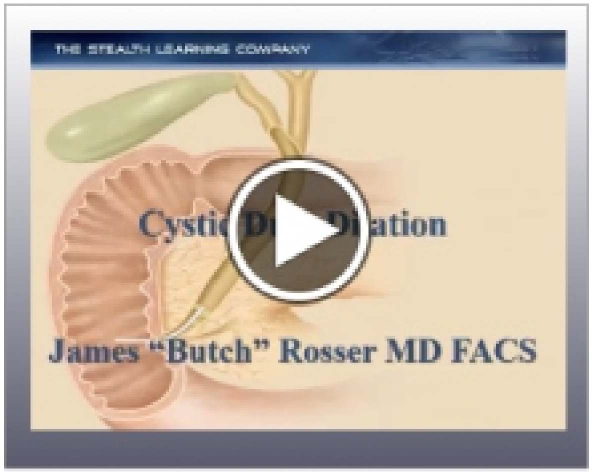
Once the cholangiogram has been completed and you have confirmation that there are common bile duct stones, proceed with the following algorithm to initially try to clear the duct. If the stones are small, you should simulate the injection of glucagon to attempt flushing of the stones from the duct. If this maneuver is not successful, you may now proceed with a transcystic laparoscopic common bile duct exploration (TLCBDE). The first step is to establish guidewire access to the biliary tract. Release the jaws of the Olsen clamp in the midclavicular port and leave it in an open position. This secures an unobstructed path for the guidewire to pass through the cholangiography catheter into the biliary tract. Remove the guidewire from its cradle and thread it through the center port of your three-way adapter. Once you have inserted a considerable amount of wire into the biliary tract, confirm its location with fluoroscopy.

After the position of the wire has been located, continue to advance it until it enters the duodenum. If this cannot be achieved, it is acceptable to establish placement in the distal common duct. The goal is to place enough of the guidewire in the biliary tract to assure that you will not dislodge it when the catheter is removed. Now, remove the cholangiogram catheter while maintaining the position of the guidewire. This can be accomplished by your assistant withdrawing the Olsen clamp from the abdomen while the surgeon secures the guidewire with a grasper through the epigastric port. If there is any doubt about the maintenance of the position of the wire while removing the clamp and catheter from the abdomen, recheck the location with fluoroscopy.

Now that you have established guidewire access to the biliary tree, the next step is placement of the Berci Introducer. This device allows the efficient ingress and egress of the choledochoscope from the abdomen. Thread the guidewire through the inner cannula of the Berci Introducer until you observe it exiting from the proximal end. Hand the appliance to your assistant as you (surgeon) maintain the position of the guidewire with a grasper through the epigastric port. The assistant should pull to straighten the guidewire and then push to slide the introducer into the abdomen. Now, instruct the assistant to remove the gray inner cannula from the appliance. Once again, make sure this is done with continuous security of the guidewire. The final task in this step is to push the blue introducer sheath close to the point of entrance of the guidewire into the cystic duct.

Step 3: Cystic Duct Dilation

The insertion of the choledochoscope into the biliary tree is frequently facilitated by balloon dilation of the cystic duct. This is especially true during the early learning curve. If there has been significant dilation of the biliary tract because of high-grade obstruction, insertion of the choledochoscope can be successfully accomplished without this step. In a similar fashion to the insertion of the Berci Introducer, take the balloon catheter and thread the guidewire into its distal opening. Please ask your assistant to help with this while you maintain control of the guidewire. Continue this action until the wire exits from the proximal end of the balloon catheter. Secure the end of the guidewire and have the assistant tread the balloon catheter into the abdomen until its distal tip is placed near the entrance of the cystic duct. Now, using a padded grasper through the epigastric port, thread the balloon into the cystic duct until about a third of the proximal balloon is showing. Be careful when using the grasper to avoid injury of the balloon. Because there are proximal and distal radiopaque markers on the balloon, you can use fluoroscopy to confirm position. However, this is not usually necessary.



At this time, slowly inflate the balloon with saline using the supplied 11cc syringe. It takes approximately 7-10 cc to fully inflate the balloon. How much, depends on the surgeon's judgement. Halt inflation if the duct is in danger of splitting. Maintain this inflation pressure for about 5 minutes. It is very important that you wait for at least 5 minutes to achieve effective dilation. Once 5 minutes has passed, use the syringe to remove the saline from the balloon. Make sure the balloon has completely deflated before attempting to remove the catheter. Next, the balloon is removed from the abdomen by the assistant while the surgeon maintains control of the guidewire with a grasper through the epigastric port.

Step 4: Choledochoscope Insertion and Maneuvering

Now it is time to insert the choledochoscope. Grasp the distal tip of the guidewire that is in place. Identify the working channel on the distal end of the scope. Next, advance the guidewire into the scope until it exits the proximal working port. Now, ask your assistant to secure the guidewire and grasp the choledochoscope.

While the surgeon maintains internal security of the guidewire, the scope is pushed into the abdomen until it comes into view of the laparoscope.

Next, the surgeon uses a padded grasper through the epigastric port to advance the scope into the common bile duct. The padded grasper is best suited for this task to protect the scope. Remember this is a 10 mm instrument which necessitates the use of the larger epigastric trocar. Once the scope is in the cystic duct, connect the irrigation solution to the appropriate port on the scope. Usually, a three-liter bag of half normal saline solution is used and runs continuously. Now, advance the scope into the common bile duct. You will be able to see the guidewire as you progress. Remove the guidewire once you are in the distal duct or when the common bile duct stones are visualized.

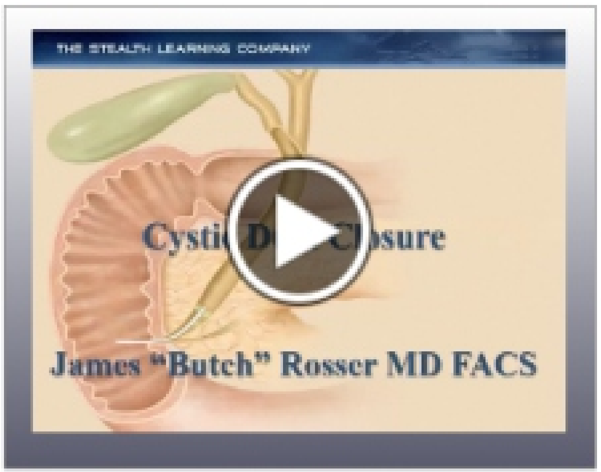
Step 5: Stone Capture and Extraction

Now, it is time for stone capture and extraction. This step is accomplished with the use of a webbed basket. The one featured is called a Nitinol Tip-less Stone Extraction Basket. Before insertion into the scope, verify that the basket is in a closed position. Now, hand the basket handle to the assistant and practice opening and closing the appliance. Next, place the basket through the proximal working channel of the scope. The surgeon should make sure to maintain visualization of the stone at all

times. Once the basket is visualized, push the tip past the stone, while keeping the basket in a closed position. Now, the surgeon should request the assistant to open the basket. Once it is open, pull the basket back in order to entrap the stone.

This may take multiple attempts and adjustments of the position of the scope. Two suggestions while attempting this maneuver include: 1) Keep a small amount of distance between the end of the choledochoscope and the basket. 2) Rotating the scope can sometimes facilitate capture. Once the stone is captured, request the assistant to close the basket. Next, pin the stone to the tip of the choledochoscope. Then remove the basket, stone, and scope as a single unit from the biliary tract. Once it is inside the abdomen, release the stone and extract it through the 10 mm epigastric trocar with or without a specimen bag.

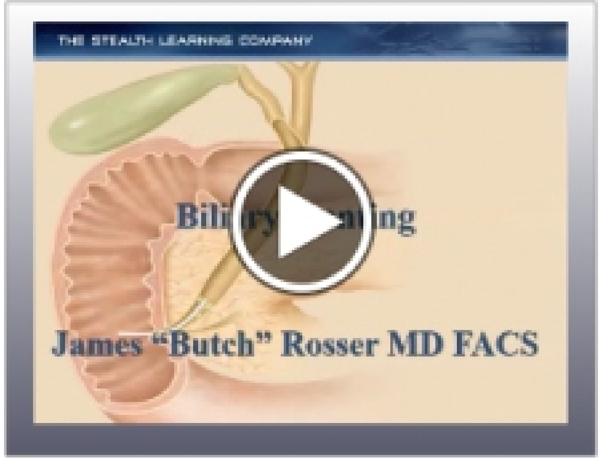
Step 6: Cystic Duct Closure



Once the stones are removed and you have documented complete extraction, the cystic duct has to be closed. Because of obstruction, the biliary tract is often dilated and this frequently includes the cystic duct. A clip is usually not adequate for closure because of the resultant enlargement of the duct. An Endoloop is a very effective appliance to achieve closure. The first step in using this device is to place the Endoloop into the abdomen using the epigastric port. Next, place the cystic duct in the center of the loop. Now, bring a grasper through the mid-clavicular port to grasp the cystic duct. The grasper is then handed to the assistant. At this time, the surgeon should fracture the proximal tip of the Endoloop with the right hand. With the left hand controlling the shaft of the appliance, place the knot of the suture on the cystic duct. While maintaining the knot on the cystic duct, the surgeon pulls back on the fractured tip to tighten the loop with the right hand. Once the loop has been closed securely around the duct, a scissor is brought in through the epigastric port to divide the suture.

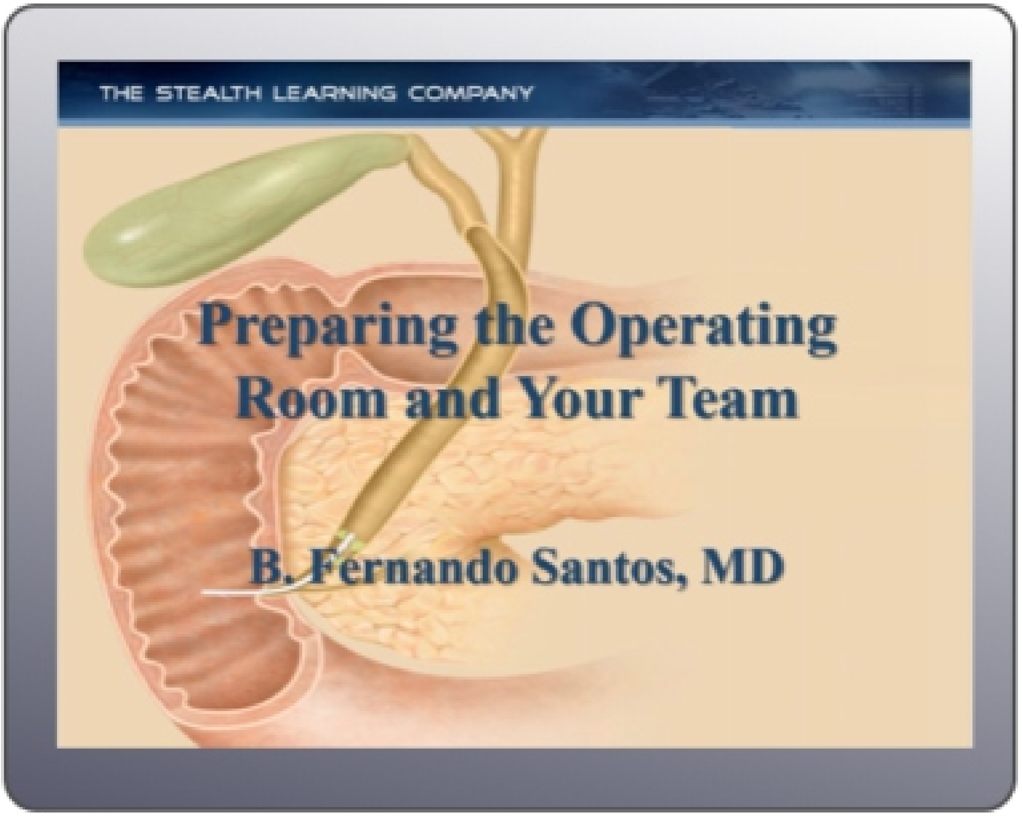
Step 7: Biliary Stenting

There are times when the common bile duct cannot be cleared and stones remain. This is an indication for the placement of a biliary stent to establish drainage of the biliary tract until definitive clearing of the duct can be accomplished. A specialized appliance tailored for the transcystic laparoscopic approach is required. The instrument featured is the Cook Medical Fanelli Endobiliary Stent. To place the stent, you will have to establish guidewire access to the common bile duct. Insert the guidewire into the center working channel of the Fanelli Cholangiogram Catheter three-way adapter. Keep threading the guidewire until it is visualized in the common bile duct, and track it until it enters the duodenum. This should be done under fluroscopic guidance to assure proper placement. Remember to open the Olsen clamp to allow uninterrupted passage of the guidewire. Once the guidewire has been confirmed in the duodenum, the next step is to remove the Olsen clamp and cholangiogram catheter while leaving the guidewire in place. Remember that the surgeon must secure the guidewire when this is done. If you need to reconfirm placement, you may use fluoroscopy.



Now, place the guidewire into the distal tip of the stent. Once the guidewire exits the proximal channel, hand the appliance to the assistant. While the surgeon maintains control of the guidewire, the stent is placed into the abdomen and inserted into cystic duct. The surgeon then feeds the stent into the biliary tract under fluoroscopic guidance until it enters the duodenum.

Now, it is time to deploy the stent. The surgeon must grasp the proximal handle and pull back on the black portion of the outer sheath until the proximal edge touches the white portion of the stent backstop. This will remove the outer security of the stent. During, this maneuver the surgeon must be careful not to dislodge the device. Next, remove the guidewire. Now, rotate the white portion of the inner carrier counterclockwise (it touches the purple Luer lock of the stent backstop) and remove it. This will accomplish final deployment of the stent. Verify proper placement with fluoroscopy.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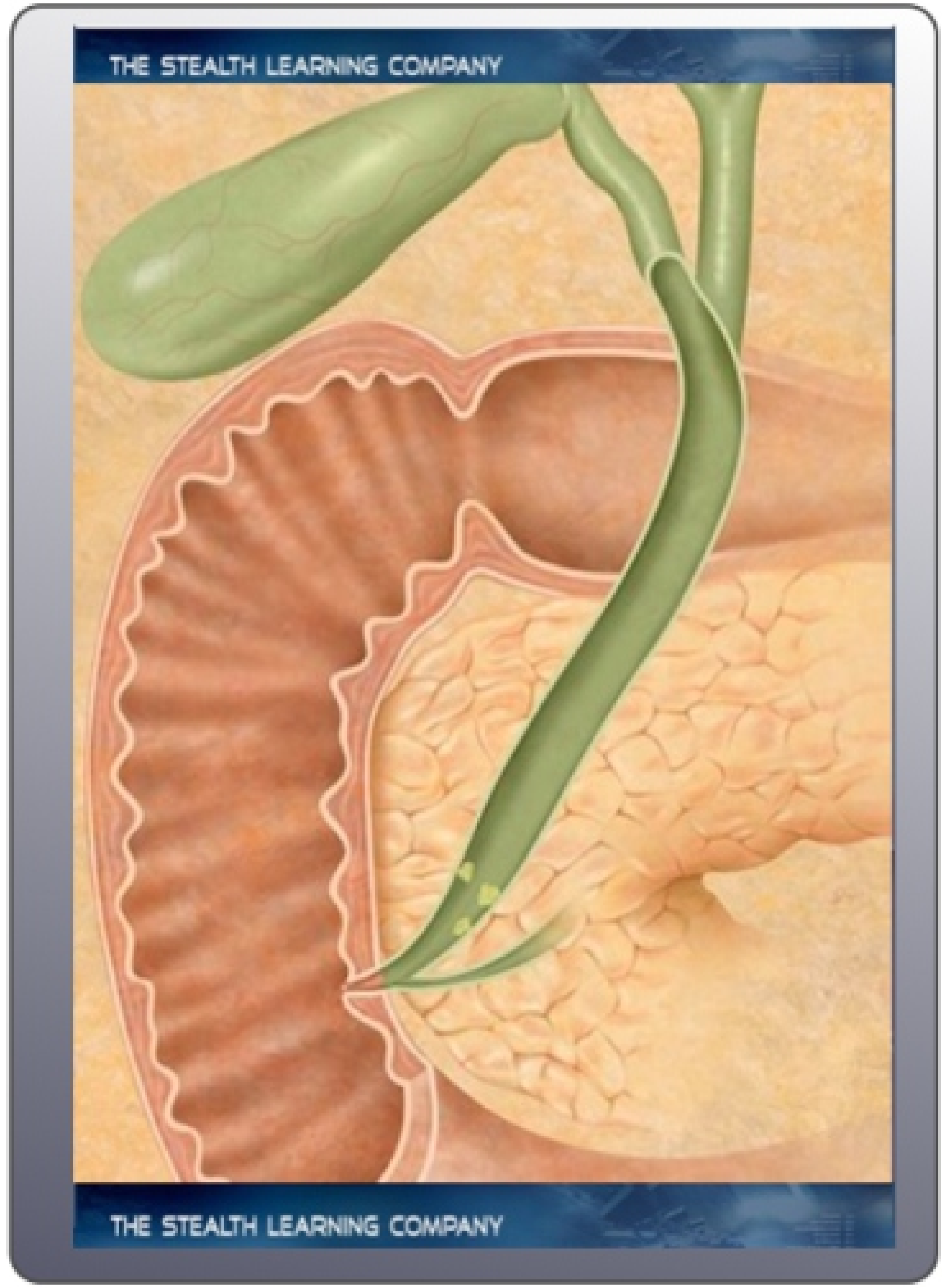
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CHAPTER 10

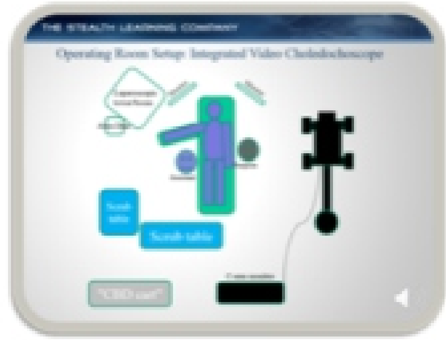
Preparing the Operating Room and Your Team

Introduction

Preparing the operating room and your team for laparoscopic common bile duct explorations is critical for successful adoption of this procedure. There are various aspects of preparation that need to be taken into consideration including, setting up the operating room, organizing your supply and distribution chain, preparing nursing and other members of your operating room team, and reaching out to referring providers and institutional leadership.

First, the operating room. Choose a large operating room that will accommodate the extra equipment that will be required.

Integrated Operating room



You should make sure that the OR table that you are going to use is compatible with fluoroscopy. You should also try to have the C-arm in the room at the beginning of the procedure. This prevents delays from bringing the C-arm in and also prevents clashes between other services that may need it. Also, having a common bile duct cart in the room, or immediately available, helps reduce the amount of scrambling that is required to deploy equipment.

The use of an Alton Dean pressurized saline irrigation unit will also facilitate the procedure by maintaining reliable visualization of the biliary tract. Remember, if you have a nonintegrated video system and need an extra laparoscopic tower for other video inputs, plan for this ahead of time.

Nonintegrated Operating Room

Showcased in the presentation is a typical operating room set up for TLCBDE. It features an integrated video choledochoscope set up. Usually, the C-arm comes in from the pa-

Surgeons Performing a Common Bile Duct Exploration

tient's left side. Typically, the left arm of the patient will be positioned in a tucked fashion so as to not interfere with the C-arm. It should be noted that the surgeon and the assistant typically switch sides once it is decided to perform the bile duct exploration. In an integrated operating room with a video choledochoscope, the choledochoscope typically comes in from the laparoscopic tower or boom with its own light and video cable. This is the most efficient setup.

During the procedure, the C-arm may need to be moved back and forth depending on whether it is interfering with the instruments. Remember, it is important to have enough room to be able to move the C-arm as necessary. If you have a nonintegrated or separate choledochoscope, or one that requires a separate camera head and light cord, an extra laparoscopic tower will have to be brought in in order to connect the choledochoscope. This produces a larger equipment footprint, and is not the ideal setup. However, in some institutions, this is the only available option.

CBD Cart (Posterior View)

CBD Cart (Anterior View)

As mentioned earlier, the Alton Dean unit is the preferred saline pressurization device. It is noteworthy for a number of reasons. Most importantly, it is an adjustable automated pressurization system that insures maintenance of visualization of the biliary tree by stabilizing saline pressure throughout the procedure. Additionally, the unit can use three-liter capacity bags that rapidly replenish the system with saline. The other option is using a one-liter bag with a pressure cuff. This carries a lower cost but it is more labor intensive for the staff and pressurization of the system is not consistent.

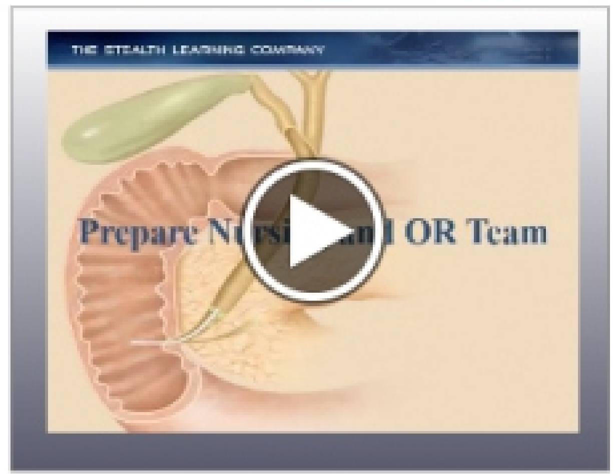
Organize the Supply and Distribution Chain

Next, make sure that you organize your supply and distribution chain. Gather a list of all the necessary supplies needed. You may be surprised to find that your operating room may have many of these products.

Also, check other procedure-based units such as endoscopy, cardiology, or urology. Once all items are gathered, place them on a dedicated common bile duct cart. This cart should only be used for this procedure. Clearly label the drawers and make sure they are barcoded, so they can be routinely inventoried and restocked. Please take note of the picture of a CBD cart used by the author. The anterior view of the cart features various drawers that are labeled and barcoded and on the posterior view there are larger supplies on hooks. This helps to prevent damage to supplies when placed in storage. Presented in a figure is a list of the equipment used for common bile duct exploration.

