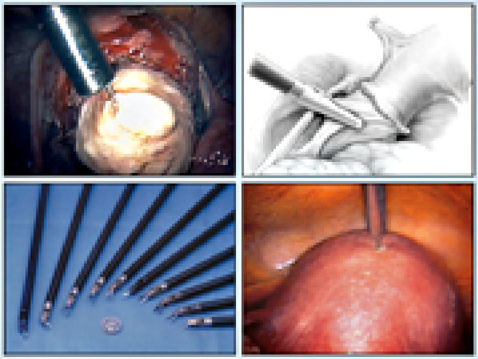
Nezhat's

Operative Gynecologic Laparoscopy and Hysteroscopy



EDITED BY

CAMRAN NEZHAT

FARR NEZHAT

CEANA NEZHAT

CAMBRIDGE Medicine

CAMBRIDGE www.cambridge.org/9780521862493

NEZHAT'S OPERATIVE GYNECOLOGIC LAPAROSCOPY AND HYSTEROSCOPY

During the past 25 years, gynecologic endoscopy has evolved into a major surgical tool used to treat a multitude of gynecologic indications. Laparoscopy and hysteroscopy are the most common surgical procedures performed by gynecologists today.

This book catalogs the full spectrum of laparoscopic and hysteroscopic procedures in gynecology, oncology, and infertility treatment. The authors describe different techniques in minimally invasive surgery and review the evidence-based medical literature supporting these techniques. The book includes sections on the management of complications during laparoscopy, ranging from vascular injury to bladder or bowel injury. It contains expanded chapters on laparoscopic anatomy, infertility procedures, operative hysteroscopy, pelvic floor repair, and laparoscopic management of gynecologic malignancy. High-quality color pictures supplement many of the presentations.

The three editors have pioneered some of the most important laparoscopic procedures used today. Their work has opened up the field of operative endoscopy for surgeons worldwide. The contributors have extensive experience in laparoscopy and hysteroscopy, and many of them have established some of the surgical techniques discussed.

Dr. Camran Nezhat is Clinical Professor of Obstetrics and Gynecology at the University of California, San Francisco, and Stanford University Medical Schools and Fellowship Director of the Center for Special Minimally Invasive and Robotic Surgery. He has served as president of the Society of Laparoendoscopic Surgeons. He is coauthor of *Endometriosis: Advanced Management and Surgical Techniques* (1995) and has published articles in numerous journals.

Dr. Farr Nezhat is Professor and Director of the Gynecologic Minimally Invasive Surgery, Robotic, and Gynecologic Oncology Fellowship Program in the Department of Obstetrics and Gynecology at Mount Sinai School of Medicine. He is coauthor of *Endometriosis: Advanced Management and Surgical Techniques* (1995) and has published extensively.

Dr. Ceana Nezhat is Director of the Nezhat Medical Center in Atlanta and Associate Clinical Professor of Obstetrics and Gynecology at the Stanford University School of Medicine. He is coauthor of *Endometriosis: Advanced Management and Surgical Techniques* (1995) and has published articles in multiple journals.

NEZHAT'S OPERATIVE GYNECOLOGIC LAPAROSCOPY AND HYSTEROSCOPY

Third Edition

EDITED BY

Camran Nezhat

Stanford University Medical School, Palo Alto

Farr Nezhat

Mount Sinai Hospital, New York

Ceana Nezhat

Nezhat Medical Center, Atlanta

CAMBRIDGE
UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK
Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521862493

First published in print format 2008

ISBN-13 978-0-511-40599-0 eBook (Adobe Reader)

ISBN-13 978-0-521-86249-3 hardback

Contents

Contributing Authors

OSCAR J. ABILEZ, MD
Postdoctoral Fellow
Department of Vascular Surgery
Division of Vascular Surgery
Stanford University Medical Center
Palo Alto, CA

NADEEM R. ABU-RUSTUM, MD, FACOG
Associate Professor
Department of Obstetrics and Gynecology
Weill Medical College of Cornell University
Director, Minimally Invasive Surgery
Gynecology Service, Department of Surgery
Memorial Sloan-Kettering Cancer Center
New York, NY