Prepare Nursing and OR Team

Next, you want to prepare your OR team. You should think of the adoption of this new procedure as the initiation of a new clinical program. It is an undertaking that can be very intimidating. Therefore, generate a concerted effort to get the operating room team up to speed. Your first goal is to get the team on your side. Eliminating the unknown can go a long way in achieving this goal, so that everyone is on the same page as you. Remember, that this procedure will be initially perceived as causing them to work harder, spend more time in the OR, and learn a completely new procedure. Change can make people uncomfortable.



All of this goes away once they have an established practice pattern. You can reduce the initial resistance to change by

Alton Dean Unit

sharing with them the "why." Explain to them that the reason for adopting this procedure is because it is better for the patient. It features "one-stop shopping", eliminates the patient having multiple procedures, and shortens the patient's hospital stay. These are emotional targets people can identify with and it establishes the team on common ground. Remember, as David Rakoff said, "Altruism is innate, but it's not instinctual. Everybody's wired for it, but a switch has to be flipped." In addition, it will take more than heart to establish success. It will also take leadership. Therefore, pick a champion. This is somebody that will take responsibility for nurturing the project and getting everybody organized and on the same page.

As you start out, tactics and equipment requirements will change. Therefore, remember to update your pick sheets. This prevents scrambling for supplies and equipment at the time of the procedure. No surgeon wants to have the operating room team running all over the hospital trying to find equipment while the patient is on the table. It can be detrimental to the patient and fatal to morale. Checklists can play an important role in preventing this from happening. This procedure has many moving parts and you can't keep everything in your head. Create one and use it!!

Saline Bag with Pressure Cuff

Another factor that can help maintain the readiness of your operating room team is the adoption of routine cholangiography as part of your practice. Cholangiography is the foundation of common bile duct explorations, and preparation and execution of this on a regular basis will build confidence and competence. Of utmost importance is having the CBD cart and the choledochoscope immediately available instead of waiting to call for them. Lastly, you have to perform formal education. You should take the leadership initiative and do an in-service to educate the team on equipment and team functions. It is highly encouraged that you train them using simulation. This will allow the staff to practice what they have learned outside of the operating room to establish efficiency and safety inside the operating room.

Another important factor in building a successful laparoscopic common bile duct exploration program is building institutional support and reaching out to referring providers. The emergency department providers and hospitalists are prime targets to provide you patients. Reach out to identify venues where you can present the program to them. Explain the rationale, the benefits of laparoscopic common bile duct exploration, and why it is really better for the patient. Offer to assist them with triage decisions. Provide information on how to rapidly contact you and always provide quality and expedient service as a consultant. This will make them want to call you whenever they have a patient.

Also, aggressively engage gastroenterologists. At first glance, this may not seem to be sound advice, because of perceived conflicts. Once again, explain the rationale and the benefits for the patient. Illuminate the fact that this potentially avoids

LCBDE Equipment List

Laparoscopic Common Bile Duct Exploration Equipment List

Description	Manufacturer	Product Code	Comments
Choledochoscope setup:			
Two laparoscopic video monitors w/ video inputs and picture-in-picture capability			Allows integration of choledochoscope and/or fluoroscopic views with laparoscopic view.
Flexible video choledochoscope IMAGE1 S	Karl Storz	11292 VSK	Deflection of distal tip: 270 degrees Working channel inner diameter: 3.6 Fr/1.2 mm Sheath size: 8.5 Fr/2.8 mm Working length: 50 cm
LUER-Lock tube connector	Karl Storz	27502	Connects saline tubing to scope
Endoscopic seal	Karl Storz	27550ZAG/1	Scope working channel seal
Alton Dean pressure irrigation unit			Pressurizes saline bag for continuous irrigation
Cystoscopy irrigation tubing	Medline	DYND15140	Connects to saline bag
Silastic tubing extension			Extension tubing to facilitate scope handling
3L saline bag			1L bag is acceptable but may have to be replaced more frequently
LCBDE Accessories (have available):			
Fanelli cholangiography catheter	Cook Medical	C-FCC100	
Common bile duct exploration set	Cook Medical	C-CDES-100	Includes: - Biliary wire guide (.035 inch diameter, Teflon coated), (BFSPC-35-145) - Wire stone basket, straight, (C-NTSE-2.4-115-NCT4) - 8mm x 4cm Angioplasty dilating balloon, (C-ATB5-35-40-8-4.0-CDES) - Berci introducer set 12F, (C-CDIS-4.0-15-BERCI)

LCBDE Equipment List
(continued)

LCBDE Accessories (continued):			
High pressure inflation device	Cook Medical	G31027	For pressure-controlled inflation of angioplasty balloon.
5mm x 4cm angioplasty dilating balloon	Cook Medical	G26897	For dilating smaller diameter cystic ducts (3-4mm)
0.025 inch Visiglide guidewire	Olympus	G-240-2545S	For difficult cannulations, smaller diameter but has same stiffness as 0.035 guidewire. Long length allows compatibility with other biliary devices commonly used for ERCP.
14F red rubber catheter			For vigorous flushing of duct through transcholedochal approach.
Segura Hemisphere basket	Boston Scientific	M0063901000	2.4F x 90cm stainless steel basket, has greater radial force to allow easier dislodgement and capture of stones in the papilla.
3-lumen balloon extraction device	Olympus	B-230Q-A	Multiple lumens allow contrast injection, balloon inflation, and use of guidewire to position balloon.
7F Fanelli biliary stent	Cook Medical	C-FBSS-100	7F laparoscopic delivery system – transcystic delivery is possible.
8.5F Advanix biliary stent	Boston Scientific	M00534630	8.5F stent if necessary for improved drainage – transcholedochal delivery is easier than transcystic delivery given proximal flare on stent.
T-tubes, 14F	Bard-Davol	99820	
Laparoscopic Instruments:			
Olsen cholangiography fixation clamp	Karl Storz	26379 CH	
Berci grasping forceps (padded grasper)	Karl Storz	33531 PG, 30510 PX	For gentle choledochoscope handling if necessary
Berci micro-knife (pointed, retractable)	Karl Storz	26169 DO	For making choledochotomy
4-0 Vicryl Suture on RB-1 needle	Ethicon		For choledochotomy closure

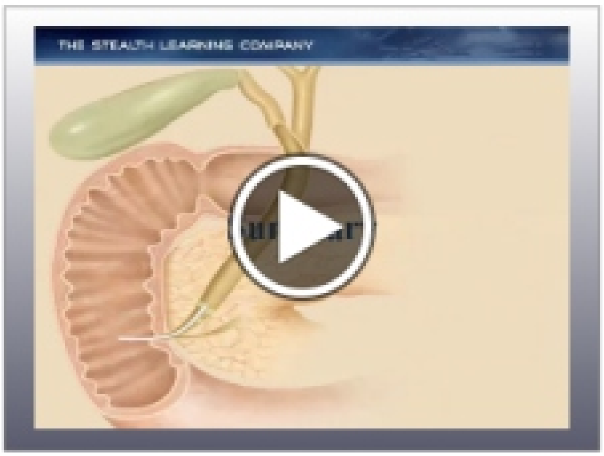
Note: similar products may be available from alternate manufacturers.

ERCP related complications. Reassure them that you are not trying to supplant them for ERCP. Frankly, there are times when the surgical approach will fail. However, with the placement of endobiliary stents, patients can be sent home post-op, and the ERCP to clear the duct becomes non-emergent and easier to perform. In addition, there will be clinical situations where ERCP will always be the procedure of choice. Gastroenterologists today are increasingly busy and will not lose business because of your efforts.

Lastly, make sure the administrative leadership of the surgery department and hospital administration are aware of the rational for starting this program. Explain that this can be a critical asset for institutions that do not have ERCP capability. Emphasize that the competent performance of laparoscopic common bile duct exploration reduces the need to transfer patients. Additionally, in a recent study, it was shown that hospital stays are shortened by two days. Other positive attributes of TLCBDE include a decrease in cost per hospitalization, and a 3.8 to 1 return on investment ratio.

Summary

In summary, it is critical to prepare the OR team to take on the adoption of laparoscopic common bile duct exploration ahead of time. Identify the necessary supply streams and optimize them, inspire and educate your team to do the right thing. Build a system that is organized and always has the equipment you need. Identify your referral base and build it based on patient friendly facts. The initiative has to make sense. Lastly, sell the benefits of TLCBDE to your institution's leadership so they can understand it is worthwhile investing in this program.

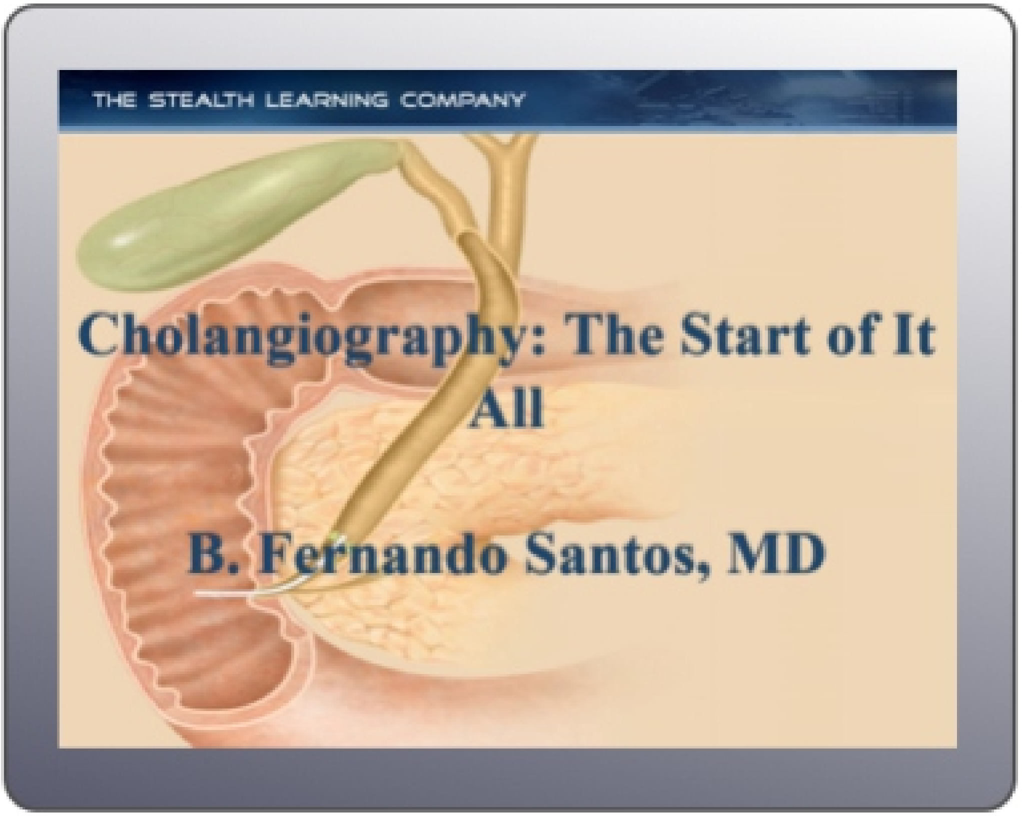


Question 1 of 5

Performing LCBDE using an integrated video choledochoscope requires all of the following except:

- **A.** Pressurized saline source (i.e Alton Dean Unit)
- **B.** Additional laparoscopic tower, camera head, and light cord
- **C.** C-arm
- **D.** CBD Exploration Kit

Check Answer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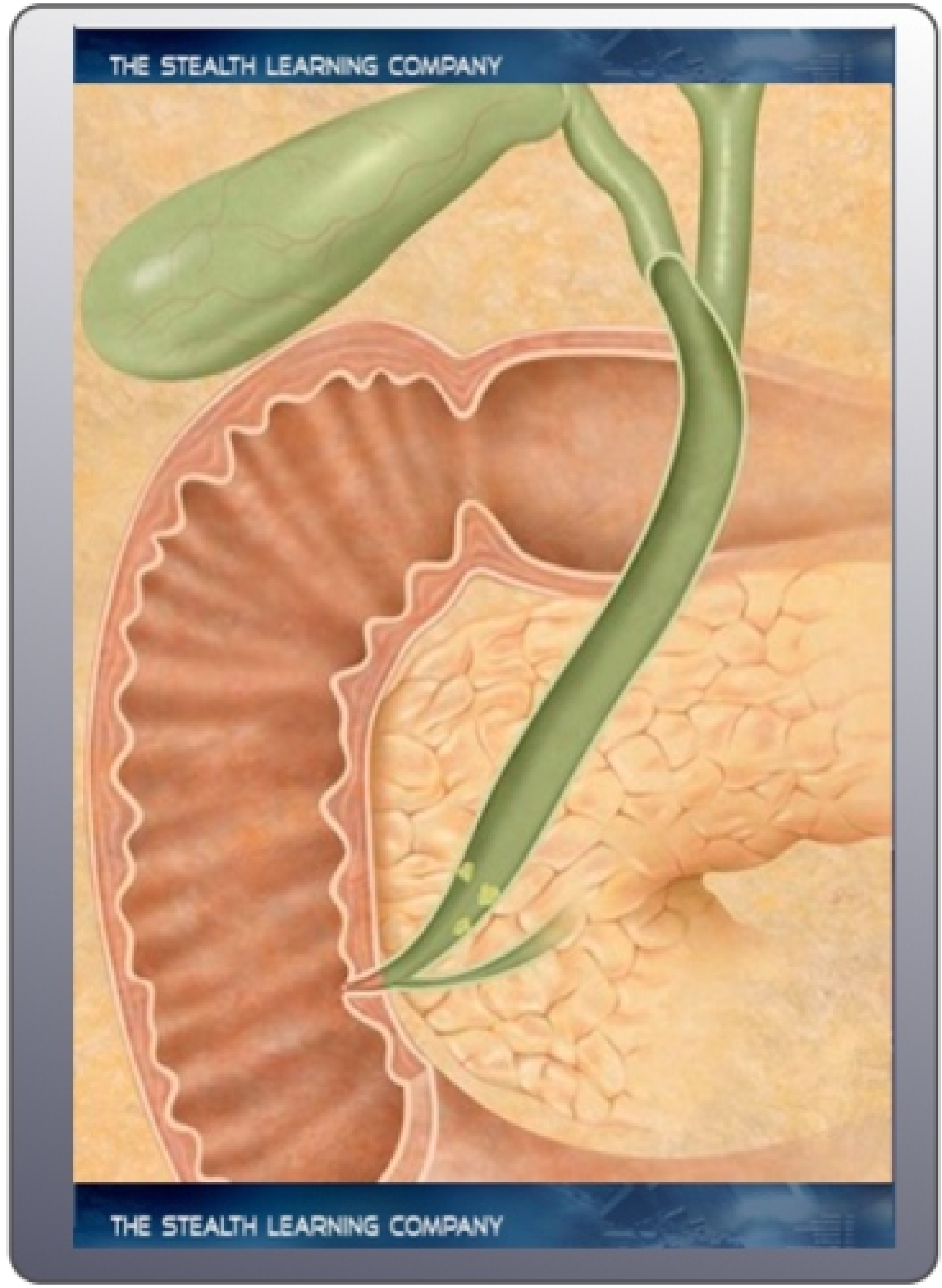
Cholangiography: The Start of It All
B. Fernando Santos, MD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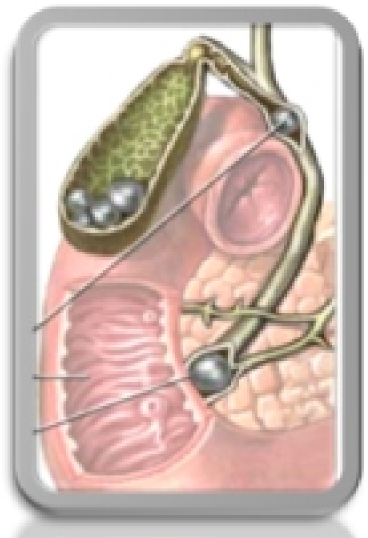
CHAPTER 11

Cholangiography: The Start Of It All

Introduction

This chapter covers all aspects of performing cholangiograms including the rationale for them and how they can be accurately interpreted. The first question to be answered is, why do we care about bile duct stones?

Common bile stones represent a hidden trap in the care of gallstones and laparoscopic cholecystectomy. Bile duct stones are a preventable source of morbidity that can lead to major consequences for the patient including postoperative pain, readmissions, pancreatitis, cholangitis, and bile leaks. Most bile duct stones are silent preoperatively, and



Multiple Common Bile Duct Stones

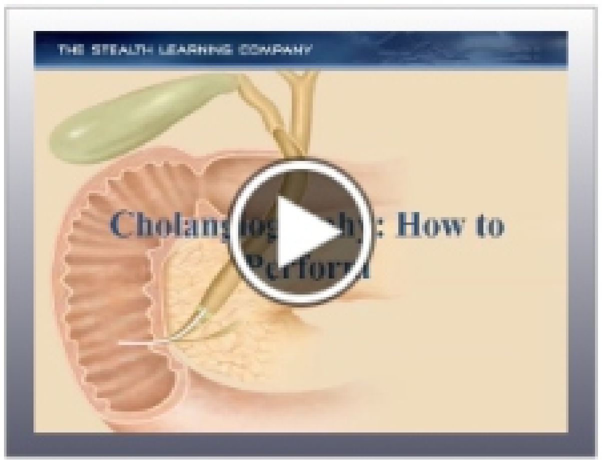
existing preoperative risk stratification strategies, including the ASGE guidelines, can be unreliable in predicting who will actually have stones intraoperatively. Likewise, trending liver function tests does not improve the accuracy of predicting which patients have stones, nor does it reliably predict stone passage.

Some have argued, “Why worry about asymptomatic or small incidental stones in the first place? Don’t these stones just pass?” Actually, newer literature suggests that these stones may not have as benign of a natural history as once thought. Analysis of 30-day outcomes from the GallRiks database from Sweden has shown that 25% of untreated gallstones discovered at the time of cholecystectomy lead to complications if untreated, and this risk is still 16% even for small stones less than 4mm. The data also shows that interventions to clear the biliary tree reduce this risk by at least 50%.

Intraoperative cholangiography, or IOC, has excellent sensitivity and specificity for detection of bile duct stones. It also provides a roadmap of the biliary tree and is safe as long as principles to minimize radiation exposure are followed. Routine IOC leads to competence secondary to regular practice for the surgeon, trainees, and the OR staff. It reduces the risk of inadvertently leaving bile duct stones, identifies biliary injuries or leaks, and it sets up the surgeon to transition to TLCBDE. In the opinion of this author, surgeons who are serious about learning TLCBDE should perform routine IOC.

Cholangiography: How to Perform

The basic tools needed for IOC include a 5 French cholangiogram catheter that allows passage of an 0.035 inch guidewire if necessary. Another appliance that facilitates cholangiograms is the Olsen clamp. It has a channel for passage of the catheter and facilitates fixation of the catheter in the cystic duct. Diluted contrast, typically 50%, is more sensitive for detection of stones compared to full standard concentration contrast. When connecting the catheter to IV tubing, a three-way stopcock, and syringes of saline and diluted contrast, care should be taken to ensure that everything is flushed and no air bubbles are in the system. After securing the Olsen clamp, the operating table should be flattened, and the C-arm brought in.

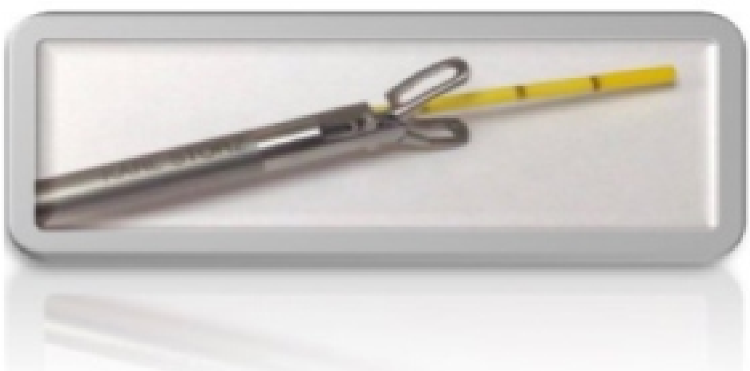


After obtaining a proper position using "live" fluoroscopy, the operator is ready for the cholangiogram. "Cine" mode should preferably be used to record the cholangiogram rather than static images, as it allows for a video replay that helps identify subtle signs of stones and or injuries. Apnea should be maintained by the anesthesia team during the run to minimize motion artifact. In some cases, the patient's spine overlaps and obscures the biliary anatomy on the cholangiogram. An animation is presented in the video that shows a CT scan image corresponding to the patient's anatomy during the cholangiogram. The x-ray beams leave the x-ray tube, pass through the patient, and enter the image intensifier. The cholangiogram on the left side of the animation shows that the vertebral bodies are superimposed directly over the biliary tree in this position. The gallbladder and common bile duct are visible in green on the CT image, along with the vertebral body in blue. One can see that the vertebral body will interfere with the image in this configuration. Rotation of the C-arm to the left anterior oblique, or LAO position moves the vertebral body out of alignment with the bile duct, and produces a cleaner image seen on the left side of the image.

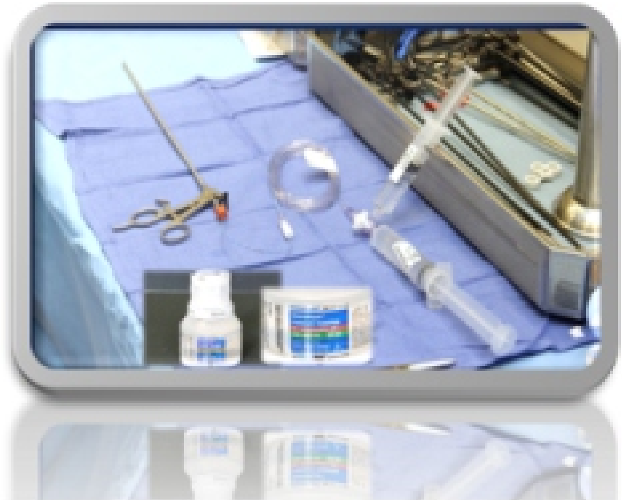
The video presented shows a standard technique for obtaining a cholangiogram. Once the "critical view of safety" has been achieved, a clip is placed on the specimen side of the cystic duct high near the gallbladder. Scissors are then used to create a ductotomy in the cystic duct. It is best to use the left hand for the scissors. Also, establishment of competence using the non-dominant hand can facilitate cannulation of the duct later. The cystic duct is then milked starting from below and compressing upward. In the case presented, stone debris is removed from the cystic duct. Next, the cholangiogram clamp and catheter are placed into the abdomen through the mid-clavicular port. Only a short length of catheter is needed to accomplish the cholangiogram. Once inserted, the jaws of the clamp are closed the duct is infused with saline. If there is a leak the jaws are clamped tighter until there is no leak.

Once the contrast has been infused, you are ready for interpretation of the cholangiogram. The video illustrates the technique of cholangiography, including tricks for difficult cases. If the cystic duct is short, a tie may be placed at the infundibulum to effectively extend the length of the cystic duct for a cholangiogram. A tie placed around the infundibulum is more effective than a clip in this situation, as clips generally are too short to fully occlude the wider infundibulum. The tails should be left long so that the infundibulum can be manipulated easily.

Olsen Clamp and Cholangiogram Catheter



Routine Cholangiography Materials



It is preferable to make the ductotomy with the left hand, as this will prevent the cystic ductotomy location from rotating when it is passed to the right hand. The duct is gently milked from below, along its length, to clear small stones. The catheter is then brought in with the left hand, and the Olsen clamp is secured. Only about 1 cm of catheter length is necessary for insertion into the cystic duct. If the catheter does not pass easily, it may be due to a valve of Heister, or to a narrow duct. Scissors can be used to carefully extend the ductotomy longitudinally past the valve if necessary. Another trick for narrow ducts is to pass a guidewire through the catheter into the biliary tree. The catheter may then be threaded over the wire into position.

The case presented involves a subtotal cholecystectomy in which the anterior wall of the gallbladder is opened and the orifice of the cystic duct is visible. In this situation a balloon tip catheter, an ERCP balloon extraction device, is used to create a seal to occlude the cystic duct enough for a cholangiogram. Filling the balloon with saline allows for a secure seal to perform a cholangiogram. This image shown in this clinical scenario illustrates good positioning of the Olsen clamp in the upper part of the screen, slightly to screen left, away from the spine, leading to a good quality image.

Cholangiography: Systematic Interpretation

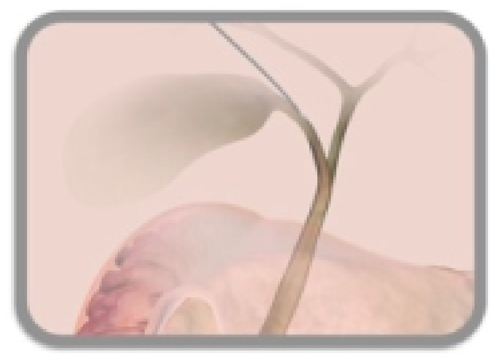
The reading of cholangiograms should be done in a systematic fashion. After obtaining proper position of the c-arm, as described, a "cine" run should be performed while injecting contrast. After reviewing

these images, the surgeon should first determine the position of the cholangiogram catheter. The questions to be asked and answered include, "Is the catheter in the cystic duct as intended? What is the anatomy of the cystic duct and what type of insertion into the common duct does it have?"

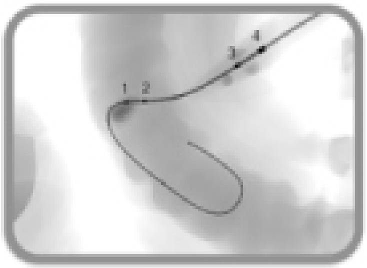
Previous work by Dr. George Berci shows that there is significant variability in the configuration of the cystic duct and its insertion into the common duct, with a "classic" lateral insertion being present in only 17% of patients. Other configurations include anterior or posterior insertion, a medial or spiral insertion, a parallel cystic duct, or a duct with a low or high-insertion into the biliary tree. The diameter of the cystic duct should be noted. This can determine whether a transcystic or transcholedochal approach is necessary.

Next, the common bile duct should be examined, noting its diameter, the presence of any filling defects, and whether contrast empties into the duodenum. If the hepatic ducts are not well visualized, an additional "cine" run should be performed after repositioning the C-arm. The hepatic ducts should be examined to confirm that both right anterior and posterior sectional ducts as

Common Bile Duct



View of Guidewire and Stent in Place

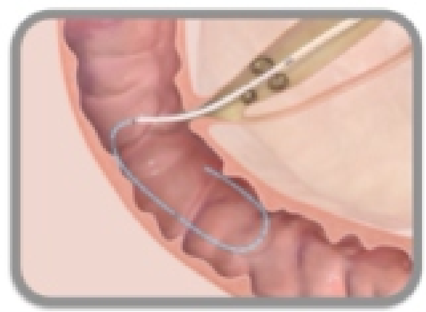


well as the left hepatic duct fill appropriately. Absence of either of these three ducts raises the question of whether they have been occluded or ligated inadvertently. Lastly, the cholangiogram should be examined for any evidence of contrast extravasation which could indicate a biliary injury.

A few practice cases are presented in the video to demonstrate how to systematically read cholangiograms. In case one, the position of the catheter appears to be in the cystic duct, and it has an anterior or posterior insertion, as the cystic duct fills fully and then overlies the position of the common duct as it opacifies. Next, examine the diameter of the cystic duct. The diameter of the Olsen clamp can be used as a reference point because it measures 5 mm in diameter. Comparison of the Olsen clamp with the cystic duct reveals it to be about 5-6 mm in this case. Next, determine the size of the common bile duct. Its diameter is about 9 mm, and has what appears to be a distal filling defect consistent with a stone. There is emptying of contrast into the duodenum in this case. The hepatic ducts (right anterior seen more cephalad, and right posterior seen more caudad, along with the left hepatic duct) all fill and appear normal. Lastly, there is no contrast extravasation or sign of injury.

After a TLCBDE and stone removal a closing cholangiogram should be completed. You must start your systematic interpretation all over again. Once again, start by examining the cystic duct. There is no contrast extravasation from the duct, which had been balloon dilated. Next, examine the common bile duct, which appears free of filling defects and there is good emptying of contrast into the duodenum. The hepatic ducts are normal. There are no signs of injury, although there is opacification of an additional structure just medial to the papilla.

Image Showing Guidewire Being Used



This is retrograde filling of the pancreatic duct, which can be seen in some cases. In summary, this shows a normal closing cholangiogram after LCBDE.

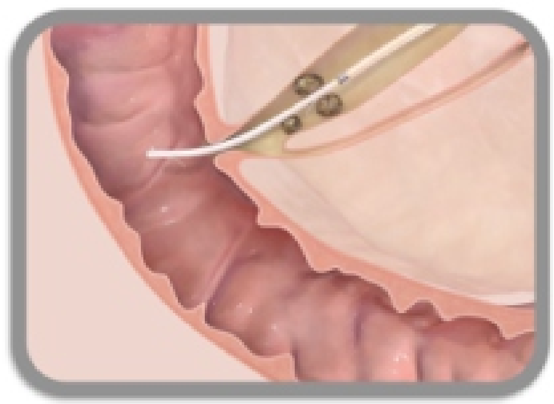
In case two, the initial cholangiogram is shown to illustrate the interpretation process. Again, start with the evaluation of the position of the catheter. In this case, it does appear to be cannulating the cystic duct. The cystic duct is a spiral duct with a medial insertion into the common bile duct. The diameter of the cystic duct is about 5-6 mm based on the reference diameter of the Olsen clamp. The common bile duct is approximately 9 mm in diameter and shows no obvious filling defect. However, there is a lack of emptying distally into the duodenum. An obstructing stone was later confirmed with TLCBDE. The hepatic ducts are normal and fill appropriately on both sides. There are no signs indicating bile duct injury. Subsequently, a completion cholangiogram is presented. It shows brisk emptying of contrast into the duodenum. There is extravasation that is noted in the cholangiogram. However, this is due to leakage of contrast around the catheter rather than bile duct injury.

Image Showing Contrast Medium Being Used

A third case is presented showcasing the initial cholangiogram. It should be noted that the position of the Olsen clamp is too far to the screen right, which may limit the view of the biliary tree. Start again with the cystic duct and confirm that the catheter is indeed cannulating the cystic duct. The cystic duct has a squiggly appearance due to the valves of Heister. It enters the common duct laterally. In this case, it is approximately 2-3 mm in diameter. The common bile duct appears to be 8 mm in diameter and has a small 3-4 mm filling defect distally. There is emptying of contrast into the duodenum. The hepatic ducts are not seen, due to positioning of the C-arm. Likewise, the vertebral bodies interfere with a clean view of the bile duct. The cholangiogram should be repeated at a higher position, and with a 10-15 degree LAO rotation to move the vertebral bodies out of the way of the bile duct. Lastly, in this case, there are no signs of injury.

A fourth case is presented. Once again, start with examination of the catheter. It does appear to be cannulating the cystic duct, noted by the appearance of the valves of Heister. There is a lateral insertion of the cystic duct into the common bile duct, and the cystic duct is approximately 2 mm in diameter. The common bile duct itself is about 8 mm at its proximal segment, and then tapers slightly distally. At the distal end of the common bile duct, one notices an abrupt cutoff of the contrast, called a "meniscus sign". This sign occurs when contrast only reaches the proximal surface of an obstructing stone without any of the contrast passing around the stone. Thus, only the proximal surface of the stone is visible, rather than what

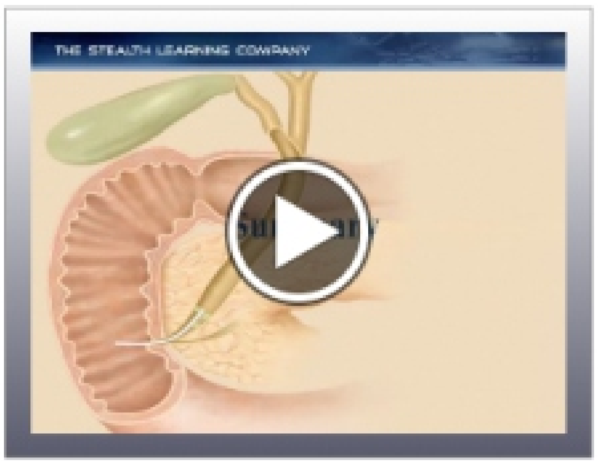
Stent with Backstop Engaged



might otherwise be seen as a round filling defect inside the contrast column. In this situation, there is no emptying of contrast into the duodenum. The hepatic ducts are not seen in this image. Again, the cholangiogram should be at some point repeated with a higher view to delineate the intra-hepatic ducts. Despite the limited view, there does not appear to be any sign of injury here.

Summary

In summary, IOC is an effective and safe tool for detecting stones and increases the margin of safety in laparoscopic cholecystectomy and TLCBDE. We recommend routine IOC as it improves technical performance and facilitates TLCBDE. The surgeon should become familiar with tricks to successfully complete IOC, even in difficult cases. Systematic interpretation of IOC images becomes straightforward with practice and is essential to maximize diagnostic accuracy and maintain safety.

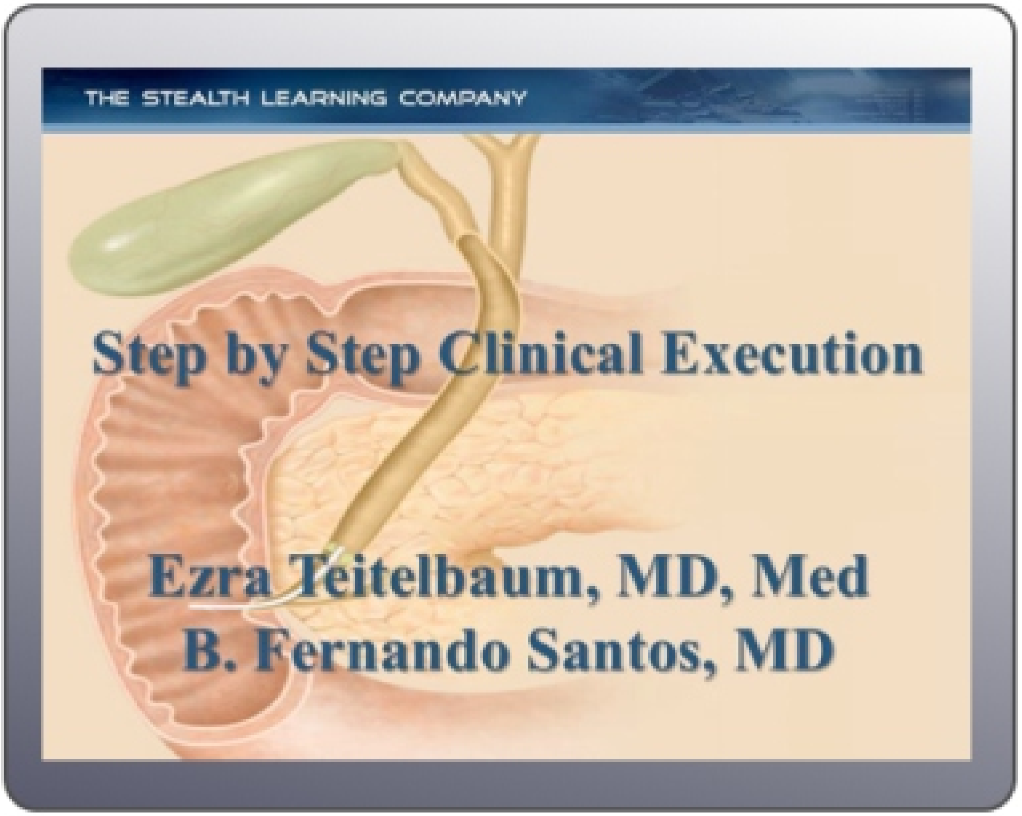


Question 1 of 5

The most accurate means of predicting common bile duct stones at the time of laparoscopic cholecystectomy is:

- **A.** Preoperative MRCP
- **B.** Calculate the ASGE criteria and trend liver function tests
- **C.** Preoperative ERCP
- **D.** Cholangiography

Check Answer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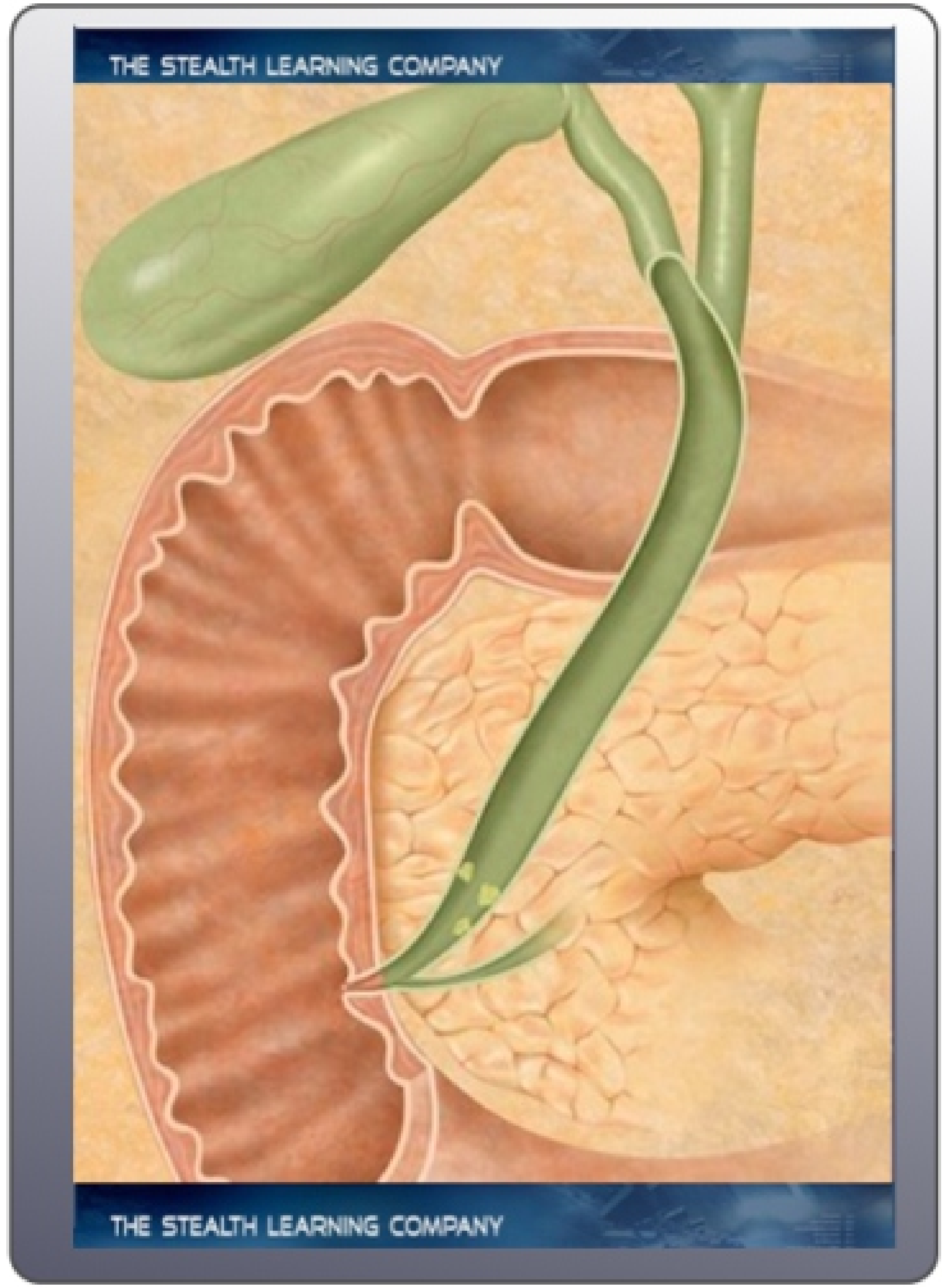
Step by Step Clinical Execution
Ezra Teitelbaum, MD, Med
B. Fernando Santos, MD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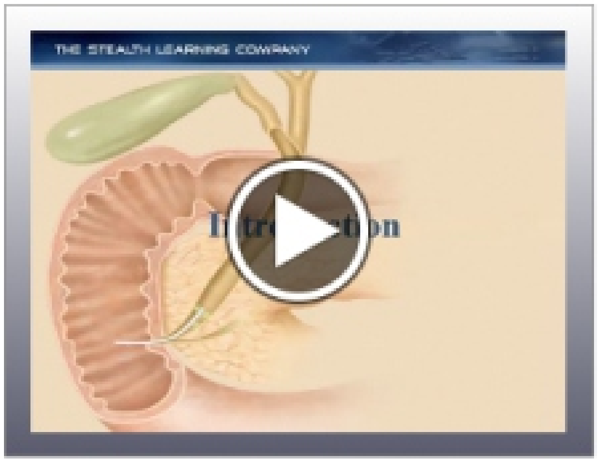
CHAPTER 12

Step By Step Clinical Execution

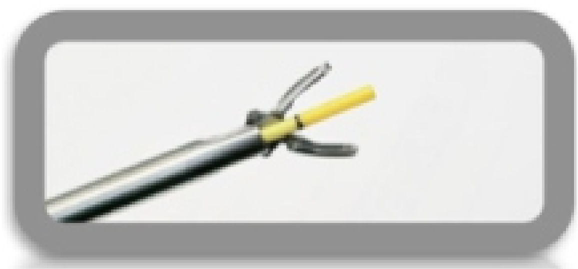
Introduction

This section will review introductory considerations for the TLCBDE. This includes patient selection and the management algorithm. First, we will focus on appropriate patient selection. You will encounter a variety of clinical presentations of gallstone disease as a general surgeon. Most patients presenting for cholecystectomy will have either biliary colic or acute cholecystitis. Some of these patients may have underlying common duct stones that are either asymptomatic or may present as biliary colic. There may be liver function test abnormalities or imaging findings that suggest the possibility of common duct stones, but these are not always present. If there are no medical contraindications, these patients may be approached with a "surgery-first" strategy, especially if routine intraoperative cholangiography is planned.



Patients with common duct stones may also present with pancreatitis. Patients with mild to moderate gallstone pancreatitis should undergo cholecystectomy with cholangiography once the pancreatitis has resolved, ideally during the same hospital admission, to reduce the risk of recurrent pancreatitis. The algorithm for patients with severe pancreatitis or with peri-pancreatic fluid collections is different, however. These patients are generally critically ill and should only be considered for interval cholecystectomy once they have fully recovered, typically at least 6 weeks after the episode of pancreatitis. Early intervention in these patients increases the risk of infecting the peri-pancreatic fluid collections and has higher morbidity compared with delayed intervention.

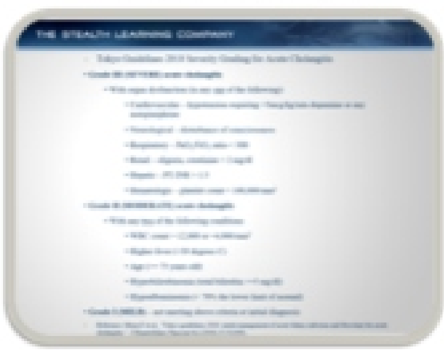
5 Fr Open Tipped Cholangiogram Catheter



Patients presenting with cholangitis should be assessed and the severity of cholangitis determined using the Tokyo criteria. Patients with mild cholangitis according to the Tokyo criteria are generally suitable candidates for cholecystectomy with IOC and bile duct exploration. Patients with more severe cholangitis; however, especially those with hemodynamic instability, should generally undergo endoscopic drainage first, as surgery is associated with higher morbidity in this setting.

Many patients presenting with symptomatic biliary obstruction may have benign stone disease as the underlying etiology and may be approached surgically. However, the surgeon should have a higher suspicion for possible malignancy in this setting, especially if there is associated weight loss, painless jaundice, or other imaging findings suspicious for cancer. Patients with a suspicion of malignancy should undergo appropriate workup first with MRCP, and/or ERCP/EUS to confirm that the obstruction is due to biliary stone disease, and not cancer, prior to cholecystectomy.