ARNOLD P. ADVINCULA, MD
Associate Professor
Director, Minimally Invasive Surgery Program & Fellowship
Department of Obstetrics and Gynecology
University of Michigan Medical Center
Ann Arbor, MI

CRAIG T. ALBANESE, MD, MBA
Professor and Chief
Department of Surgery, Division of Pediatric Surgery
Stanford University Medical Center
John A. and Cynthia Fry Gunn Director of Surgical Services
Lucile Packard Children's Hospital
Stanford, CA

CHANDRAKANTH ARE, MD, FRCS, FACS
Assistant Professor
Department of General Surgery
University of Nebraska Medical Center
Omaha, NE

CHARLES J. ASCHER-WALSH, MD
Assistant Professor
Department of Obstetrics, Gynecology, and Reproductive Science
Mount Sinai School of Medicine
New York, NY

AMR M. A. AZIM, MD, MSc, FACOG
Fellow
Center for Reproductive Medicine and Infertility
Weill Medical College of Cornell University
New York, NY

BULENT BERKER, MD
Associate Professor
Department of Obstetrics & Gynecology
Ankara University School of Medicine
Ankara, Turkey

NICOLA BERLANDA, MD
Department of Obstetrics and Gynecology
San Paolo Hospital
University of Milan
Milan, Italy

STEFANO BIANCHI, MD
Department of Obstetrics and Gynecology
San Paolo Hospital
University of Milan
Milan, Italy

ERIC J. BIEBER, MD, MSHCM
Chairman
Department of Obstetrics and Gynecology
Geisinger Health Systems
Danville, PA

WILLIAM H. BRADLEY, MD
Division of Gynecologic Oncology
Department of Obstetrics and Gynecology
Mount Sinai School of Medicine
New York, NY

MICHAEL BRODMAN, MD
Professor and Chairman
Department of Obstetrics, Gynecology, and Reproductive Science
Mount Sinai School of Medicine
New York, NY

PHILIP G. BROOKS, MD
Clinical Professor
Department of Obstetrics and Gynecology
David Geffen School of Medicine at UCLA
Attending Physician
Department of Obstetrics and Gynecology
Cedars-Sinai Medical Center
Los Angeles, CA

Alessandro Bulfoni, MD
Department of Obstetrics and Gynecology
San Paolo Hospital
University of Milan
Milan, Italy

Richard O. Burney, MD, MSc
Clinical/Research Fellow
Division of Reproductive Endocrinology and Infertility
Department of Obstetrics and Gynecology
Stanford University School of Medicine
Stanford, CA

James E. Carter, MD[†]
Clinical Professor
Department of Obstetrics and Gynecology
University of California at Irvine School of Medicine
Irvine, CA

Jérôme Cau
Department of Vascular Surgery
University Hospital
Poitiers, France

Venita Chandra, MD
Resident
Department of Surgery
Stanford University Medical Center
Palo Alto, CA

Robert L. Coleman, MD
Associate Professor
Department of Gynecologic Oncology
The University of Texas M. D. Anderson Cancer Center
Houston, TX

Alan B. Copperman, MD
Associate Clinical Professor
Director, Reproductive Endocrinology
Department of Obstetrics, Gynecology, and Reproductive Science
Mount Sinai School of Medicine
New York, NY

Myriam J. Curet, MD
Professor
Director, Minimally Invasive Surgery Program
Department of Surgery
Stanford University Medical Center
Palo Alto, CA

M. Shoma Datta, MD
Department of Obstetrics and Gynecology
St. Luke's–Roosevelt Hospital
New York, NY

Andrew DeFazio, MD
Clinical Fellow
Atlanta Center for Specialty Pelvic Surgery
Atlanta, GA

[†]Deceased

Edie L. Derian, MD
Department of Obstetrics and Gynecology
Geisinger Medical Center
Danville, PA

Sanjeev Dutta, MD, MA
Assistant Professor
Division of Pediatric Surgery
Department of Surgery
Stanford University Medical Center
Lucile Packard Children's Hospital
Palo Alto, CA

Tommaso Falcone, MD
Professor and Chairman
Department of Obstetrics and Gynecology
Cleveland Clinic Foundation
Cleveland, OH