Tokyo Guidelines



Lastly, some patients may be asymptomatic and present with stones as an incidental finding on imaging. These patients do need cholecystectomy, and are the ideal candidates for bile duct exploration as the preparations for common duct exploration can be made ahead of time. To summarize, most candidates for cholecystectomy will be suitable for a "surgery-first" approach without needing preoperative ERCP. The surgeon should be familiar with the contraindications to this approach including severe cholangitis, severe pancreatitis, medical contraindications to cholecystectomy, and patients in whom the surgeon suspects malignant obstruction.

The Management Algorithm

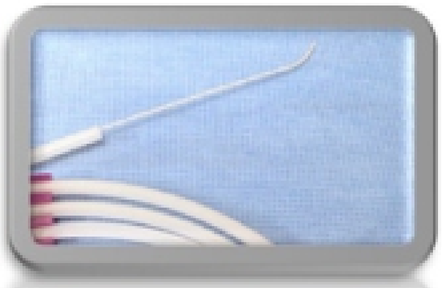
Next, we will discuss an intraoperatively management algorithm for how to identify and treat common bile duct stones. A laparoscopic cholecystectomy is begun in usual fashion.

Once the "critical view of safety" has been obtained, the next step is to perform an intraoperative cholangiogram in order to define ductal anatomy and identify choledocholithiasis. Accurate interpretation of the cholangiogram is essential in identifying stones in the common duct. Furthermore, there should be definition of their size and location.

This is often not entirely straightforward. Maturation of competence in cholangiogram interpretation can be facilitated by performing routine cholangiography during cholecystectomy. This will assist in gaining a thorough familiarity with what normal intraoperative cholangiograms look like.

If choledocholithiasis is identified, and the stones are 3 mm or less, an attempt should be made to flush the stone or stones into the duodenum. If this is successful a TLCBDE can be avoided. Glucagon, 1 or 2 mg IV, can be given to relax the sphincter of Oddi. Several hundred milliliters of saline are then flushed through the cholangiogram catheter and the IOC is repeated. Remember, this is typically only effective for stones 3 mm or smaller. Attempting to flush larger stones is not encouraged given that sometimes the stones migrate proximally into the hepatic ducts and may become difficult to remove. If flushing is unsuccessful, then the optimal treatment approach must be determined. The best option varies based on stone characteristics (size, number, and location), cystic duct anatomy, and the surgeon's familiarity with different approaches for LCBDE.

0.035 Inch Flexible Tip Hydrophilic Guidewire



If choledocholithiasis is identified and flushing is unsuccessful, the next step is to determine the optimal treatment approach for clearing the common duct. Transcystic exploration is generally favored as the initial approach given its relative safety and lower technical complexity compared to transcholedochal exploration. With this goal in mind, the surgeon should first determine whether the stone characteristics are appropriate for transcystic removal. Stones located in the common duct are easily reached from the cystic duct, compared to stones in the common hepatic or proximal hepatic ducts which are less common and more difficult to reach from a transcystic approach. Proximal stones are usually better approached through a transcholedochal CBDE or postoperative ERCP.

Next, the stone size should be measured. Stones larger than 6 mm will be more safely and easily approached through transcholedochal CBDE or postoperative ERCP. Attempting to remove stones greater than 6 mm from the cystic duct increases the risk of entrapping a stone basket or causing an avulsion injury of the cystic duct-common duct junction and should generally be avoided. Stones 6 mm or less may be amenable to a cystic duct approach, if the cystic duct size is adequate. Next, the surgeon should assess the stone burden in the duct. Generally, if the patient has more than 5 stones, transcystic removal will be a tedious and drawn-out affair and these cases are generally better managed with transcholedochal CBDE or postoperative ERCP. If 5 or less stones are present, transcystic exploration is reasonable.

Next, the cystic duct diameter should be measured to determine whether it will be safe to extract stones through the cystic duct. A cystic duct less than 4 mm in diameter will generally not allow passage of a scope or dilation to 6 mm, and these patients should be approached with transcholedochal CBDE or postoperative ERCP. Of course, this depends on the expertise of the providers and equipment available at the institution.

Finally, the surgeon should examine the anatomy of cystic duct insertion. A medial spiral insertion, a low insertion into the common duct, or insertion into the right hepatic duct, for example will be less amenable to transcystic exploration, and alternative approaches should be considered. A lateral or anterior/posterior insertion of the cystic duct will be more amenable to transcystic exploration. If TLCBDE is attempted and is not successful, intraoperative biliary stenting or postoperative ERCP should be considered.

Transcystic LCBDE Procedure Overview

This section will feature a discussion of the specific steps and techniques for performing a TLCBDE. First, there will be an overview of the procedure steps, followed by a more detailed explanation. The steps are as follows:

1) Port placement and dissection to obtain critical view of safety

The surgeon first places ports similar to a laparoscopic cholecystectomy and performs a dissection of the hepatocystic triangle until reaching the critical view of safety.

2) Cholangiogram

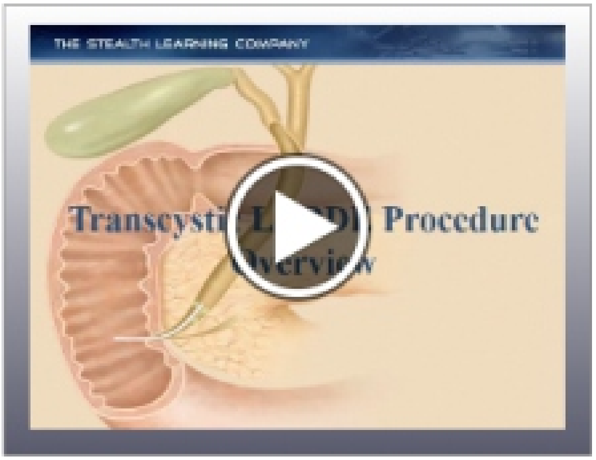
The surgeon then performs a cholangiogram.

3) Wire access

If common bile duct exploration is necessary, the surgeon obtains wire access into the common bile duct and duodenum.

4) Cystic duct dilation (if necessary)

Next, the surgeon must determine if cystic duct dilation is necessary and, if so, what diameter dilation is required.



5) Choledochoscope insertion and maneuvering

Next, a flexible

choledochoscope is inserted over the guidewire and through the cystic ductotomy. The scope is maneuvered through the cystic duct and into the common duct until the first stone is encountered.

6) Stone capture and extraction

The stone is then captured using a wire basket and the scope is withdrawn in order to extract the stone. If more than one stone is present in the common duct, steps 5 and 6 must be repeated until all the stones have been removed.

7) Completion cholangiogram

After the common duct has been completely cleared, a completion cholangiogram is performed to ensure no stones have been missed.

8) Cystic duct ligation

Lastly, the cystic duct is ligated and then the cholecystectomy is completed in the standard fashion.

Port Placement

Port placement is the same as a conventional laparoscopic cholecystectomy with the lateral trocar for a retractor holding the fundus cephalad over the liver, and the surgeon's left and right hands performing the gallbladder dissection. An extra right lower quadrant trocar may be inserted to assist with ex-

posure of the gallbladder neck, especially in obese patients. Once it is time to perform a cholangiogram, the Olsen clamp should be placed in the surgeon's left hand to secure it in the cystic duct. At this time, the lateral retractor is secured to the patient's skin by using a non-penetrating towel clip. This maintains exposure of the operative site by allowing the assistant to let go of the instrument while the cholangiogram and exploration is performed. The mid-clavicular trocar will serve as the portal through which wire access, balloon dilation, and choledochoscope passage will occur.

Cholangiogram

Next step is to obtain a cholangiogram. Please refer chapter 11, Cholangiography: The Start of it All for more details.

Guidewire Access

After the cholangiogram confirms common duct stones that are amenable to TLCBDE, the first step is to pass a guidewire through the cholangiogram catheter and into the common duct and duodenum. A 0.035 inch flexible-tip hydrophilic guidewire is used and can be passed through a 5 French open-tipped cholangiogram catheter. The contrast and saline syringes can be removed and the guidewire threaded directly into the IOC catheter, or an adapter can be used that allows for wire insertion. Wire passage should be observed under fluoroscopy, so that the surgeon can control the path of the wire and confirm advancement into the duodenum. Gentle back and forth movements of the wire will encourage its passage.

The wire typically gets hung up in one of two places, either on the spiral valves of the cystic duct or at the ampulla. Both obstructions can be overcome by gently manipulating the wire back and forth, while torqueing it one way or the other to change the orientation of its angled tip. Try to avoid curling the wire too much and avoid advancing against excessive resistance to minimize the risk of perforation by the wire. If a 0.035 inch guidewire is difficult to pass, a 0.025 inch guidewire may be tried instead. Once the wire passes through the ampulla, it should be advanced far into the duodenum until only 10 to 20 cm of wire remains outside the patient. This will help prevent retrograde migration of the wire and loss of access during subsequent steps.

Cystic Duct Dilation

The next step of the procedure is determining the need for cystic duct dilation. If dilation is required, the dilation diameter must also be chosen. This is done based on a number of factors. As mentioned previously, the shaft of the Olsen clamp serves as an ideal 5 mm ruler and should be compared against the other structures. A cystic duct with a large diameter, and with a diameter larger than the diameter of the largest stone, does not usually require dilation. A cystic duct smaller than 4 mm will not be amenable to transcystic scope insertion and should generally not be dilated. If the duct is at least 4 mm, and the stone is larger than the cystic duct, the surgeon should determine how much to safely dilate the cystic duct. A cystic duct of 4 mm in diameter can be dilated to 6 mm. A cystic duct 6 mm in diameter may be dilated to 8 mm. Thus, a good rule of thumb is to not dilate the cystic duct more than 2 mm larger than its native diameter to minimize the chance of causing ductal injury.

Next, the diameter of the common bile duct is assessed, which in the case presented is about 10 mm. Under no circumstances should you dilate to a diameter wider than the common duct. This can risk causing a common duct injury. In the case shown in the video, the cystic duct measures 4-5 mm and the size of the stone is 3-4 mm. The diameter of flexible choledochoscopes is typically 2-3 mm. Thus, the duct does not need to be dilated in order to accommodate the choledochoscope and to remove this stone unless spiraling or valves block its passage.

Once the need for dilation has been determined, the dilation procedure proceeds using a Seldinger technique, in which instruments are sequentially thread over a guidewire and through the cystic ductotomy. When removing instruments, such as the cholangiogram catheter shown in the presentation, it is important to hold the wire in position using a laparoscopic grasper. This prevents retrograde migration, which can cause it to flip out of the cystic ductotomy. This will necessitate starting the procedure over from the beginning. After removing the Olsen clamp, thread the cystic duct introducer sheath over the wire. The stiff gray obturator should not be advanced into the duct. It may be removed once the sheath is in the abdomen. Advance the sheath and the trocar until it is near the cystic ductotomy. The sheath will reduce leakage of carbon dioxide from the trocar and will minimize bowing of wire-guided instruments.

If on the cholangiogram, it is determined that cystic duct dilation is required, the next step is to remove the IOC catheter and insert the appropriate-sized balloon dilator catheter over the wire. The inner channel of the dilator should be irrigated with saline, to facilitate smooth passage over the hydrophilic guidewire. The dilator has two radiopaque markers at either tip. It should be inserted into the cystic duct until the second marker is barely visible just outside the ductotomy. With or without a pressure injector, the balloon catheter is filled with contrast to inflate the dilator. The dilator is held inflated for at least 5 minutes to ensure full ablation of all of the spiral valves of the cystic duct.

Dilation should be performed under fluoroscopy to confirm the position of the balloon in relationship to the cystic duct and common duct. Also, this ensures that the cystic duct has been uniformly dilated and no areas of narrowing are present.

In the video, the two radiopaque markers on either end of the dilating balloon are shown. The balloon is inflated with contrast, so that its outline can be visualized on fluroscopy. Using a 4 cm length dilating balloon, it is sometimes necessary to perform two dilations to expand the entire length of the cystic duct. The proximal dilation should be performed first and then the balloon must be completely deflated before advancing it distally. Dilation should cross the cystic-common duct junction. For this reason, dilation should never be performed to a diameter wider than the native common bile duct to avoid CBD injury.

After dilation is complete, the balloon catheter is removed and again the wire is held with a grasper to prevent loss of wire access.

Choledochoscope Insertion and Maneuvering

Now the surgeon is ready for insertion and navigation of the choledochoscope into the distal common bile duct. To introduce the scope, the wire is fed retrograde through the distal end of its working channel and exteriorized from the proximal working channel.   The choledochoscope view should now be made available to assist during scope insertion. This can either be a picture-in-picture view (preferred), or a view on a separate monitor.   A video choledochoscope with integrated picture-in-picture is the ideal setup. The side port on the scope is attached to cystoscopy tubing which runs continuous saline through it. It is pressurized to approximately 180 mmHg. This is essential to achieving good visualization once the scope has entered the ductal system. Lastly, a padded grasper is used to hold and manipulate the scope internally without damaging it.

The scope is then gently advanced over the guidewire and into the ductotomy. This can usually be done by pushing the scope from outside the patient, but in some cases, there is too much of an angle between the scope and the cystic duct, and the scope must be grasped internally with a padded grasper and gently advanced. Once the scope is within the common duct, the guidewire can be removed. This improves the flow of irrigation and in turn visualization. The scope is then slowly advanced down the common duct until the first stone is encountered.

Choledochoscope insertion may also be done using a "freehand" technique without a guidewire. The saline irrigation should be turned on prior to scope insertion to distend the ducts and maintain visualization. The tip of the scope is guided into the cystic ductotomy, and through the cystic duct using fine steering maneuvers. Attention to both laparoscopic and choledochoscopic views is necessary to ensure the scope is not bowed and is able to steer through the cystic duct and into the common bile duct. Traditional flexible choledochoscopes utilize fiber optics for visualization. Due to the small size of the scope, and the nature of fiber optic bundles, these scopes suffer from relatively poor visualization. They require adjustment of the focal length and light intensity, have a pixelated appearance, and are extremely fragile. Recently, digital video choledochoscopes have been made commercially available that utilize video chip cameras. As shown in the comparison presented in the video, this technology results in dramatically improved visualization.

Stone Capture and Extraction

Now, it is time to capture and remove the stones. First, a wire basket is passed through the working channel of the choledochoscope. A nitinol basket that has 4 wire tines with a netting element at its distal tip is a very effective appliance for this task. However, a basket without netting can also be used. Next, the wire basket is advanced in a closed position past the stone and then opened distal to it. The basket is then slowly trawled backwards in order to capture the stone.

At times the stone can be impacted at the ampulla. Opening the basket distal to the stone and trawling backwards is useful in dislodging such stones. Once the stone is free and alongside the basket, a gentle back-and-forth motion with the basket can be used to capture the stone. When the stone is within the basket, it is slowly closed to entrap it. If one is not successful dislodging a stone from the papilla with a nitinol basket, a steel wire basket with greater radial expansion force may be tried. Once the stone is free-floating, the basket is maneuvered around it and then closed. Next, pin the stone against the face of the scope by carefully pulling all of the slack out of the wire.

Typically, the scope can be slowly withdrawn with a small amount of resistance as the stone comes through the cystic duct. Once out of the cystic duct, the stone can be collected using a laparoscopic stone grasper and removed from the abdomen. However, in the first case presented, the stone was approximately 10 mm in diameter and a grasper was needed to milk it

through the cystic duct. This illustrates the need for careful selection of stones when using a transcystic approach. Generally, stones no more than 6 mm should be treated with a transcystic approach. A stone basket can become stuck in the cystic duct and is a scenario best avoided by not being overly aggressive with patient selection.

After all the common duct stones have been removed in this manner, drive the scope back into the common duct and through the ampulla into the duodenum to confirm clearance. The ampulla can be carefully inspected on withdrawal, and any small stones or sludge still stuck there can usually be flushed into the duodenum by injecting saline with a syringe through the scope's working channel.

Completion Cholangiogram

Even when the common duct is confirmed to be clear with the choledochoscope, a completion cholangiogram should always be performed. Completion IOC confirms that no stones have migrated up into the hepatic ducts during the exploration and serves as a functional study to ensure that ampullary edema is not causing a partial or complete biliary obstruction. Completion IOC is also used to evaluate for biliary injury from the procedure, which would be demonstrated by contrast extravasation.

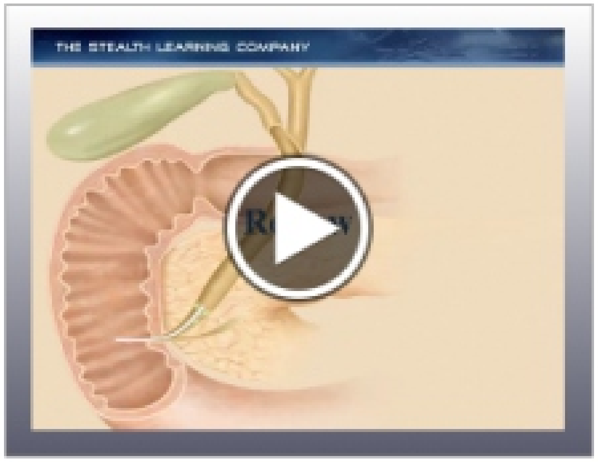
Cystic Duct Ligation

The cystic ductotomy usually becomes quite stretched during TLCBDE. This is from dilation, scope manipulation, and stone extraction. For this reason, it is preferable to use a ligating loop, rather than clips to close the cystic duct stump. For TLCBDE, it is not necessary to leave an intraperitoneal drain, unless there is concern regarding the cystic duct closure or another source of bile leak. See chapter 6, You Are Only As Good As Your Tools, for details on how to apply the loop ligature.

Review

Once again, let's review the major steps of the procedure:

1) Port placement and dissection to obtain critical view of safety



The surgeon first places ports similar to a laparoscopic cholecystectomy and performs a dissection of the hepatocystic triangle until reaching the critical view of safety.

2) Cholangiogram

The surgeon then performs a cholangiogram.

3) Wire access

If common bile duct exploration is necessary, the surgeon obtains wire access into the common bile duct and duodenum.

4) Cystic duct dilation (if necessary)

Next, the surgeon must determine if cystic duct dilation is necessary and, if so, what diameter dilation is required.

5) Choledochoscope insertion and maneuvering

Next, a flexible choledochoscope is inserted over the guidewire and through the cystic ductotomy. The scope is maneuvered through the cystic duct and into the common duct until the first stone is encountered.

6) Stone capture and extraction

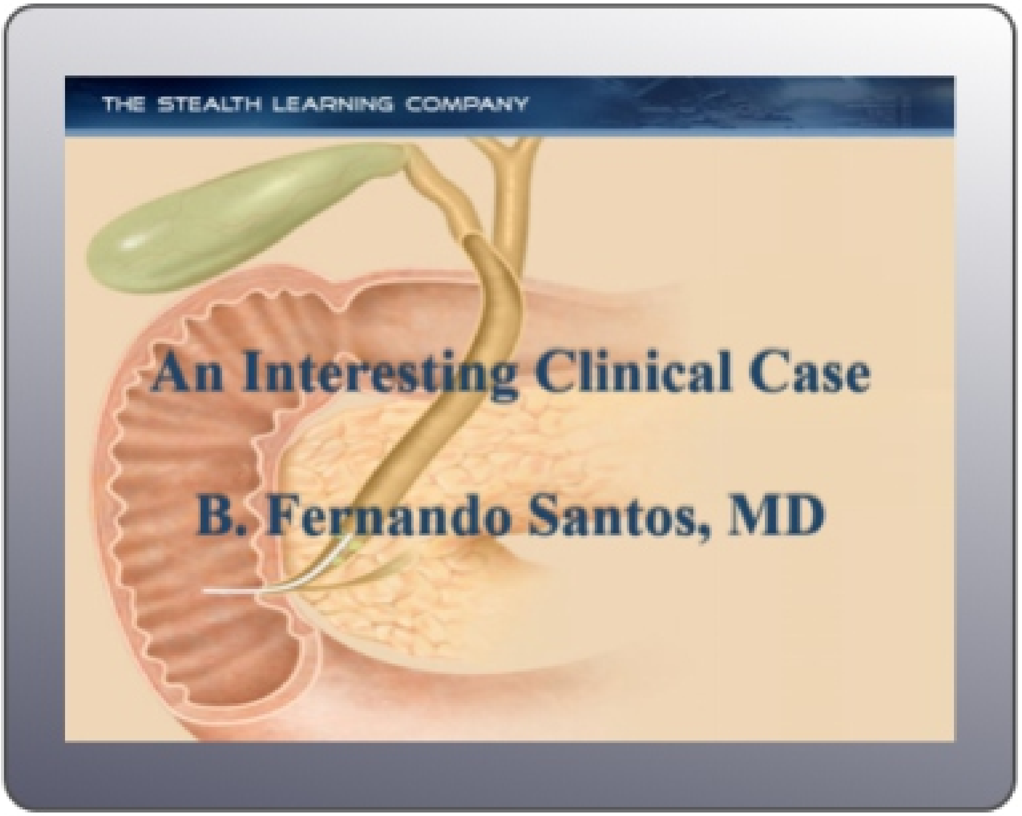
The stone is then captured using a wire basket and the scope is withdrawn in order to extract the stone. If more than one stone is present in the common duct, steps 5 and 6 must be repeated until all the stones have been removed.

7) Completion cholangiogram

After the common duct has been completely cleared, a completion cholangiogram is performed to ensure no stones have been missed.