Luigi Fedele, MD
Professor
Department of Obstetrics and Gynecology
San Paolo Hospital
University of Milan
Milan, Italy

Roger Ferland, MD
Associate Clinical Professor
Department of Obstetrics and Gynecology
Brown University School of Medicine
Providence, RI

Deidre T. Fisher, MD, MHA, FACOG
Clinical Fellow
Atlanta Center for Special Pelvic Surgery
Nezhat Medical Center
Associate
The Center for Endometriosis Care
Atlanta, GA

Eric Flisser, MD
Medical Director, Long Island Office
Reproductive Medicine Associates of New York
New York, NY

Eleonora Fontana, MD
Department of Obstetrics and Gynecology
San Paolo Hospital
University of Milan
Milan, Italy

Alan D. Garely, MD
Vice-Chairman and Chief of Gynecology
Director, Urogynecology and Pelvic Reconstructive Surgery
Department of Obstetrics and Gynecology
Winthrop-University Hospital
Mineola, NY
Clinical Associate Professor
Department of Obstetrics and Gynecology
School of Medicine in the State University of New York at Stony Brook

Linda C. Giudice, MD, PhD, MSc
The Robert B. Jaffe MD Professor and Chair
Department of Obstetrics, Gynecology, and Reproductive Sciences
University of California, San Francisco
School of Medicine
San Francisco, CA

Mark H. Glasser, MD
Chief
Department of Obstetrics and Gynecology
Kaiser Permanente Medical Center
San Rafael, CA

Olivier Goëau-Brissonnière, MD, PhD
Department of Vascular Surgery
Ambróise Pare University Hospital
Boulogne-Billancourt, France

Jeffrey M. Goldberg, MD
Head, Division of Reproductive Endocrinology and Infertility
Department of Obstetrics and Gynecology
Cleveland Clinic
Cleveland, OH

Jamie A. Grifo, MD, PhD
Professor
Director, Division of Reproductive Endocrinology
Department of Obstetrics and Gynecology
New York University School of Medicine
Attending Physician
Department of Obstetrics and Gynecology
Tisch Hospital
New York, NY

Wm. LeRoy Heinrichs, MD, PhD
Past Chair
Department of Obstetrics and Gynecology
Stanford University Medical Media and Information Technologies (SUMMIT)
Stanford University School of Medicine
Stanford, CA

Thomas Herzog, MD
P & S Alumni Professor of Clinical Obstetrics and Gynecology
Director, Division of Gynecologic Oncology
Department of Obstetrics and Gynecology
Columbia University Medical Center
New York, NY

Georgios E. Hilaris, MD
Clinical Instructor
Department of Obstetrics and Gynecology
Center for Special Minimally Invasive Surgery (Laparoscopic and Robotic)
Stanford University Medical Center
Palo Alto, CA
Gynecologic and Oncologic Surgery
Paradeisos Amarousion
Athens, Greece

Senzan Hsu, MD
Clinical Fellow
Center for Special Minimally Invasive Surgery
Stanford University Medical Center
Palo Alto, CA

Thomas H. S. Hsu, MD
Assistant Professor
Director, Laparoscopic and Minimally Invasive Surgery
Department of Urology
Stanford University School of Medicine
Palo Alto, CA

Keith Isaacson, MD
Director, Minimally Invasive Gynecological Surgery Unit and Infertility
Newton-Wellesley Hospital
Associate Professor of Obstetrics and Gynecology
Harvard Medical School
Boston, MA

Mary Jacobson, MD
Clinical Assistant Professor
Department of Obstetrics and Gynecology
Stanford University School of Medicine
Palo Alto, CA

Thomas M. Krummel, MD, FACS
Professor and Chair
Department of Surgery
Stanford University School of Medicine
Susan B. Ford Surgeon in Chief
Lucile Packard Children's Hospital
Palo Alto, CA

Keith L. Lee, MD
Resident
Department of Urology
Stanford University Medical Center
Palo Alto, CA

Charles Levenback, MD
Professor
Department of Gynecologic Oncology
The University of Texas M. D. Anderson Cancer Center
Houston, TX

Sharyn N. Lewin, MD
Fellow
Gynecologic Oncology
Memorial Sloan-Kettering Cancer Center
New York, NY

Anthony A. Luciano, MD
Director of Center for Fertility and Women's Health, P.C.
Director of Endoscopic Surgery
The Center for Advanced Reproductive Services
Professor, Obstetrics and Gynecology
University of Connecticut School of Medicine
Farmington, CT

JAVIER F. MAGRINA, MD
Professor
Department of Gynecology
Director, Gynecologic Oncology
Barbara Woodward Lips Professor
Mayo Clinic Arizona
Scottsdale, AZ

PAUL M. MAGTIBAY, MD
Assistant Professor and Chairman
Department of Gynecology and Gynecologic Surgery
Mayo Clinic Arizona
Scottsdale, AZ

ALI MAHDAVI, MD
Clinical Fellow and Instructor
Division of Gynecologic Oncology
Department of Obstetrics and Gynecology
University of California at Irvine Medical Center
Orange, CA

ANDREA MARIANI, MD
Assistant Professor
Department of Gynecology
Mayo Clinic Rochester
Rochester, MN

AMIN A. MILKI, MD
Professor
Director, Reproductive Endocrinology and Infertility
Department of Obstetrics and Gynecology
Stanford University School of Medicine
Palo Alto, CA

ROSA MOGHADAM, MD
Clinical Research Fellow
Reproductive Medicine and Advanced Laparoscopic Surgery
Center for Special Minimally Invasive Surgery
Palo Alto, CA

STEPHANIE N. MORRIS, MD
Clinical Instructor
Harvard Medical School
Associate Medical Director, Minimally Invasive Gynecologic Surgery Center
Newton-Wellesley Hospital
Boston, MA

CAMRAN NEZHAT, MD, FACOG, FACS
Fellowship Director, Center for Special Minimally Invasive and Robotic Surgery
Stanford University Medical Center
Clinical Professor
Department of Obstetrics and Gynecology
University of California at San Francisco School of Medicine
Departments of Obstetrics and Gynecology and Surgery
Stanford University School of Medicine
San Francisco/Palo Alto, CA

CEANA NEZHAT, MD, FACOG, FACS
Fellowship Director
Atlanta Center for Special Minimally Invasive Surgery and Reproductive Medicine
Atlanta, GA
Director, Nezhat Medical Center
Adjunct Clinical Associate Professor of Obstetrics and Gynecology
Stanford University School of Medicine
Palo Alto, CA

FARR NEZHAT, MD, FACOG, FACS
Professor of Obstetrics and Gynecology
Chief, Minimally Invasive Surgery and Robotics
Fellowship Programs
Division of Gynecologic Oncology
Department of Obstetrics, Gynecology, and Reproductive Science
Mount Sinai School of Medicine
New York, NY

MARIO NUTIS, MD
Clinical Fellow
Center for Special Minimally Invasive Surgery
Stanford University Medical Center
Palo Alto, CA

JAIME OCAMPO, MD
Clinical Fellow
Center for Special Minimally Invasive Surgery
Stanford University Medical Center
Palo Alto, CA

CEDRIC K. OLIVERA, MD
Fellow
Division of Female Pelvic Medicine and Reconstructive Surgery
Department of Obstetrics and Gynecology
Mount Sinai Medical Center
New York, NY

KUTLUK OKTAY, MD, FACOG
Professor of Obstetrics and Gynecology
Medical Director, Institute for Fertility Preservation
Center for Human Reproduction
New York, NY
Director, Division of Reproductive Medicine and Infertility
Department of Obstetrics and Gynecology
New York Medical College
Valhalla, NY

BARBARA J. PAGE
University of California at Berkeley
Berkeley, CA

TANJA PEJOVIC, MD, PHD
Assistant Professor
Department of Obstetrics and Gynecology
Oregon Health & Science University
Portland, OR

Jean Picquet, MD
Division of Vascular and Thoracic Surgery
University Hospital of Angers
Angers, France

Mark R. Preston, MD
Director, Center for Female Continence and Minimally Invasive Pelvic Surgery
The GYN Center for Women's Health
Waterbury, CT
Clinical Instructor
Department of Obstetrics and Gynecology
University of Connecticut School of Medicine
Farmington, CT