8) Cystic duct ligation

Lastly, the cystic duct is ligated and then the cholecystectomy is completed in the standard fashion.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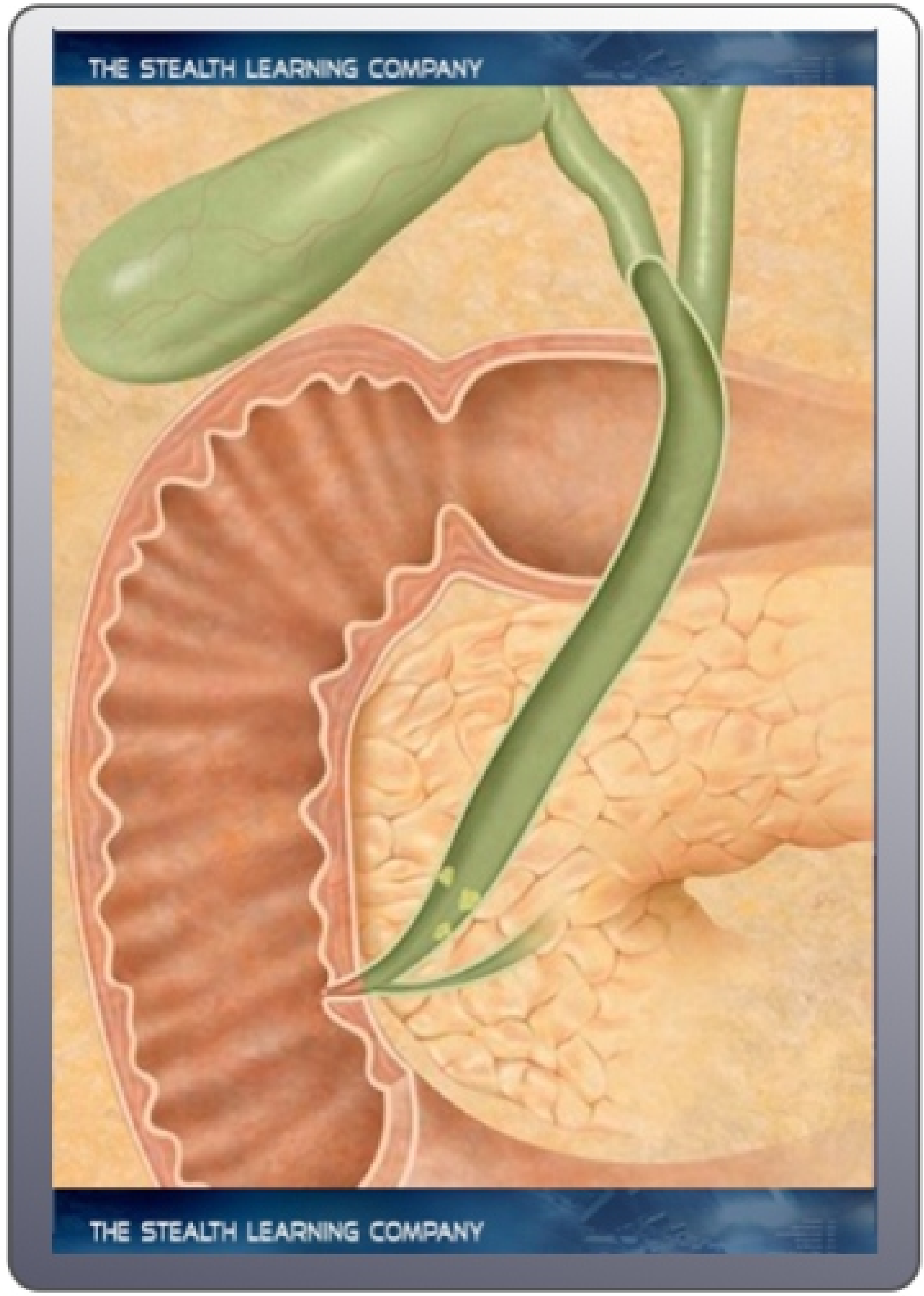
An Interesting Clinical Case
B. Fernando Santos, MD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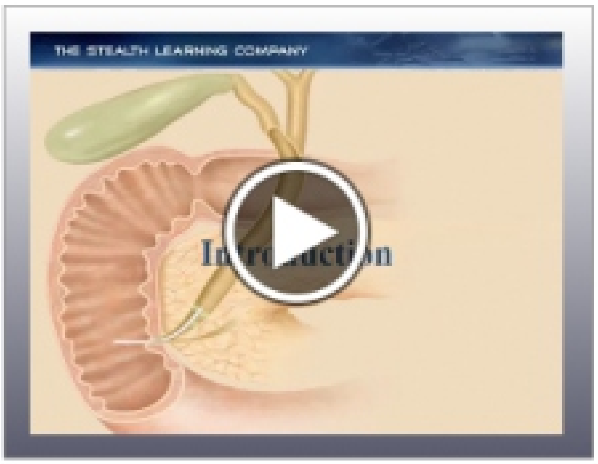
CHAPTER 13

An Interesting Clinical Case

Introduction

This case will highlight the many tools that are available to the surgeon from a transcystic approach, as well as cover the decision-making that determines how to apply these tools.

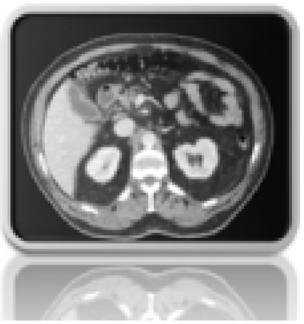


The patient is a 72-year-old man admitted with a 1-day history of epigastric and right upper quadrant pain, with associated nausea, vomiting, and fevers at home. On exam the patient had a low-grade temperature, but no hemodynamic instability. He was noted to have scleral icterus and on abdominal exam was tender in the right upper quadrant, but without clear signs of localized gallbladder inflammation. Laboratory studies showed a leukocytosis, as well as elevated liver function tests consistent with biliary obstruction. Pancreatic enzymes were normal.

Pertinent Findings

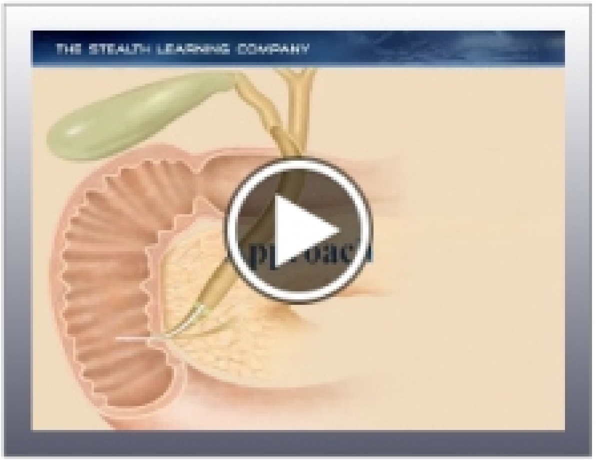
A CT scan was obtained by the Emergency Department showing mild gallbladder wall thickening, but no biliary dilatation. A follow-up ultrasound was obtained to try to better determine whether this represented acute cholecystitis or cholangitis. The study was read as showing a normal-sized common bile duct. No gallstones were noted, but there was pericholecystic fluid and gallbladder wall thickening, possibly consistent with acute cholecystitis. Applying the Tokyo guidelines for cholecystitis and cholangitis, this patient had cholecystitis, and suspected cholangitis of moderate severity.

Patient's Abdominal CT Scan



Approach

The recommended algorithm for how to approach patients who need cholecystectomy, such as the one in the current case, is described below. This algorithm is for surgeons who perform routine intraoperative imaging, and who also perform transcystic common duct exploration and/or biliary stent placement.



The first question to ask is, does the patient possess any contraindications to a surgery-first strategy? Severe cholangitis would be a contraindication, and these patients are better served with endoscopic drainage first. In this case, the patient has non-severe cholangitis according to the Tokyo classification. Medical comorbidities such as a recent myocardial infarction would also be a contraindication but does not apply with this case. Finally, this patient does not have any concerning signs for malignancy.

Thus, a laparoscopic cholecystectomy with intraoperative cholangiography was done. If stones are found, transcystic clearance is performed when appropriate and feasible. If this is not successful, or the common bile duct is small (3 mm or less), then postoperative ERCP with or without placement of a biliary stent through a transcystic approach is the next step.

Alternatively, if the surgeon possesses the expertise, and the bile duct is enlarged (7-10 mm or greater), a transcholedochal approach is an option.

Operative Procedure

The intraoperative video from the case is presented. A standard 4-port lap cholecystectomy trocar configuration is used. With the gallbladder retracted, the medial and lateral peritoneal attachments of the gallbladder are incised. There was a degree of edema and inflammation apparent in the tissues, consistent with a biliary infection. Dissection was continued until a critical view of safety is achieved. A clip was placed on the specimen side of the cystic duct. A ductotomy is made into the cystic duct with the left-hand instrument. The same angle of approach is used

to insert the cholangiogram catheter. Purulent fluid can be seen draining from the cystic duct rather than normal clean-appearing bile. This is consistent with acute cholangitis. The right hand retracted the gallbladder infundibulum so that the cystic duct is aligned with the angle of approach of the catheter and the clamp is secured. A cholangiogram of the distal duct is obtained with a 50% contrast concentration. Contrast is injected gently to prevent translocation bacteremia. The initial cholangiogram showed a distal meniscus sign consistent with a stone and poor emptying of contrast into the duodenum.

Performance of Cholangiogram and Interpretation

The cholangiogram should preferably be done in "cine" mode, so that the surgeon can replay the imaging sequence to look for subtle signs of stones. This is very effective in increasing interpretation accuracy. At this point, a common duct stone is suspected based on the meniscus sign and poor emptying of dye into the duodenum. When the anatomy of the ducts is examined, the cystic duct appears to have a lateral insertion into the common bile duct. Next, measure the diameter of the ducts. The cholangiogram clamp width serves as a 5 mm reference marker. Thus, we measure the distal common bile duct as 5-7 mm in diameter, and the cystic duct as approximately 5 mm in diameter. The favorable cystic duct anatomy and its 5 mm size along with a 5 mm common bile duct make a transcystic approach here favorable. Due to the small distal common duct diameter, a transcholedochal approach in this case should be avoided.

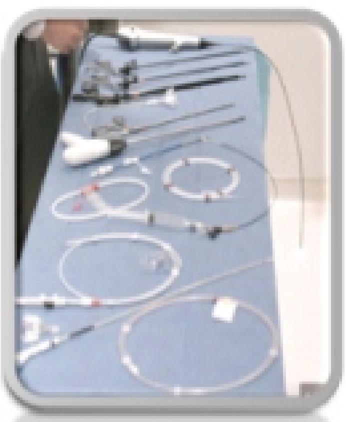
Laparoscopic Common Bile Duct Exploration

The procedure starts with the surgeon passing a guidewire through the catheter into the common bile duct and duodenum. In this case a smaller 0.025 inch guidewire was used, as the larger wire kept curling in the distal common bile duct. The assistant pins the wire with a grasper,

and 12 French cystic duct introducer sheath is inserted, and a wire-guided 6 mm dilation balloon is passed into the cystic duct. The assistant should place the cystic duct on tension, and in some cases assist with gentle manual balloon advancement over the guidewire.

In this case, a 6 mm balloon was chosen to prevent injury to the common bile duct from excessive dilation. The balloon is positioned across the cystic duct with fluoroscopy. The assistant should secure the balloon catheter with the grasper to prevent it from sliding forward during inflation. Inflate the balloon with contrast under fluoroscopy until no "neck" in the balloon is observed. This indicates full inflation. The surgeon monitors the balloon on the inflation so as not to exceed the rated burst pressure of the specific balloon. After 3-5 minutes of inflation, the balloon is deflated, and the balloon and wire are both removed. The choledochoscope is now advanced into the cystic duct either free-hand as shown, or over a wire under Seldinger technique with the wire removed once in the common duct. Make sure to turn on the pressurized saline to distend the ducts and facilitate cannulation.

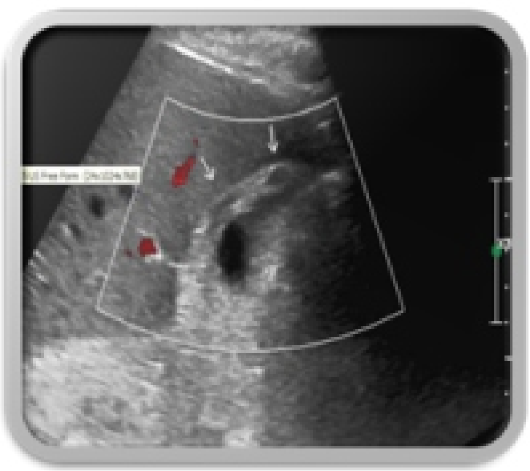
Common Bile Duct Exploration Set



The scope is advanced into the common duct towards the papilla. In the case presented, a stone was lodged in the papilla. Unlike with free-floating stones, when a stone is lodged in the papilla, a steel wire basket is chosen since it has greater radial expansion force. One can more easily dislodge these types of stones with the steel basket. Next, advance the basket in a closed configuration just past the stone, then open it fully. The opened basket is withdrawn slowly to dislodge the stone. As the basket meets resistance, it pulls the scope towards the papilla. The scope operator must pull back on the scope gently to maintain a view. It is important to not close the basket prematurely while it is across the papilla so as not to ensnare the papilla.

In the case presented, the video shows that the stone becomes dislodged. Irrigation sometimes causes the stone to flow towards the papilla, in which case the stone has to be recaptured and removed through the cystic duct. After removing the stone, the scope is reinserted to examine the papilla. The 2.8 mm scope is advanced into the duo-

Ultrasound of Gallbladder and Common Bile Duct



denum to confirm stone clearance. Alternatively, a cholangiogram may be performed to confirm emptying.

As shown, a narrow papilla was encountered which did not allow scope passage. Given the patient's cholangitis, and the narrow papilla, maximum postoperative ductal drainage was needed. A balloon sphincteroplasty was done to dilate the papilla. Wire access across the papilla was re-established, and the 6 mm dilating balloon was advanced across the papilla under fluoroscopy. The balloon was inflated to 6 mm for 5 minutes to perform a gentle dilation. Next, the choledochoscope was reinserted and can be seen, it could now easily advance into the duodenum. The proximal biliary tree can sometimes be examined from a transcystic approach, especially with the newer choledochoscopes capable of 270-degree flexion. The scope is slowly withdrawn, looking for the cystic duct, common duct junction, which is seen at the 9 o'clock position on the image presented. The choledochoscope is advanced just past the junction, rotated counterclockwise, and maximally flexed while gently advancing to retroflex up into the hepatic ducts. Visualizing the confluence of the bile ducts confirms the proximal location of the scope.

After performing balloon sphincteroplasty, there is still a risk of postoperative sphincter spasm and edema from the dilation, so a biliary stent was placed. A 7 French Fanelli Stent was placed over a guidewire under fluoroscopic guidance. A closing cholangiogram should always be performed to confirm stent position, rule out additional filling defects, confirm ductal patency, and the absence of any extravasation which would indicate a ductal injury.

Postoperative Course

Postoperatively the patient did well. His bilirubin slowly decreased and his cholangitis resolved. As can occur in some cases with papillary manipulation, he did have a mild postoperative pancreatitis that resolved within 48 hours with supportive care. He was discharged home. Six weeks postoperatively the patient was doing well and had his biliary stent removed

with an outpatient EGD. Stent removal is generally a straightforward procedure and usually does not require a duodenoscope. A gastroscope is used and can be fitted with a clear cap, as in this case, to facilitate visualization of the stent and the papilla. A foreign body forceps or snare is used to capture the stent. Once the stent is captured, the entire scope is removed along with the stent.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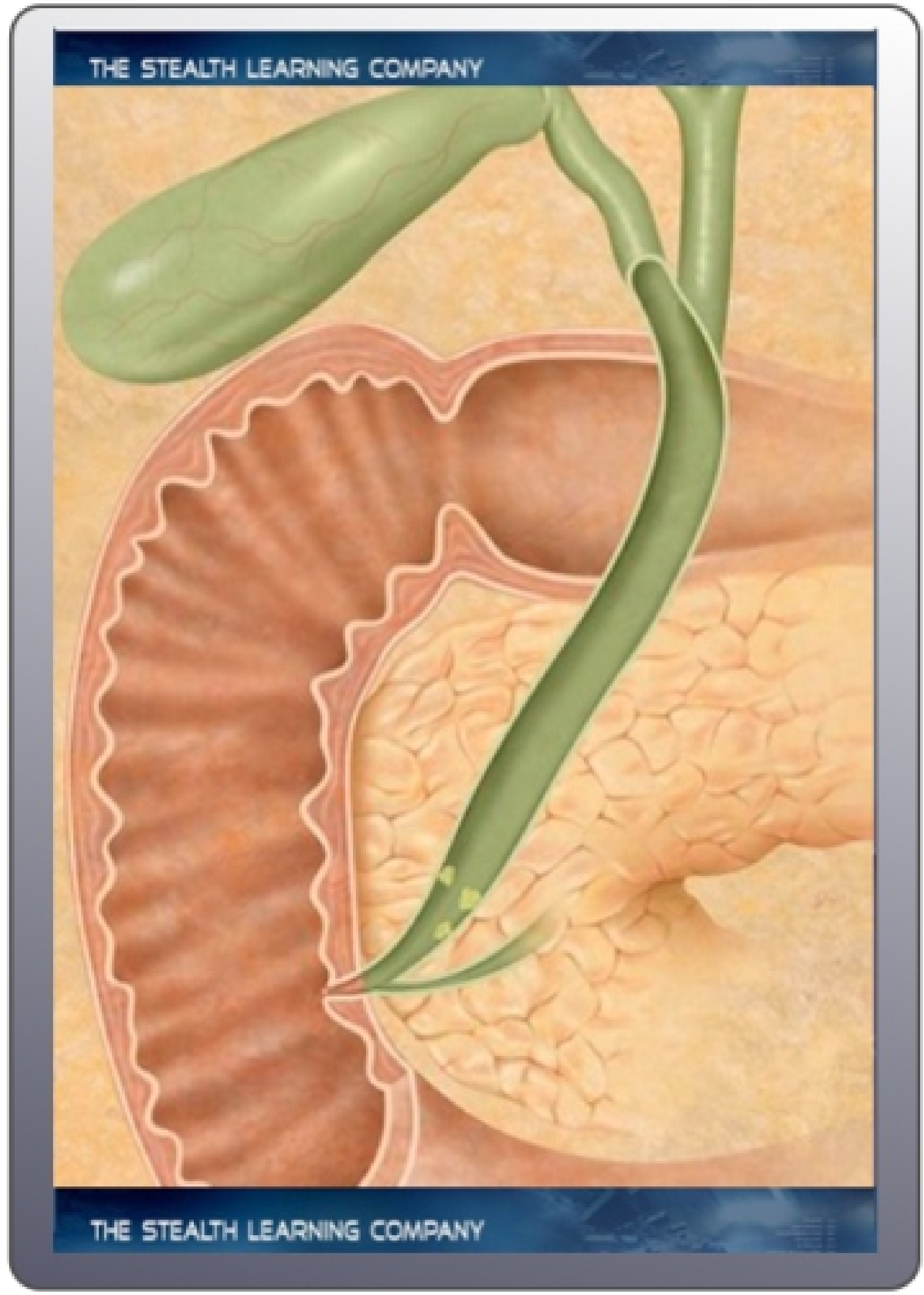
Helpful Tips
James "Butch" Rosser, MD FACS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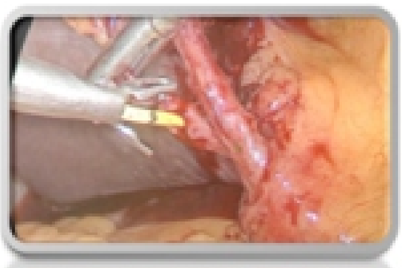
Helpful Tips

Performing a Cholangiogram

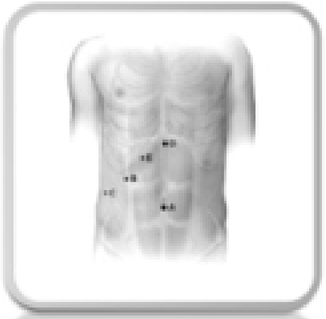
Catheter (Cath.) Position

External positioning of the cholangiography catheter in the upper right quadrant of the patient is essential for successful placement of the catheter.

Internal View



External View

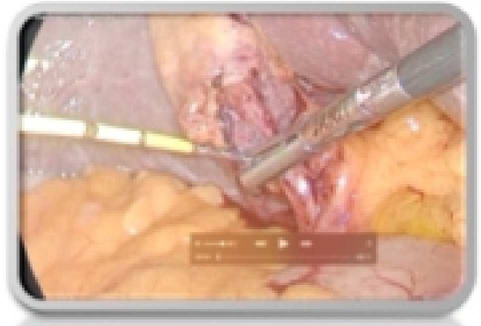


A catheter placed in the proper angle parallel to the cystic duct will allow the procedure to progress in an easier and smoother fashion.

Using Guidewires

Guidewires are useful for maneuvering catheters through the challenging valves of Heister. The curved and flexible tips of guidewires facilitate movement through the spiral folds. Once in place, catheters and choledochoscope can be passed along the guidewire. Guidewires allow for easy transition from cholangiography to CBDE when stones are detected.

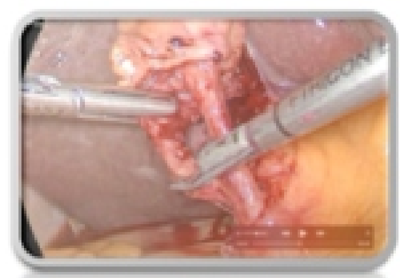
Guidewire



Clipping the Cholangiogram Cath.

Clipping the catheter may occlude the passage of guidewire or contrast. It is suggested that the surgeon use a device that allows control of how much pressure is applied by the clip to the catheter. Sometimes the surgeon may be able to insert the catheter without the need

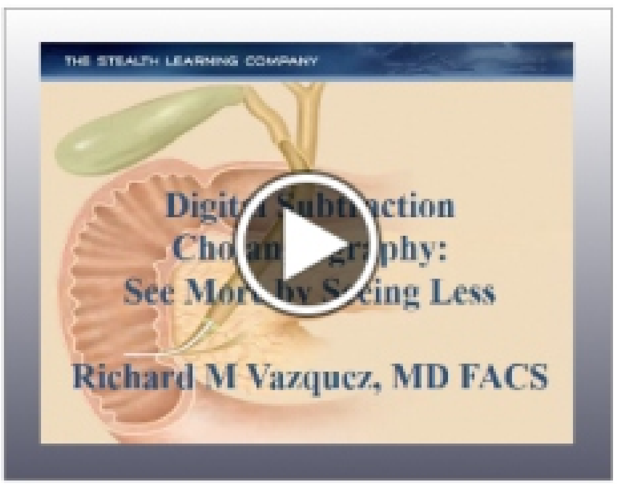
Clipping



for a clip. A 7.5 French catheter is generally large enough for the cystic duct to secure itself around the catheter. As long as there is no extravasation or bile leaking, the surgeon can proceed to performing a cholangiogram. An alternative to clipping across the catheter is placing a clip next to the cystic duct in a way that squeezes it against the catheter.