Pedro T. Ramirez, MD
Associate Professor
Director of Surgical Research and Education
Department of Gynecologic Oncology
The University of Texas M. D. Anderson Cancer Center
Houston, TX

Mahmood K. Razavi, MD
Director, Center for Clinical Trials and Research
St. Joseph Vascular Institute
Orange, CA

Jim W. Ross, MD, PhD
Director, Center for Female Continence
Salinas, CA
Clinical Professor
Department of Obstetrics and Gynecology
David Geffen School of Medicine
University of California, Los Angeles
Los Angeles, CA

Sophia Rothberger, MD
Resident
Department of Obstetrics and Gynecology
Oregon Health and Science University
Portland, OR

Naghmeh Saberi, MD
Assistant Clinical Professor
Department of Obstetrics and Gynecology
University of California at Irvine School of Medicine
Irvine, CA

Daniel S. Seidman, MD
Professor
Department of Obstetrics and Gynecology
Sackler School of Medicine, Tel-Aviv University
Tel-Aviv, Israel

Babac Shahmohamady, MD
Clinical Assistant Professor
Department of Obstetrics and Gynecology
University of Miami School of Medicine
Miami, FL

Andrew A. Shelton, MD
Assistant Professor
Department of Surgery
Stanford University School of Medicine
Palo Alto, CA

Yukio Sonoda
Assistant Attending Surgeon
Gynecology Service, Department of Surgery
Memorial Sloan-Kettering Cancer Center
New York, NY

Tatum Tarin, MD
Resident
Department of Urology
Stanford University Medical Center
Palo Alto, CA

Salli Tazuke, MD
Department of Obstetrics and Gynecology
Palo Alto Medical Foundation
Portola Valley, CA

Maureen M. Tedesco, MD
Resident
Department of Surgery
Stanford University School of Medicine
Stanford, CA

Michelle Tham, MD
Obstetrics and Gynecology Attending Physician
New York University Medical Center
New York, NY

Togas Tulandi, MD, MHCM
Professor and Milton Leong Chair in Reproductive Medicine
Department of Obstetrics and Gynecology
McGill University
Montreal, Canada

Rafael F. Valle, MD
Professor Emeritus
Department of Obstetrics and Gynecology
Northwestern University Feinberg School of Medicine
Chicago, IL

LINDSEY VOKACH-BRODSKY, MB, CHB
Clinical Associate Professor
Department of Anesthesia
Stanford University School of Medicine
Palo Alto, CA

JYOTI YADAV, MD
Department of Obstetrics and Gynecology
Our Lady of Mercy Medical Center
Bronx, NY

PATRICK YEUNG, MD
Clinical Fellow
Department of Obstetrics and Gynecology
University of Louisville School of Medicine
Louisville, KY

CHRISTOPHER K. ZARINS, MD
Professor
Director, Division of Vascular Surgery
Department of Surgery
Stanford University School of Medicine
Palo Alto, CA

Forewords

Progress in surgical science has been characterized by a continuous cycle of innovation from bedside to bench and back to bedside. Beginning 30,000 years ago with the first bone needles to the current armamentarium today, each quantum leap has resulted from the convergence of technical advances and creative surgeons.

Some surgical capability has been enhanced by relatively simple or more complex tool manufacture or modification, usually for a single purpose. Kocher's addition of a tooth to a straight clamp facilitated the grasping of a thyroid goiter; the more modern fixed-ring retractors have added considerable utility in abdominal retraction.

A few very special tools or techniques revolutionize our work. The development of the simple balloon catheter by Fogarty was the seminal event in initiating the concept of all endovascular procedures, beginning with the procedure of intra-luminal thrombectomy. It has expanded to balloon dilatation, angioplasty, stent placement, and now drug delivery systems in the form of drug-eluting stents.

Dr. Camran Nezhat's creative and ingenious contribution to the field of laparoscopic surgery has been similarly revolutionary. Operating off the video monitor during endoscopic surgery by the addition of a video camera to the laparoscope as developed by Camran Nezhat was a critical step in facilitating the entire field of minimal access surgery, moving it out of its initial realm in gynecologic and pelvic surgery to the entire abdomen, the chest, and beyond. He further demonstrated for the first time that even the most advanced pathology, including bowel, bladder, and ureter diseases, can successfully be managed laparoscopically. (Surgical treatment of endometriosis via laser laparoscopy, *Fertility & Sterility* 1986; Safe laser and endoscopic excision or vaporization of peritoneal endometriosis, *Fertility & Sterility* 1989; Operative laparoscopy (minimally invasive surgery): state of the art, *Journal of Gynecological Surgery*, 1992.)

The laparoscopic revolution has been startlingly rapid. In the early days of my surgical career, I heard three quotations that described surgeons' views of themselves.

"If it's easy for me, it's easy for the patient."

"Incisions heal side-to-side, not end-to-end."

"Big hole, big surgeon."

In other words, the collateral damage of incisions for access was either not relevant to the surgeon or even defined the surgeon. Dr. Nezhat's contributions began a revolution, where bigger is no longer better, and what is easy for the patient dominates our thinking. The entire field of minimal access surgery and its application is not just a set of tools and technologies but a new way of thinking. No longer is the default procedure an open one; it is fair to say that the current state of the art in most surgical arenas makes the default procedure one done with scopes.

Accordingly, this textbook, written and edited by the genius pioneers in the field, reflects that way of thinking. As such, it is both a masterpiece and a treasure.

Thomas M. Krummel, MD, FACS
Professor and Chair
Department of Surgery
Stanford University School of Medicine
Susan B. Ford Surgeon in Chief
Lucile Packard Children's Hospital
Palo Alto, CA

Laparoscopic surgery has revolutionized medicine – in gynecology and in multiple other disciplines – and offers additional opportunities to address surgical conditions through a minimally invasive approach. Camran Nezhat and his brothers, Farr and Ceana, have been and continue to be the pioneers in this effort, and this edition of *Nezhat's Operative Gynecologic Laparoscopy and Hysteroscopy* has advanced applications of the laparoscope and the hysteroscope in surgical therapies to new heights. In particular, the title and text have added *hysteroscopy* – a valuable approach to evaluate the uterine cavity and for surgical correction of abnormalities contained therein. In addition to the detailed and beautiful illustrations and clear and precise text, new sections have been added, such as the role of the laparoscope and hysteroscope in fertility evaluation and treatment, management of adnexal masses, pathogenesis and treatment of endometriosis, uterine fibroid embolization, and multiple procedures to address pelvic floor disorders. Furthermore, as experience has been derived in the minimally invasive approach to treat gynecologic malignancies, the section on gynecologic cancer has been expanded to include a comprehensive presentation of the laparoscopic approach to lymph node dissection, radical hysterectomy, and endometrial and ovarian cancer. Furthermore, the issue of trocar metastases has a dedicated section for this relatively uncommon complication of surgery. Other pioneering applications of laparoscopic surgery are discussed in detail and with accompanying informative illustrations, including laparoscopic surgery during pregnancy and in the pediatric patient and the use of the laparoscope in vascular surgery. Experience derived from performing laparoscopic procedures can, in well-trained and well-experienced surgeons, be expanded to a minimally invasive approach to gastrointestinal and genitourinary disorders. The sections on these procedures are also detailed and well illustrated. The book also includes a unique chapter on the use of simulators in laparoscopy and a visionary, multidisciplinary approach to the use of robotics and computer-assisted surgery in the treatment of surgically amenable disorders.

Laparopscopy has come a long way from the operator looking through the laparoscope. It now uses adjunctive surgical approaches and new technologies and instruments. This book says it all and says it well!