Digital Subtraction Cholangiography

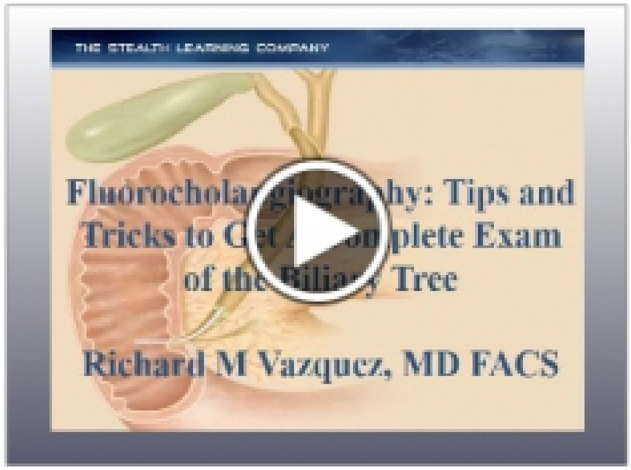
Radiopacities on the screen make interpretation of the next intraoperative cholangiogram somewhat difficult. Therefore, a subtraction run can be very helpful in improving visualization. Not all technologists are familiar with the setup for this technique. It is best to review the subject matter with your radiology technologists ahead of time. The radiology technologists capture a mask, which is a plain film of the abdomen without contrast material being present. This is done, unless the surgeon is using the subtraction study, to subtract the image of



extravasated contrast material. The subtraction study can be used to subtract out images of ports or bony anatomy, or the surgeon may wish to enhance the detail of the study to exclude stones being present in an initial nonsubtraction study. The technologist will need to set up the fluoroscopy cart for a subtraction run. Neither the patient nor the C-arm can be moved after that mask has been obtained. The mask is obtained during apnea of the patient. The team needs to be coordinated and the patient needs to be preoxygenated before the subtraction run takes place. The surgeon waits for instruction from the technologist to inject the contrast. The team waits for an icon of a syringe to appear on the fluoroscopy cart image. The surgeon then injects the contrast material while the technologist captures the subtraction run. The patient is oxygenated immediately upon completion of the run.

Fluorocholangiography

Be mindful that the technical attributes of an acceptable cholangiogram are, complete opacification of the entire extrahepatic biliary system, and good flow into the duodenum, with no filling defects in the absence of extravasation. When too much contrast goes into the duodenum, and an insufficient amount of contrast is available to opacify the extrahepatic biliary system above. As illustrated in this example, one needs to observe that in fact only the right ductal system is visible. The left system is not visible at all. No filling defects are noted in the distal common duct, and there is a good flow of contrast into the duodenum. After an intravenous dose of Fentanyl is given, the left-sided ducts become apparent.



This is another example of a similar situation. One can see that only ducts in the right ductal system have become visible during the cholangiogram. Once again, a dose of opioid is given and the entire system can be visualized. Notice that in both videos when one waits long enough to see the entire cholangiogram, the valves of Heister are very evident in the cystic duct.

In the next example, one can see that the duodenum has quite a bit of contrast in it. A bright jet of contrast can be seen going into the duodenum. There is opacification of the cystic duct and the distal common bile duct. There are no filling defects seen. This is not a normal cholangiogram. The proximal ducts must be seen because there is a question of the possibility that the proximal ducts are being obstructed due to a clip, etc. on the common bile duct. Why won't they opacify? So, once again, one can rotate the fluoroscope slightly to get the spine away from the common duct. In addition, give the patient an injection of opioid and these maneuvers usually allows you to finally see the entire ductal system.

Common Bile Duct Exploration/ Balloon Cath. Inflation

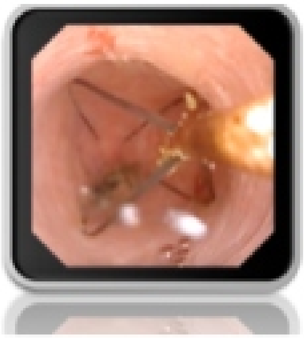
A pressure gauge is not necessary during balloon inflation. A 10-cc syringe or larger will inflate the balloon automatically to a maximum of 6 atmospheres of pressure. Six atmospheres of pressure are the maximum delivery pressure of the 10-cc syringe and the maximum pressure that the balloon will accept. Depressing the syringe slowly or quickly exerts the same pressure to the balloon which inflates automatically to 6 mm. The length of time for dilating the cystic duct with the balloon is 4-5 minutes.

Balloon Cath./Tracking over Guidewire

Tracking Over Guidewire

To prevent the balloon catheter, as well as other equipment tracking over a guidewire. It is important to use the mechanics of both pushing and pulling to avoid catheter bunching. This method keeps the guidewire and instruments moving forward in a straight line. When both remain straight, the balloon and the guidewire can be maneuvered forward into the cystic duct in an easier fashion. To employ a push-and-pull method, the surgeon should pull the guidewire slightly while pushing the balloon catheter or other equipment forward.

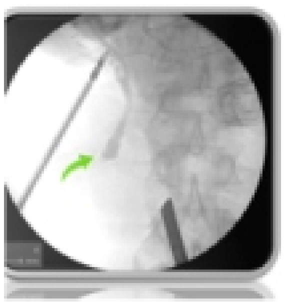
Four Wire Basket



Basket Cath./Four-wire

Some surgeons find that 4 wire baskets are easier to see and use for grasping and pulling stones while viewing with the choledochoscope.

Cholangiogram



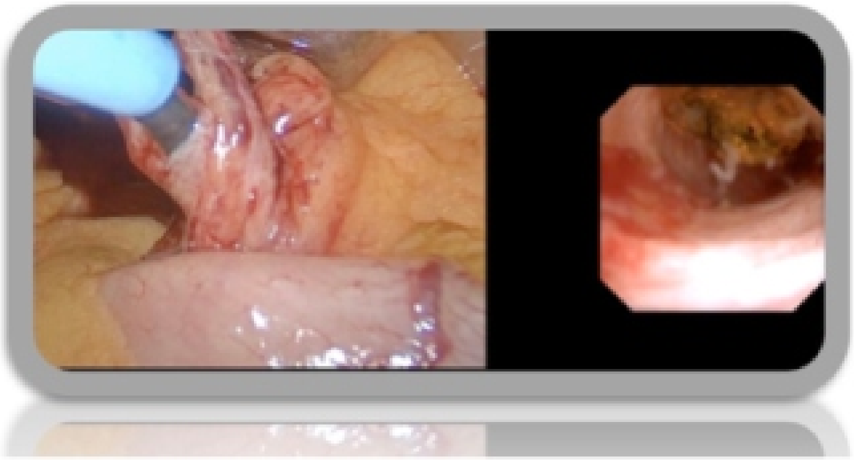
Basket Cath./Under Fluoroscopy

Under fluoroscopy, the surgeon cannot see the opening and closing of the basket. It is extremely important to check the opening and closing of the stone basket before use.

Basket Cath./Stone Extraction

The technique to extract stones with a basket involves pushing the closed basket past the stone before attempting to remove it. Then, the basket is opened and pulled back to entrap the stone.

Choledochoscope: View With Stone

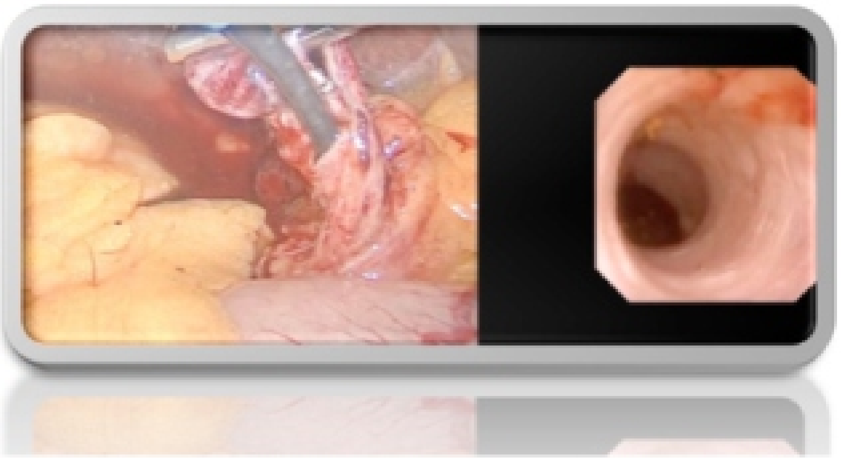


Using a Choledochoscope

Size

The choledochoscope can be a challenging instrument to insert into the cystic duct. Understanding the appropriate sizes of scopes, guidewires, and basket catheters is important to determine before beginning the procedure. Generally, choledochoscope larger than 9.0 French or a 3.0 mm will not fit into the cystic duct. A 3.0 mm, 9.0 French choledochoscope will have an inner working channel between 1 mm and 1.7 mm, which means that it will accept up to 3.0 French stone baskets.

Choledochoscope: View Without Stones



Torquing

Understanding how to manipulate the choledochoscope properly might very well be the most difficult part of choledochoscopy. It requires practice for the surgeons to become comfortable in manipulating the scope and basket at the same time. The technique involves torquing the scope and pushing and pulling the basket. Be careful, choledochoscopes have a tendency to be damaged easily when improperly used.

Removal

When removing stones either with a choledochoscope or under fluoroscopic control, the surgeon must remove both the scope or catheter and the stone basket simultaneously from within the cystic duct.

Dilation Balloon Inflation: Using a Pressure Inflation Device

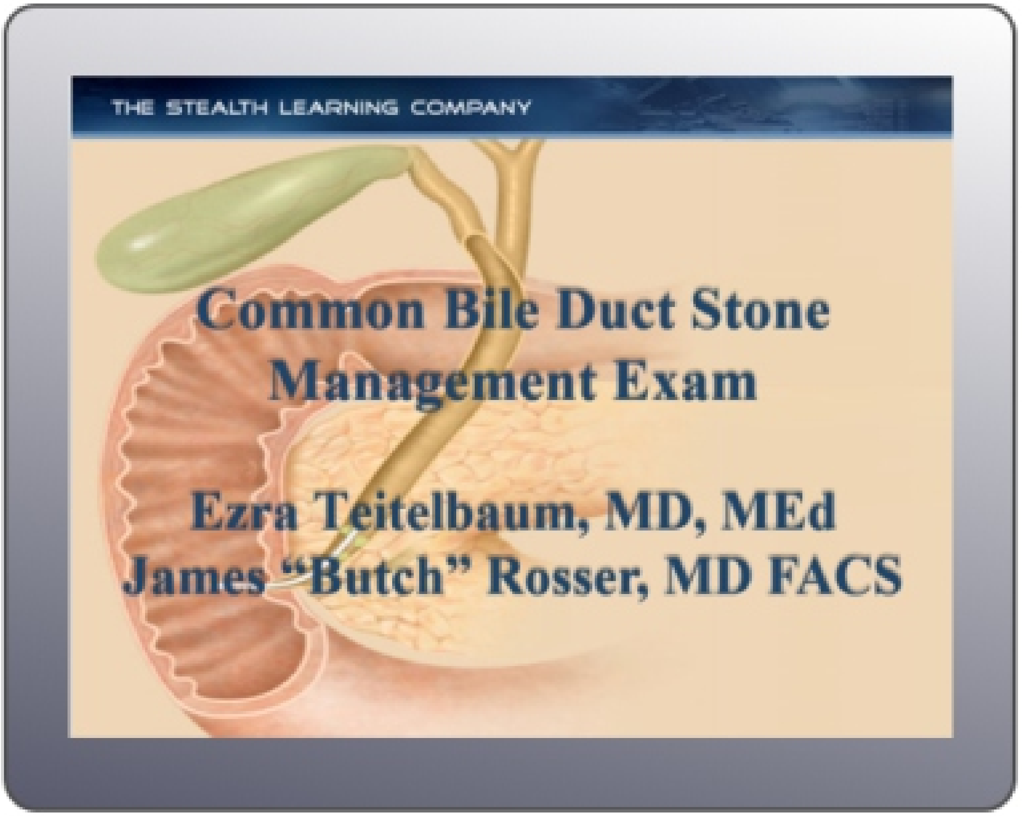
Dilation balloons come in various sizes and lengths and are used either for dilation of the cystic duct or to perform a balloon sphincteroplasty. In general, balloons should be filled with liquid, which is compression resistant and more effective for dilation compared to air. It is important to understand the concept of nominal pressure, which is the pressure at which the balloon is inflated to a predetermined diameter. Some balloons may have a variable range of diameters according to the pressure used. Burst pres-

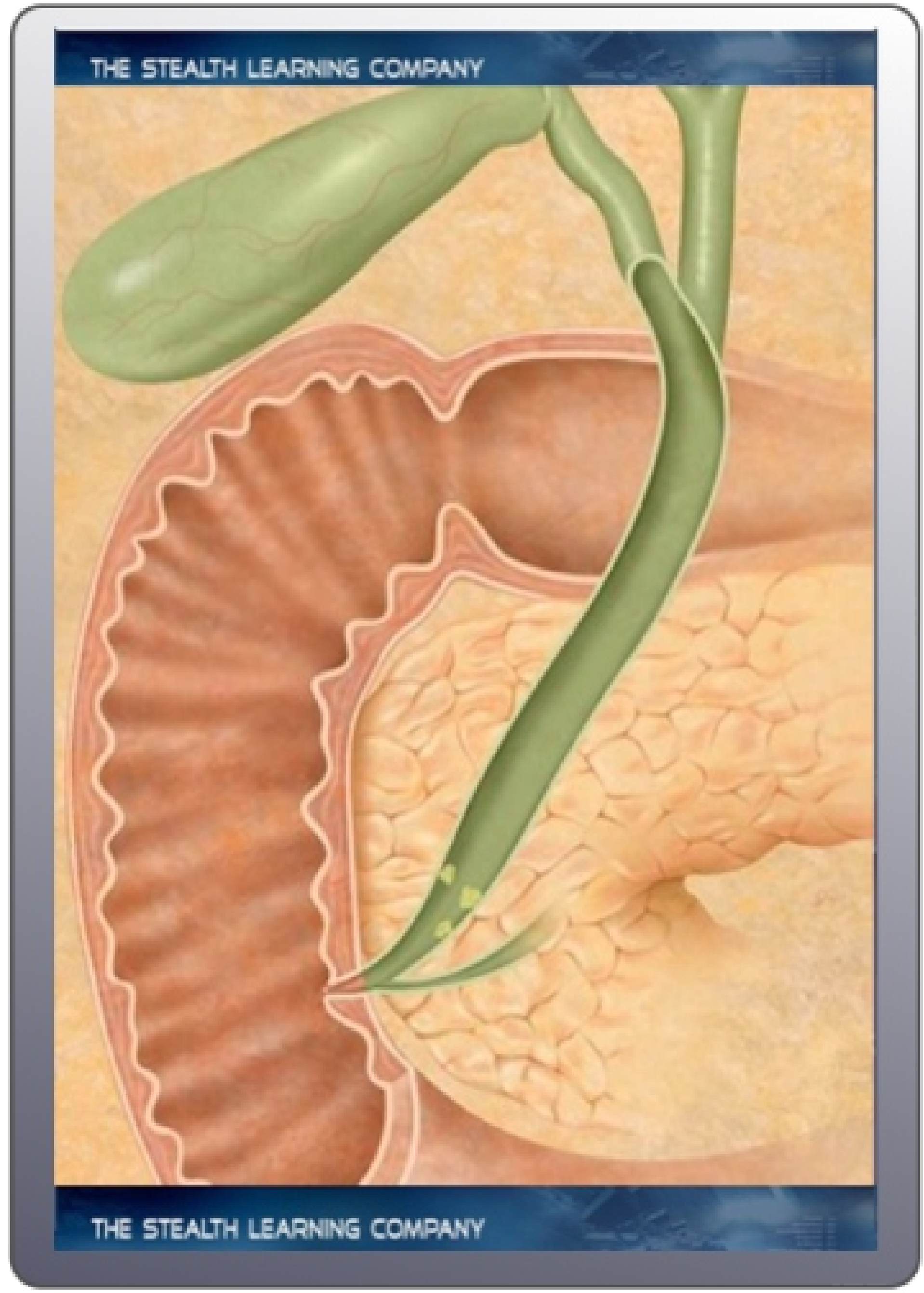
sure is also critically important to understand. It is the highest pressure at which 99.5% of balloons will not burst. While performing balloon dilation, it is important to monitor the balloon pressure and never exceed the burst pressure. Always refer to the specific balloon's instructions to determine the specific nominal pressure and burst pressure of the device you are using.

The balloon inflation device is what is used to fill and pressurize the balloon. Fifty percent contrast is used to fill the device so that balloon inflation can be monitored under fluoroscopy. The device typically has a Luer-lock connector to attach to the balloon. The handle typically has a latch (or button on some models) which alternates between two plunger modes. The first mode allows free movement in and out of the plunger. This is handy for rapidly filling the syringe with contrast or for rapidly deflating the balloon. The second mode is activated by moving the latch (or button) and is for controlled, slow advancement of the plunger using a rotating mechanism. It the video presentation typical balloon inflation device is shown. There is a moveable latch switches between plunger modes. In the movie observe the demonstration of free movement of the plunger out, and in. Once the device is filled with contrast and connected to the balloon, switch the mode.Turning the plunger clockwise advances the plunger and pressurizes the balloon.

While turning the plunger, the surgeon should monitor the pressure gauge and continue inflating until the desired pressure is reached.

In summary, the surgeon should be aware of the nominal and burst pressures of the specific balloon dilator being used. Use 50% contrast to fill the balloon, as this will allow monitoring of the balloon dilation under fluoroscopy. Finally, use a pressure inflation device to control balloon inflation and pressure.


THE STEALTH LEARNING COMPANY
Common Bile Duct Stone
Management Exam
Ezra Teitelbaum, MD, MEd
James "Butch" Rosser, MD FACS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1. The circulating nurse informs you that the choledochoscope you planned to use for transcystic LCBDE is broken. Which of the following is the best substitute?

- **A.** Flexible pediatric colonoscope
- **B.** Rigid cystoscope
- **C.** Flexible adult gastroscope
- **D.** Flexible ureteroscope
- **E.** Flexible laryngoscope

Check Answer

2. Which of the following statements about the differences between a flexible choledochoscope and other flexible endoscopes is false?

- **A.** The control knobs on a choledochoscope allow tip deflection in both the "up/down" and "left/right" axes.
- **B.** Choledochoscopes are shorter and have a smaller diameter
- **C.** Many currently available choledochoscopes are not true video endoscopes.
- **D.** Water infusion, rather than air, is required through the working port to maintain visualization of the bile ducts during choledochoscopy.
- **E.** Most choledochoscopes do not have the capacity for suction or air.

Check Answer

3. Which of the following is an advantage of a small diameter flexible choledochoscope (2-3mm) diameter over a large diameter flexible choledochoscope (4-5mm diameter)

- **A.** It is less delicate and does not often break.
- **B.** Image quality is better than that of a large scope.
- **C.** A wider variety of instruments are available for the small scope.
- **D.** Small diameter scopes are much less expensive.
- **E.** Small diameter scopes usually fit into the cystic duct, preventing the need for choledochotomy.

Check Answer

4. Which of the following pieces of equipment is not useful during transcystic LCBDE?

- **A.** Cystic duct dilators
- **B.** 5mm diameter choledochoscope
- **C.** Guidewires
- **D.** Atraumatic grasper for manipulation of choledochoscope
- **E.** Small diameter (3 Fr) extraction balloons or baskets

Check Answer

5. Which of the following is the single most useful guidewire for LCBDE?

- **A.** 0.035 inch diameter, 150 cm length
- **B.** 0.018 inch diameter, 150 cm length
- **C.** 0.035 inch diameter, 300 cm length
- **D.** 0.018 inch diameter, 45 cm length
- **E.** 0.035 inch diameter, 45 cm length

Check Answer

6. Which of the following instruments cannot be used to dilate the cystic duct?

- **A.** 8 mm diameter high pressure ballon dilator
- **B.** The tip of a curved dissector
- **C.** 18mm extraction ballon
- **D.** A set of 6-18 Fr polyethylene ureteral dilators

Check Answer

7. Biliary wire basket extraction catheters:

- **A.** Have the same handle as biliary dilation balloons
- **B.** Requires a pressure gauge and syringe to operate
- **C.** Have a second lumen for injection of contrast materials
- **D.** Are used to insert the choledochoscope into the CBD
- **E.** Come in a variety of diameters and basket configurations

Check Answer

8. Which of the following is not a contributing factor to the slow adoption of LCBDE by surgeons?

- **A.** The high success rate and low morbidity of ERCP
- **B.** The limited number of opportunities to practice LCBDE
- **C.** The fact that LCBDE is technology and equipment-intensive
- **D.** Gastroenterologist have lobbied to limit credentialing
- **E.** LCBDE requires the skills of several different disciplines

Check Answer

9. Which of the following statements about cholangiography catheters is true?

- **A.** There is a very limited range of catheter sizes available today.
- **B.** A 4 or 5 Fr catheter with 60 cm length works well in most cases.
- **C.** The 5mm cholangiography clamp will work with any commercially available catheter.
- **D.** A 12 Ga catheter introducer through the abdominal wall should never be used for cholangiography.
- **E.** Metal-tipped catheters should never be used.

Check Answer

10. The biggest disadvantage of an excessively long guidewire is:

- **A.** Expense
- **B.** The available coatings are contraindicated for use in the biliary tract
- **C.** Excessive stiffness
- **D.** It is unwieldy, easy to contaminate, and ties up an assistant
- **E.** They do not come in sterile packaging

Check Answer

11. If a biliary balloon dilator is necessary during LCBDE, a good choice for the ballon size in most cases is:

- **A.** 2 mm diameter, 4 cm length
- **B.** 2 mm diameter, 8 cm length
- **C.** 8 mm diameter, 4 cm length
- **D.** 8 mm diameter, 8 cm length
- **E.** Any ballon size is suitable

Check Answer

12. A suitable substitute for a cystic duct introducer if one is not available is:

- **A.** A 14 Ga intravenous catheter
- **B.** A percutaneous introducer sheath for interventional procedure
- **C.** The finger from a rubber glove
- **D.** The plastic cover that protect and endoscopic balloon dilator
- **E.** A choledochoscope

Check Answer

13. Which of the following improve the likelihood of successful LCBDE?

- **A.** A surgeon who is knowledgeable in all aspects of equipment set up and troubleshooting.
- **B.** Formulation of an operative plan prior to the case.
- **C.** A dedicated facility with the appropriate equipment
- **D.** A knowledgeable and interested scrub team.
- **E.** All of the above improve the likelihood of success during LCBDE.