Linda C. Giudice, MD, PhD, MSc
The Robert B. Jaffe Professor and Chair
Department of Obstetrics, Gynecology and Reproductive Sciences
University of California, San Francisco School of Medicine
San Francisco, CA

In his foreword to the first edition of *Operative Gynecologic Laparoscopy: Principles and Techniques*, Alan DeCherney predicted that because of its then encyclopedic scope and the skill and experience of the authors, the volume would "become a classic." The first edition was essentially a family affair, arranged as a tabulation of the vast experience of three Nezhats, led by Camran, the senior pioneer in the group. At the time of publication of the original edition, the Nezhats had been either primary innovators or major contributors to most aspects of the progressively evolving field of minimally invasive abdominal surgery. This ranged from the introduction of video-laparoscopy through instrument design, and extension of the minimally invasive technique to include applications conventionally considered contraindicated or at best reserved for open laparotomy. They wisely archived their video recordings of each procedure for their own analysis and personal education, and ultimately, for teaching others. They also documented their observations, outcomes, and modification of techniques to recommend best practices. Alan DeCherney was prescient!

The second edition, with somewhat expanded but only jointly attributed authorship, broadened the scope and offered the reader an expert review of new developments. This remained a reliable standard for the ensuing seven years.

The new title retains the Nezhat imprimatur but is dramatically enlarged in scope, so that the encyclopedic character embraces not only history, details of equipment, power sources, and clearly illustrated surgical technique with profit for both the novice and the senior surgeon, but there are now chapters and sections that include the patho-physiology and surgical remedy for anatomic, endocrine, and neoplastic disorders that can reasonably stand alone as reliable and eloquent treatises. By further expanding authorship and including experts who are authoritative and scholarly, this edition has become an even more essential resource.

Ever mindful of the responsibility of the complete educator, the Nezhats have included excellent chapters on the skills and disciplines ancillary but essential to successful surgical adventures, even including specialized anesthesia. They have also addressed the issues of training and have expanded the section dealing with complications, their prevalence, causes, prevention, and remedies. While all of the chapters dealing with surgical procedures are careful to describe and beautifully illustrate approaches and engagements designed to reduce risk, special emphasis in a section on complications is wise.

Discrete sections dealing with special populations, namely the pediatric or pregnant patient, or the patient with chronic and often unexplained pelvic pain, extend the scope of this edition, further informing the consultant who will certainly be called upon for opinion or intervention in these circumstances.

Finally, the new edition, typical of the authors, addresses the most recent driving trend: computer-assisted surgery, thus bridging the gap between the frontiers of accomplishment and the promise of larger unrealized achievement.

It is a pleasure to read this remarkable resource. Its design, style, and content will certainly evoke the same satisfaction for anyone considering surgical intervention as part of the remedy for any gynecologic disorder.

Carmel J. Cohen, MD
Professor of Clinical Obstetrics and Gynecology
Division of Gynecologic Oncology
Department of Obstetrics and Gynecology
Columbia University Medical Center
New York, NY

The surgical discipline of gynecologic endoscopy has progressed substantially in the seventy years since the development of the first laparoscope for gynecology. The technology has evolved to include sophisticated innovations that dramatically improve its utility. As the knowledge of the advantages and limitations of these operations has grown, the application of these surgical tools has been progressively improved. Therefore, it is appropriate to dedicate a textbook to the thorough description of the standard practice, indications, and techniques of these operations.

As with any surgical instrument, a thorough understanding of the requisite operative principals governing the use of the laparoscope is essential. The surgeon's goal is to apply those tenets in the most careful manner to ensure that the operations are truly "minimally invasive." Laparoscopy is still major surgery and must be offered judiciously in those circumstances where it is clearly necessary and appropriate.

The editors have made important contributions to our understanding of the principles and techniques for endoscopic operations in gynecology. *Nezhat's Operative Gynecologic Laparoscopy and Hysteroscopy* provides gynecologic surgeons with a current and extraordinarily clear summary of the topic.

The purpose of any contributed medical text is to bring together highly qualified experts in the field and deliver a consensus report that permits a greater understanding of the topical issues. This book accomplishes that goal. It helps us to refine our technique, to make wise use of our skills, and to provide the best possible care to our patients.

Jonathan S. Berek, MD, MMS
Professor and Chair
Department of Obstetrics and Gynecology
Stanford University School of Medicine
Palo Alto, CA

Forewords to the Second Edition

Once again the Nezhats have provided, in their second edition, an excellent text in operative gynecologic laparoscopy. Not only has this group been clinically active and leaders in the field for many years, but the fact that they document their experiences and techniques is extremely laudatory. They have been not only innovators, demonstrating great creativity and imagination, but also have studied their patients prospectively and retrospectively to draw conclusions based on experience and numbers of cases. Their knowledge of the technology that they employ, that is, lasers, electrosurgery, and Harmonic scalpel instrumentation, is profound and they freely share it in this text.