Check Answer

14. Which of the following is an indication for performing an intraoperative cholangiogram during a laparoscopic cholecystectomy?

- **A.** Morbid obesity
- **B.** Family history of hepatocellular carcinoma
- **C.** Acute cholecystitis
- **D.** Cystic duct dilation found intraoperatively

Check Answer

15. Which of the following stone sizes and locations would be most amenable to extraction via a transcystic laparoscopic common bile duct exploration approach?

- **A.** 6 mm stone in the right hepatic duct
- **B.** 7 mm stone in the distal common bile duct
- **C.** 13 mm stone in the mid common bile duct
- **D.** 10 mm stone in the proximal common hepatic duct

Check Answer

16. What is the optimal method for capturing a stone using a wire basket during a laparoscopic common bile duct exploration?

- **A.** Advance the closed basket distal to the stone, open it, and then pull it backwards towards the stone
- **B.** Open the basket proximal to the stone, and then push it towards the stone
- **C.** Use a lithotripsy laser to fragment the stone, and then capture the pieces individually using the wire basket
- **D.** Use a wire basket to fragment the stones, and then capture the pieces individually using the basket

Check Answer

17. What is the best method to ensure complete clearance of the common bile duct after performing a laparoscopic common bile duct exploration?

- **A.** Post-operative cholescintigraphy (i.e. HIDA scan)
- **B.** Intraoperative endoscopic retrograde cholangiopancreatography (ERCP)
- **C.** Intraoperative cholangiogram (IOC)
- **D.** Post-operative magnetic resonance cholangiopancreatography (MRCP)

Check Answer

18. For the treatment of choledocholithiasis, multiple randomized trials have consistently shown laparoscopic common bile duct exploration and cholecystectomy to be superior to ERCP plus laparoscopic cholecystectomy in terms of improving what?

- **A.** Mortality
- **B.** Overall complication rate
- **C.** Rate of common duct stone retention
- **D.** Hospital length of stay

Check Answer

19. What is the approximate frequency of choledocholithiasis in individuals who require surgery for symptomatic cholelithiasis?

- **A.** 1%
- **B.** 10%
- **C.** 20%
- **D.** 50%

Check Answer

20. Contraindications to a transcystic laparoscopic common bile duct exploration include:

- **A.** A dilated cystic duct
- **B.** More than one common bile duct stone
- **C.** A common duct stone larger than 10 mm
- **D.** Common bile duct dilated to more than 8 mm

Check Answer

21. Contraindications to a transcholedochal laparoscopic common bile duct exploration include:

- **A.** A stone in the common hepatic duct
- **B.** A 12 mm common duct stone
- **C.** A common bile duct with a 6 mm diameter
- **D.** Failure to extract a stone via a transcystic approach

Check Answer

22. Which of the following describes the optimal trocar placement for parallel insertion of the endoscope into the cystic duct?

- **A.** An additional trocar just to the right of the umbilicus for guidewire insertion
- **B.** An additional trocar in the upper abdominal midline for retraction of the common bile duct
- **C.** An additional trocar in the right anterior axillary line for guidewire insertion
- **D.** An additional trocar below the left costal margin for guidewire insertion

Check Answer

23. You perform intraoperative biliary ultrasound and identify sludge in the common bile duct (i.e. particles < 2 mm). After administration of glucacon and saline irrigation via cystic ductotomy the sludge remains in the common bile duct. The next step is:

- **A.** Completion cholecystectomy
- **B.** Transcystic laparoscopic common bile duct exploration
- **C.** Choledochotomy for sludge extraction
- **D.** External biliary drain placement

Check Answer

24. When performing a laparoscopic common bile duct exploration, which of the following would predispose the patient to later development of a biliary stricture:

- **A.** Using a transcholedochal approach on a non-dilated common bile duct (i.e. < 8 mm diameter)
- **B.** Using a transcholedochal approach on a very dilated common bile duct (i.e. 2 cm diameter)
- **C.** Failure to perform an antegrade sphincterotomy
- **D.** Failure to leave an intra-abdominal drain in place

Check Answer

25. Which of the following would impair choledochoscopic visualization of the common bile duct?

- **A.** Failure to perform preoperative ERCP with sphincterotomy
- **B.** A stone in the common hepatic duct
- **C.** Failure to infuse pressurized saline through the choledochoscope
- **D.** Retained contrast from the cholangiogram

Check Answer

26. If a common bile duct stone impacted at the ampulla is unable to be removed via laparoscopic common bile duct exploration, which of the following is a feasible option to relieve the biliary obstruction and aid in subsequent performance of an ERCP?

- **A.** Ligate the cystic duct with a suture loop rather than clips
- **B.** Place an antegrade biliary stent across the stone and ampulla
- **C.** Leave the cystic ductotomy open and place an intra-abdominal drain
- **D.** Make a longitudinal choledochotomy and insert a t-tube

Check Answer

27. Which of the following is an appropriate suture size and material for closing a choledochotomy after laparoscopic common bile duct exploration?

- **A.** 2-0 braided absorbable
- **B.** 4-0 braided permanent
- **C.** 4-0 monofilament permanent
- **D.** 4-0 monofilament absorbable

Check Answer

28. Which strategy for stone clearance should always be attempted before performing a laparoscopic common bile duct exploration?

- **A.** Endoscopic retrograde cholangiopancreatography (ERCP)
- **B.** Ultrasonic lithotripsy
- **C.** Administration of IV glucagon, followed by transcystic flushing
- **D.** Retrograde flushing via nasogastric tube

Check Answer

29. Under which circumstances would it be necessary to leave a t-tube in place following a transcholedochal laparoscopic common bile duct exploration?

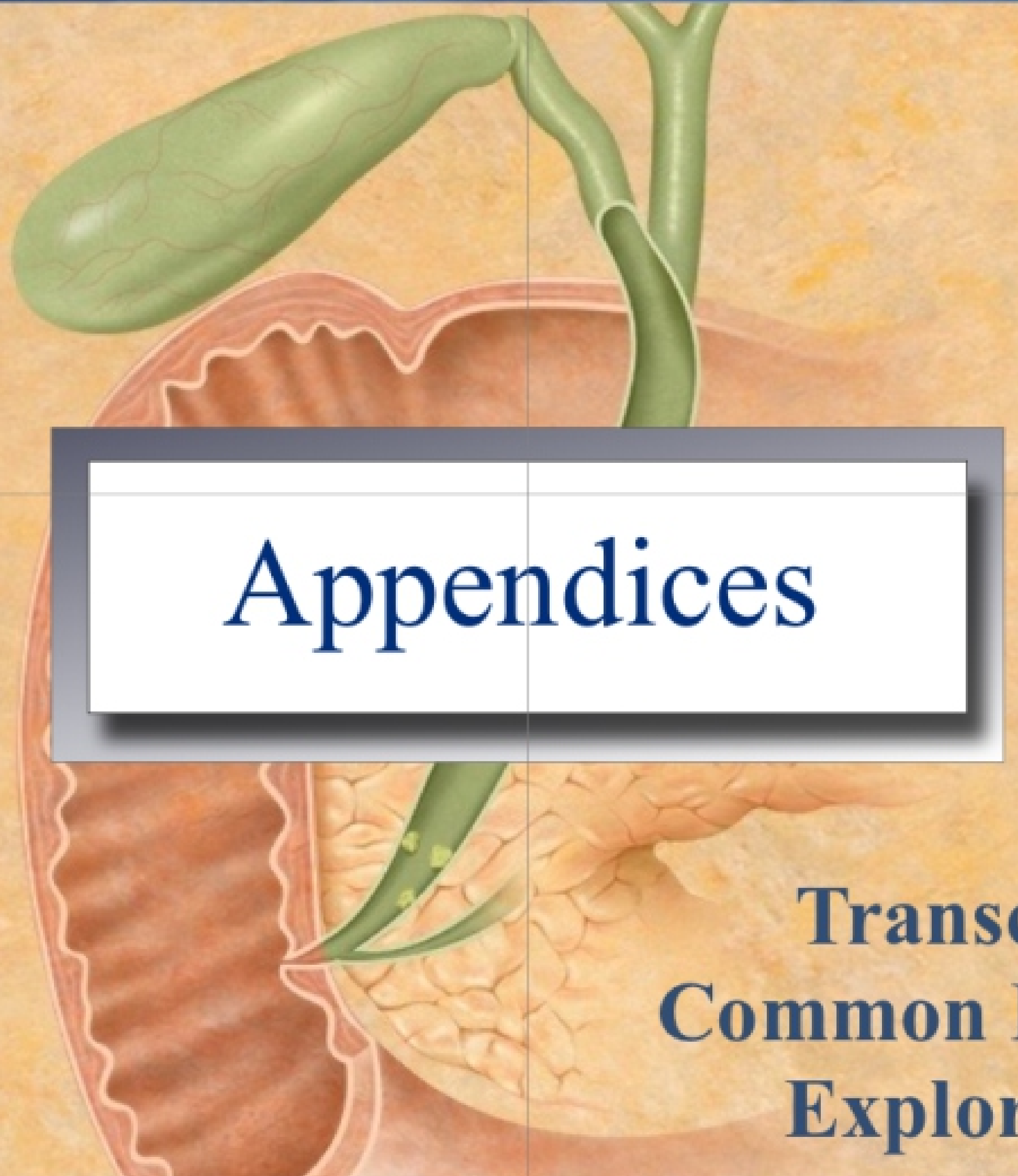
- **A.** Laboratory values indicated a biliary obstruction preoperatively
- **B.** A narrowed cystic duct precluded transcystic LCBDE
- **C.** Patient had undergone a prior distal pancreatectomy and splenectomy
- **D.** Contrast does not fill the duodenum on post-LCBDE cholangiogram

Check Answer

30. The most accurate means of predicting common bile duct stones at the time of laparoscopic cholecystectomy is:

- **A.** Postoperative MRCP
- **B.** Calculate the ASGE criteria and trend liver function tests
- **C.** Postoperative ERCP
- **D.** Cholangiography

Check Answer



Appendices

Transcystic Common Bile Duct Exploration

CHAPTER 16

Appendix I

Basic Fluoroscopy

Richard Vazquez, MD FACS

Fluoroscopy Overview

We have designed the masters CBDE training course to include the topics of basic radiation safety and optimization of use of the fluoroscope for cholangiography. Surgical training programs do not formally train general surgeons in either of these subjects, yet general surgeons who perform IOC and laparoscopic CBDE rely on biliary images that they must obtain and interpret during an operation. The surgeon must be able to produce a technically satisfactory cholangiogram and interpret the study in most settings without the consultation of a radiologist.

Cholangiography
The attributes of the technically satisfactory negative intraoperative cholangiogram are: 1) Complete opacification of the extra-hepatic biliary tree, 2) absence of extravasation of contrast material, 3) good flow of contrast material into the duodenum, and 4) the absence of filling defects. Air must be carefully purged from the system so that air bubble artifacts are not unintentionally injected into the bile ducts.

Dynamic fluorocholangiography (DFC)
Static cholangiography wastes time and does not permit the surgeon to readily diagnose the presence of artifacts such as the deformable air bubble. DFC permits real time viewing and acquisition of images. The DFC can be programmed to store acquired images on a hard drive for replay and image processing. Modern image intensifiers have the capability to deliver high quality still and cine imaging in positive, negative, and subtraction modes. The author personally prefers to use image magnification to highlight the duct system especially at the ampulla for the majority of the IOC's performed. Collimation x-ray beam will limit radiation exposure of the patient and staff and will also enhance the detail of the image.

*Many of the dynamic fluoroscopy image acquisition and enhancement functions that you will learn about on the *C-arm *GE/OEC 9900 workstation are available on the workstations of other manufacturers. It is important for the students learn the basic concepts of radiation safety and functions of dynamic fluoroscopy units. By mastering the basics, the students will be able to safely achieve the desired imaging results while remaining manufacturer neutral.*

Radiation Safety

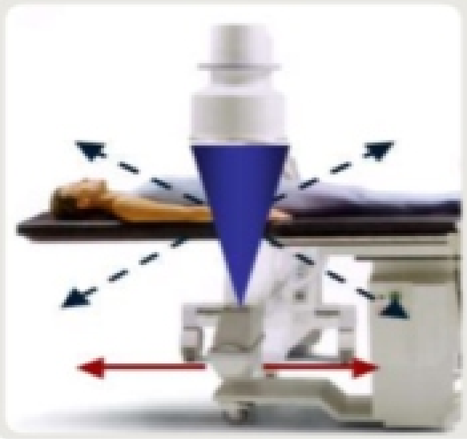
How X-Ray Radiation is created and the Concept of Dose

Radiation safety and the amount of dose the patient and staff receive during a procedure is a growing concern today. This section will help you increase your knowledge and develop safe work habits.

X-ray radiation is created and the "Dose" Concept

X-ray radiation is produced by an X-ray tube that directs a beam of energetic high speed electrons at a target. The force with which the electrons strike the target depends upon the accelerating voltage measured in kilovolt peak (kVp). In a fluoroscopic and a radiographic exposure, it is advised to use the highest kVp possible that will produce good diagnostic image quality while penetrating the patient and at the same time using the greatest filtration to minimize the patient's exposure. In other words, not all the radiation particles generated during an X-ray are used to produce the resulting images, and because radiation can cause damage to the human body, we try to achieve the greatest possible effect: the best image with the smallest amount of radiation dose.

Good Radiation Protection Practice

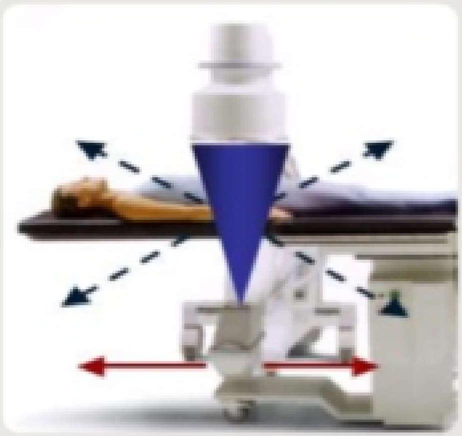


- Proper Protective Gear
  - Eye Glasses
  - Lead Apron
  - Thyroid Shielding
- Step back from Primary Beam
  - Do not put your hands in the Primary Beam
- Minimize Fluoro Time
- Collimate – Limit exposure area
- Minimum Source to Object Distance
- Monitor

- Primary Radiation – Patient
- Scatter Radiation – User
- Leakage Radiation – User

Dose Efficiency

Optimize Images at As Low X- Ray Exposure As Reasonably Achievable



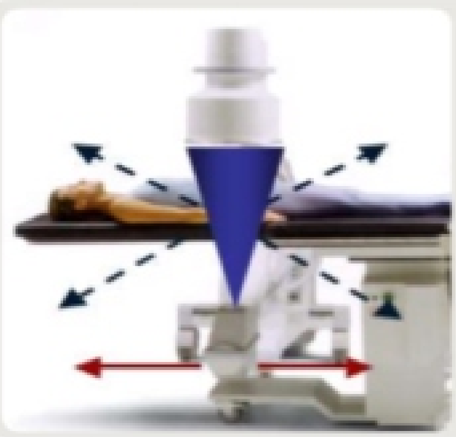
- Digital Cine /Bolus Chasing Imaging Mode
- HLF/DSA
- Pulsed HLH
- Digital Spot

Standard Fluoro Mode

- Low Dose (50% Dose Saving)
- 8PPS Fluoro Mode (80% Dose Saving)
- Low Dose and Pulse Mode (Very Low Dose)

- Provide the Best I.Q. – Reduce Dose
- Allows User Option to Save Dose by Various Imaging Modes
- Allows the user Option – I.Q. vs. Dose
- Filtration reduces soft Rad.
- Beneficial for all apps

Dose Classification



Factors Affect Exposure

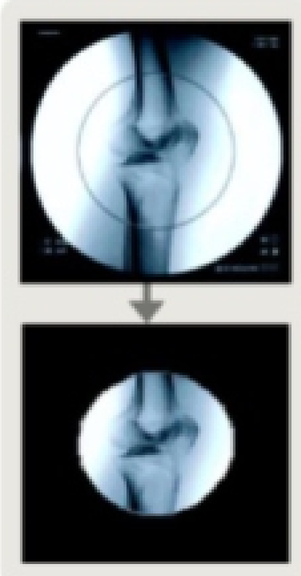
- Patient Size – Thickness/Density
- kVp
- mA
- Exposure Time
- Filtration

Processing - Collimation

Clinical Benefit

- Dual leaf
- On-screen collimation from last image
- Allows collimation & rotation without additional X-ray
- Improve user productivity
- Limits radiation exposure area
- Save radiation exposure to users
- Improves I.Q.

Processing - Collimation



Iris

Clinical Benefit

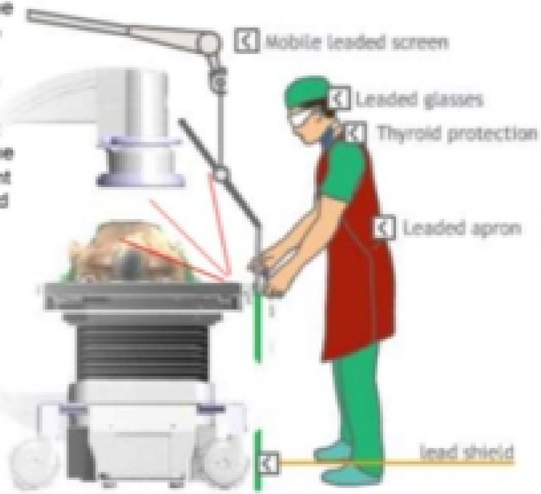
- Reduce Blooming in the Image
- Improve Image Contrast
- Improve Image Detail
- Beneficial for Spine/Ortho apps.
- Provide Diagnostic I, Q.

X-Ray Scatter Environment

Scatter radiation is composed of two parameters: Intensity (mA) and energy (kV). It is hard to measure either of these when the scatter is coming off the table or the patient. However, it is safe to say that the scatter radiation's intensity and energy will be lower than the original primary X-ray beam. As a consequence, scatter radiation cannot travel as far or as deep. Remember, the X-ray primary beam travels in a straight line; the scatter radiation is weaker and travels in all directions. A good rule of thumb is to be as far away as you can from the patient or equipment, or at least 6 feet or 2 meters when you are not directly involved in patient treatment.

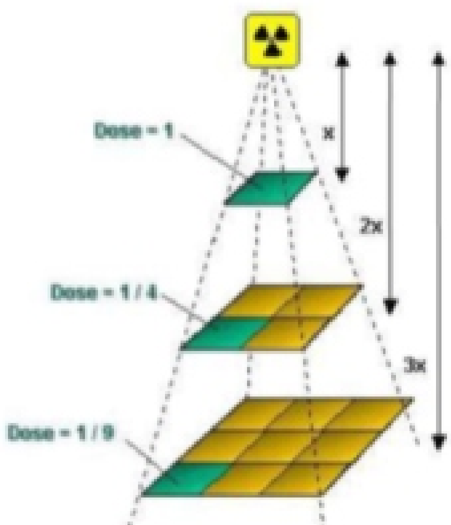
The operator is effectively protected against scatter radiation from the patient.

A leaded glass screen and a leaded apron protect against X-ray radiation.

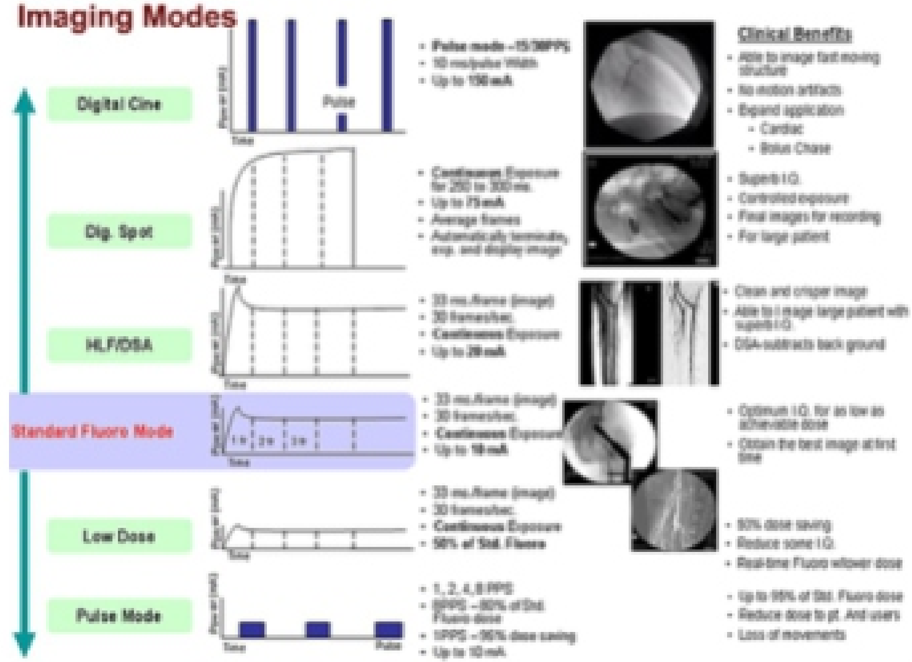


Inverse Square Law

A bundle of X-rays corresponds to the shape of a cone, with the shape of a cone, with the tube at its tip. The intensity or dose of the radiation emitted from the source of the X-ray beam diminishes with the square of its distance from the source. If you double the distance x, the dose changes by a factor of $1/(2^2)$, and if you triple it, the dose changes by a factor of $1/(3^2)$.

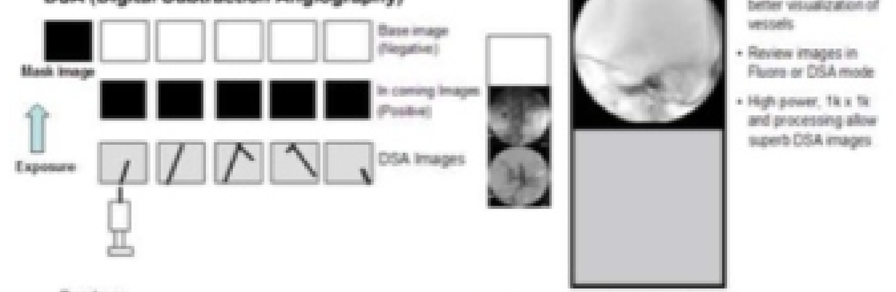


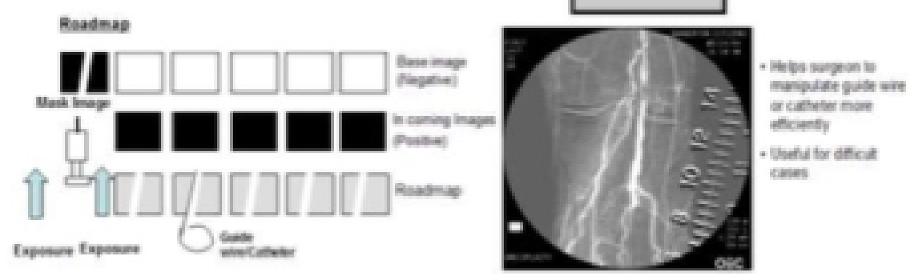
Imaging Modes



Imaging Modes

DSA (Digital Subtraction Angiography)





Collimation at Target

Collimation at the target brings about a genuine dose reduction and also produces better images quality. Collimation is performed using cones and collimators (multi-leaf collimators or iris diaphragms) that are attached directly in front of the X0ray tube. Collimation at the target is the most effective radiation protection for the patient and personnel, because it narrows the area that the radiation can strike.

Subtraction

The subtraction mode removes the visual noise of non-bile duct image anatomic structures from the cholangiogram. The surgeon must notify the technologist in advance that a subtraction study is desired. Orientation of the unit can best be accomplished by placing a hemostat or other radiopaque instrument over the general area of interest. After the fluoroscope has been positioned properly using for example clips on the cystic artery or the single clip on the cystic duct as a target, the technologist starts the subtraction process. The technologist ***must be notified in advance*** if the surgeon wishes to capture the images ***before the injection of any*** contrast material. The surgeon then requests that the anesthesiologist maintain a brief period of apnea for the patient, the technologist will acquire images and then command the injection of contrast after time interval specified by the fluoroscope. This whole process generally takes under one minute. Anesthesia may resume ventilation while the images are being interpreted. The "C" arm and the anatomy must remain stationary during the subtraction process.

The workstation software subtracts the image densities captured before the contrast media injection from the images obtained during and after the injection. The positive subtraction image presents only the structures filled with contrast and filing defects devoid of contrast material.

The author finds it useful to use the terms "scout", "regular fluoroscopy", and "acquire images". Use the "scout" command for gross positioning, "regular fluoroscopy" for fluoroscopy without image capture, and "acquire images" for a captured run for review during and after the radiation is turned off.

Negate

Reverse the displayed image white and black values on the left monitor.

Subtraction

This schema may be useful: 🡆 Review desired studies with the technologist 🡆 facilitate positioning of the "C" arm, (raise O.R. lights, Mayo stand, and table height) 🡆 Command "perform scout for location and technique" 🡆 await image presentation and check for proper position, etc. Command "ready to capture images" and wait for affirmative response from the technologist "ready" 🡆 Command "Hold Apnea" to the anesthetist 🡆 Command "acquire images" while injecting contrast. Always command acquire images ***1-2 seconds before injecting contrast***. This will allow <u>post-processing</u> subtraction if needed. Stop fluoroscopy and Command "resume patient ventilation".

Negative Fluoroscopy mode

Cholangiograms may be initially acquired using the regular fluoroscopy negative mode (no subtraction) at any time. The same comments made above about magnification and beam collimation apply here as well.

Subtraction

Subtraction is an optional feature used during Cholangiography, Angiography and Venography to subtract out the bony anatomy displaying only the contrast-filled vessels. 1, 2, 4, 8, 15 or 30 frames per second cine option are available depending on the system configuration.

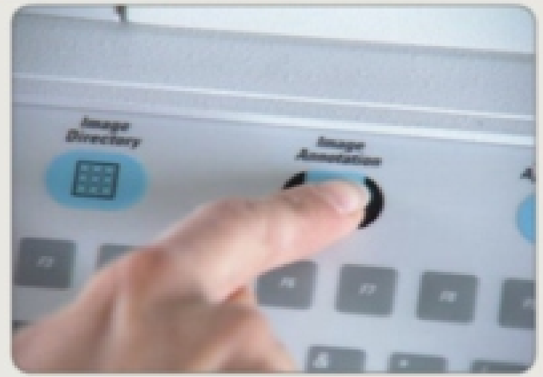
Collimation

Select the lower Iris Collimator key to close the iris collimator and the upper key to open. The iris closes in a circular presentation. Select the lower Leaf Collimator key to close the leaf collimator and the upper key to open. The leaf closes from side-to-side. Select the left Leaf Collimator rotation key to rotate counter clockwise and the right key to rotate clockwise.

Monitors

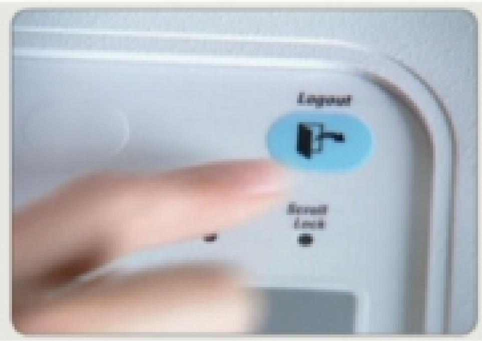
The flat panel monitors can be unlocked by pressing down on the gray handle. Lift the monitors up and out. The monitors can be extended out, rotated left and right, raised and lowered and/or tilted up and down. Always lock the monitors back into place for travel.

Image Annotation Key



Displays the image annotation screen and allows you to place markers or comments and/or perform cropping (digital collimation) and Measurement functions.

Logout



Logout is used if the HIPPA Login password has been set. Use Logout to clear patient images and information The HIPPA screen will display.

Zoom

Magnifies static image from left monitor 1, 2 or 4 times. A square region of interest box appears on the right monitor allowing you to drag it to an area of interest.

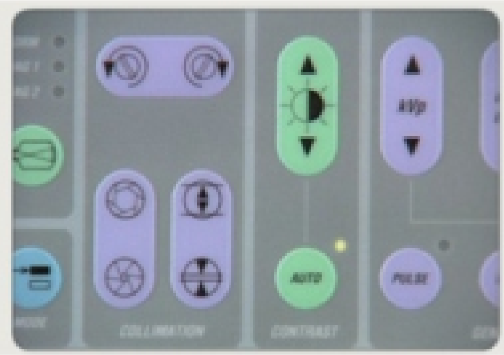
Enhance

Sharpens the edges of an image. Increase or decrease from 0 to 100 percent.

Brightness

Brightness key allows manual increase or decrease the brightness values of the left monitor during active or post processing.

Contrast

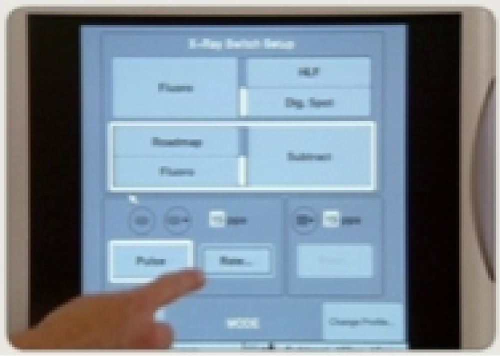


Auto contrast/brightness is active when the LED is solid. Manual contrast/brightness is active when the LED is off. The Smart Metal function is active when the LED is flashing.

CD/DVD Burner

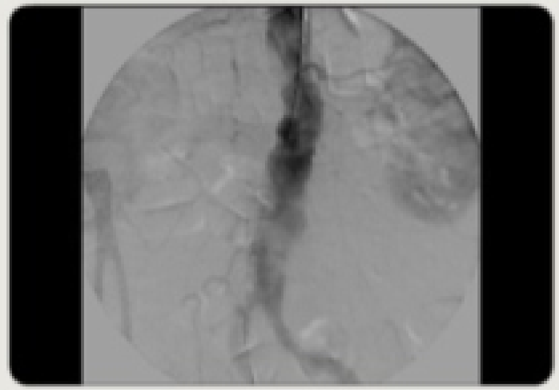
Open the CD/DVD drive by pressing the button on the face of the drive. Insert the blank CD/DVD. Press the button again to close the tray. Select COPY TO CD/DVD. Select the images to be copied. Use Image Directory, if the correct patient's images are not displayed, select Saved Exams. Images can be selected one at a time, Select All or hold down the CTL key and select multiple images or cine runs to be copied to the medium. Once the images are selected, touch Copy.

Digital Cine Pulse - Rate



Digital cine pulse is a Fluoro only function used to minimize blur caused by movement during a contrast injection. Choose either 15 or 30 pulse per second option depending on system configuration. Digital Cine Pulse cannot be used with Subtraction.

Subtraction



Subtraction is an optional feature used during Angiography and Venography to subtract out the bony anatomy displaying only the contrast-filled vessels. 1, 2, 4, 8, 15 or 30 frames per second cine option are available depending on the system configuration.

Other Useful Image Modes

The technologist can also use bolus-chasing mode (Digital Cine Pulse) to visualize and record live fluoroscopy while the C arm or the anatomy is moving. Other types of useful imaging modes are high-level fluoroscopy to increase image quality for dense anatomy and the "smart metal" mode used to counteract the effect of metal in the image. For example, use the smart metal mode when doing a cholangiogram in someone who has Harrington rods inserted in the spine.

Play/Process at the Workstation

The beauty of the image capture system then becomes apparent. The images may be reviewed with or without image enhancement modes as many times as necessary without radiating the patient and staff again. Filling defects that deform under pressure of the injecting syringe are air bubbles. The surgeon can usually flush 2-3mm calculi or air bubbles through the ampulla and into the duodenum. Those that are > 2-3 mm or simply will not flush after IV glucagon may require extraction although stones < 2mm diameter may be abandoned since they will likely pass without problem.

The workstation image processing features include image magnification, sharpening, and others.

Other Tidbits

The surgeon may review images or cine runs from the image directory. The image that you wish to save to the hard disc must display on the left hand monitor, however, you cannot delete any saved images from the system. If the cart or "C" fails, remember that the units are a set and must be changed as sets, not individually.

Please refer to the online study module for information regarding basic radiation safety and operation of the fluoroscope cart.

CHAPTER 16

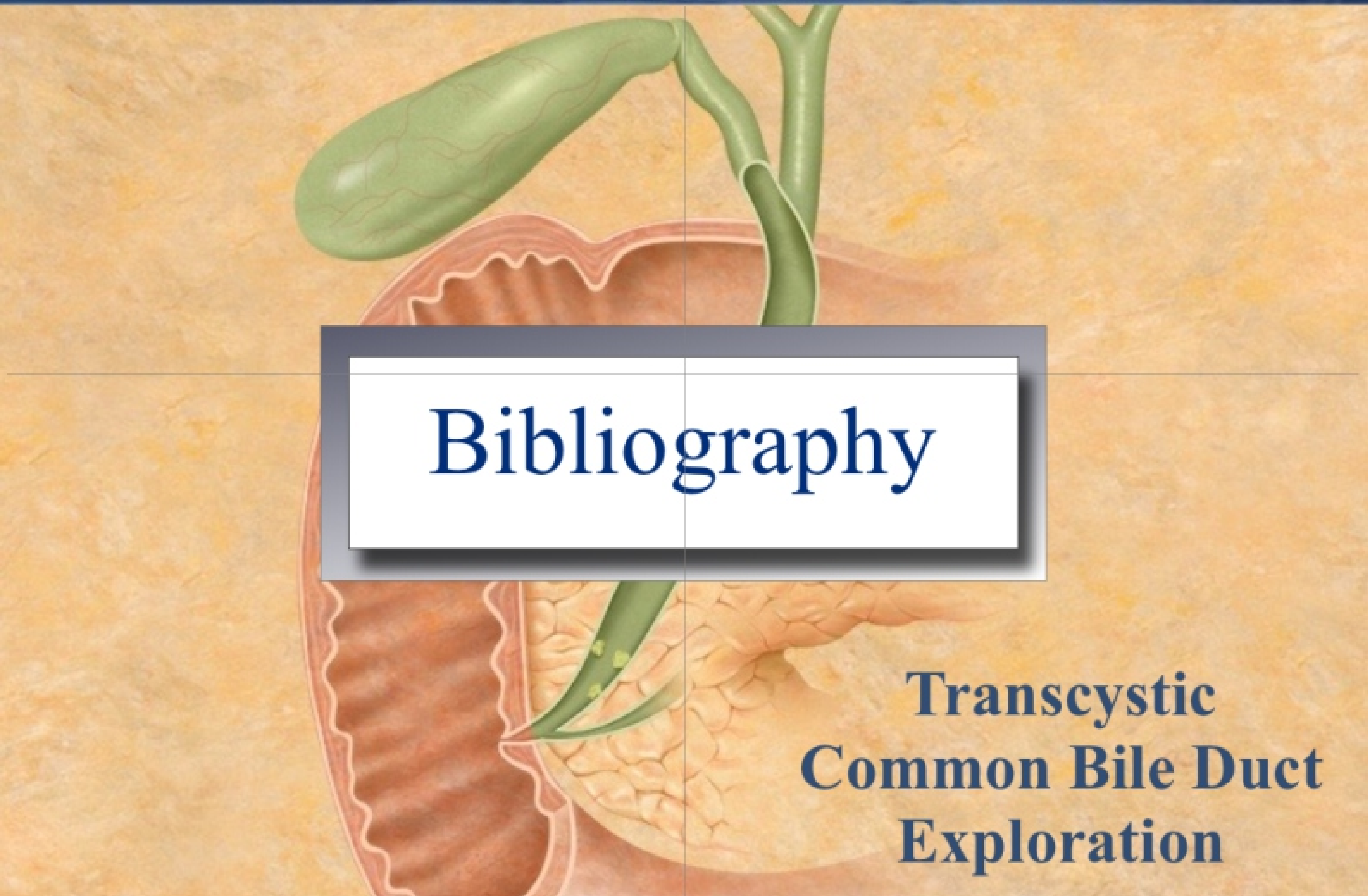
Appendix II

Laparoscopic Common Bile Duct Exploration Equipment List

B. Fernando Santos, MD

Laparoscopic Common Bile Duct Exploration Equipment List			
Description	Manufacturer	Product Code	Comments
Choledochoscope setup:			
Two laparoscopic video monitors w/ video inputs and picture-in-picture capability			Allows integration of choledochoscope and/or fluoroscopic views with laparoscopic view.
Flexible video choledochoscope IMAGE1 S	Karl Storz	11292 VSK	Deflection of distal tip: 270 degrees Working channel inner diameter: 3.6 Fr/1.2 mm Sheath size: 8.5 Fr/2.8 mm Working length: 50 cm
LUER-Lock tube connector	Karl Storz	27502	Connects saline tubing to scope
Endoscopic seal	Karl Storz	27550ZAG/1	Scope working channel seal
Alton Dean pressure irrigation unit			Pressurizes saline bag for continuous irrigation
Cystoscopy irrigation tubing	Medline	DYND19140	Connects to saline bag
Silastic tubing extension			Extension tubing to facilitate scope handling.
3L saline bag			1L bag is acceptable but may have to be replaced more frequently.
LCBDE Accessories (have available):			
Fanelli cholangiography catheter	Cook Medical	C-FCC100	
Common bile duct exploration set	Cook Medical	C-CDES-100	Includes: - Biliary wire guide (.035 inch diameter, Teflon coated), (RFSPC-35-145) - Wire stone basket, straight, (C-NTSE-2.4-115-NCT4) - 8mm x 4cm Angioplasty dilating balloon, (C-ATB5-35-40-8-4.0-CDES) - Berci introducer set 12F, (C-CDIS-4.0-15-BERCI)
LCBDE Accessories (continued)			
High pressure inflation device	Cook Medical	G31027	For pressure-controlled inflation of angioplasty balloon.
6mm x 6cm angioplasty dilating balloon	Cook Medical	G26897	For dilating smaller diameter cystic ducts (3–4mm)
0.025 inch Visiglide guidewire	Olympus	G-240-2545S	For difficult cannulations, smaller diameter but has same stiffness as 0.035 guidewire. Long length allows compatibility with other biliary devices commonly used for ERCP.
14F red rubber catheter			For vigorous flushing of duct through transcholedochal approach.
Segura Hemisphere basket	Boston Scientific	M00063801060	2.4F x 90cm stainless steel basket, has greater radial force to allow easier dislodgement and capture of stones in the papilla.
3-lumen balloon extraction device	Olympus	B-230Q-A	Multiple lumens allow contrast injection, balloon inflation, and use of guidewire to position balloon.
7F Fanelli biliary stent	Cook Medical	C-FBSS-100	7F laparoscopic delivery system – transcystic delivery is possible.
8.5F Advanix biliary stent	Boston Scientific	M00534630	8.5F stent if necessary for improved drainage – transcholedochal delivery is easier than transcystic delivery given proximal tine on stent.
T-tubes, 14F	Bard-Davol	99820	
Laparoscopic instruments:			
Olsen cholangiography fixation clamp	Karl Storz	28378 CH	
Berci grasping forceps (padded grasper)	Karl Storz	33531 PG, 30510 PX	For gentle choledochoscope handling if necessary
Berci micro-knife (pointed, retractable)	Karl Storz	26169 DO	For making choledochotomy
4-0 Vicryl Suture on RB-1 needle	Ethicon		For choledochotomy closure

Note: similar products may be available from alternate manufacturers.



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CHAPTER 17

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Chapter 2: Preface

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Chapter 6: You are Only as Good as Your Tools

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Chapter 12: Step by Step Clinical Execution

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Chapter 14: Helpful Tips

Chapter 15: Common Bile Duct Stone Management Exam

Chapter 16: Appendices

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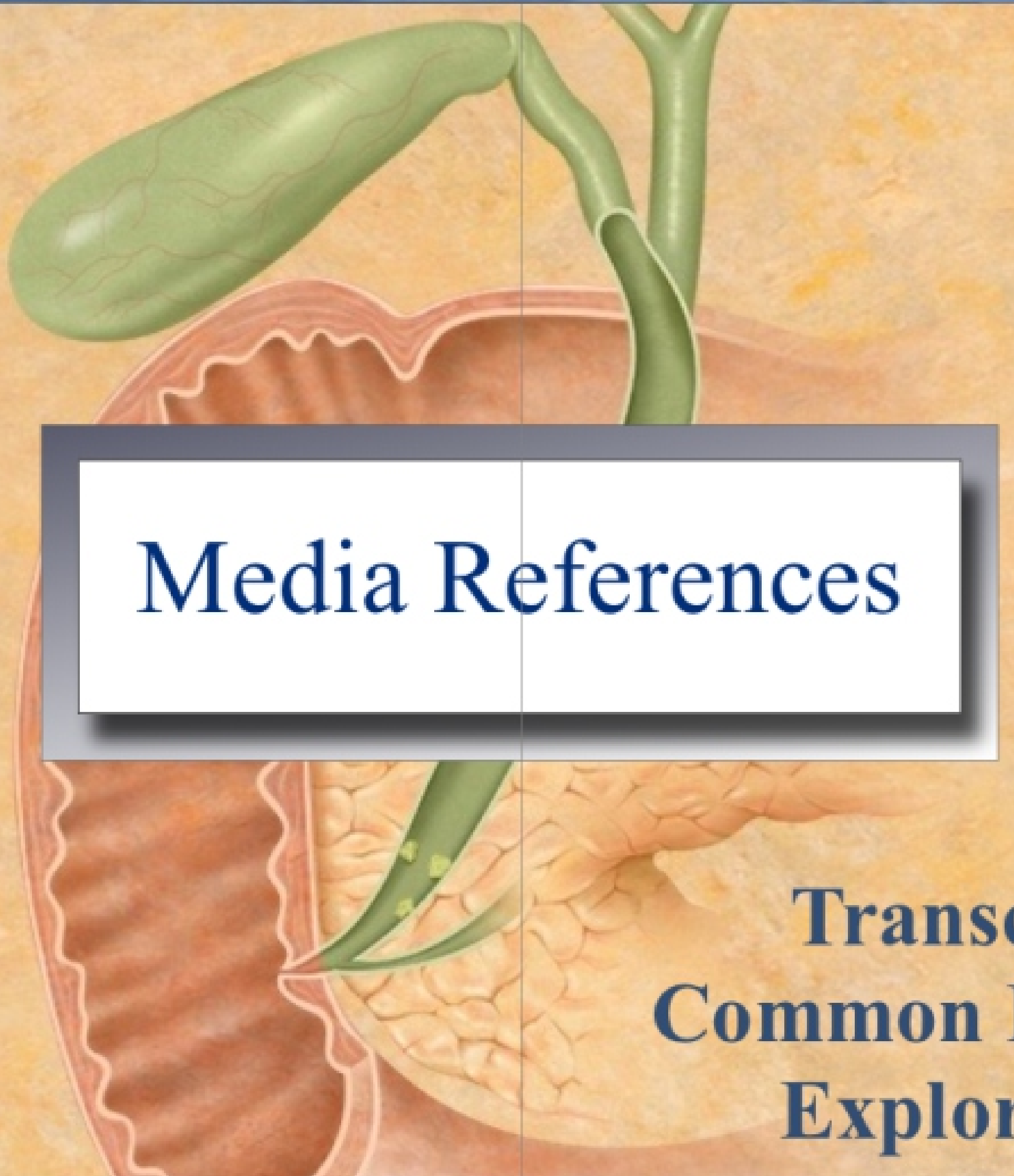

Media References

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