The scope of the book covers all aspects of the leading surgical procedure in gynecology that can be carried out by endoscopy. Areas covered include adhesiolysis, ovarian cystectomy, ectopic pregnancy, and operations on the uterus, but there are also portions on anesthesia and office microlaparoscopy, to cite a few. The authors have made a tremendous number of revisions, demonstrating their care to detail, their awareness of this rapidly changing and developing field.

It is great that this group has produced a second edition because there are many changes that have occurred since the first edition, including work on stress incontinence and the revisiting of presacral neurectomy. Each chapter is well referenced. Any surgical text must have excellent illustrations, as this one does. This text is an excellent atlas as well.

I found this a comprehensive text for its knowledge, informative because of its insight and imagination, and practical because of its illustrations and explanations. This is a proud testimony to a work well done.

Alan H. DeCherney, MD
Professor and Chairman
Department of Obstetrics and Gynecology
UCLA School of Medicine
Los Angeles, CA

Drs. Nezhat embody the entire spectrum of current knowledge regarding laparoscopy. This book is a reference book in laparoscopy for advanced surgeons and beginners alike. The Nezhats' genius in the operating room is reflected in the writing of this book, especially in descriptions of new techniques and the lucid explanations of the advantages of laparoscopy over laparotomy in a growing list of gynecologic procedures.

As a gynecologist from Germany, I began promoting laparoscopy in 1963. At that time the thinking was that laparoscopy was only performed by gastroenterologists and hepatologists under local anesthesia, and was a procedure to be avoided by all gynecologists. It was believed that turning the laparoscope toward the lower pelvis instead of the upper abdomen would be too dangerous. Structures such as the aorta, common iliac veins, intestines, and ureters were of great concern. There were fatal complications in early gynecologic laparoscopy cases, rendering the procedure obsolete in gynecology at the beginning of the 1960s. Because of these negative connotations and in order to market this innovative technology, I changed the name to "Pelviscopy." My scientific publications and my books were printed under this name.

Dr. Camran Nezhat never criticized any of my elaborate endoscopic procedures. Instead, with his genius, he widened the operative field, creating new techniques, employing new instruments and apparatuses. In my opinion, with the cooperation of his two brothers, Camran Nezhat has enlivened and enriched the entire field of surgical laparoscopy.

Since its inception, endoscopy has changed and the authors have written about a new endoscopic world. The general surgeons have now accepted surgical laparoscopy completely. Years ago, if a gynecologist was unlucky in a pelviscopic procedure, the surgeons condemned this person as an unethical surgeon who used techniques which were as yet unproven and against the current surgical rules.

This book is indeed a bible in surgical laparoscopy. At the end of each chapter an extended bibliography is included. A lengthy chapter is dedicated to complications and how they can be avoided. This is invaluable to all: Everybody can use it: the clinician, student, scientist, and lawyer. This manual should not be missed in any library.

On June 30, 1980, I performed a laparoscopic appendectomy, which ultimately opened the door for general surgeons to perform endoscopic surgery, especially since the appendix was a holy grail of surgery. Today this book opens a new door to a whole new era of endoscopic surgery.

Prof. Dr. H. C. Mult Kurt Semm

Forewords to the First Edition

This textbook on endoscopic surgery is a timely contribution and has all the trappings of being extremely successful. The competition is keen at this point in time with regards to textbooks and atlases on endoscopic surgery but none will rival this one.

In the past decade, gynecologic surgery, because of endoscopic surgery, has undergone a tremendous revolution. There are few cases now remaining in the gynecologist's surgical armamentarium that cannot be carried out through an endoscopic approach. Many of these changes are due to the courage, innovativeness, and technical skill of Dr. Camran Nezhat. Just as in *Star Trek*, he dared to go where no man went before and, by doing this, he opened up unimagined vistas to endoscopic surgeons all over the world. For his courage, Camran has over the years suffered, but he has persevered.

This book brings to a culmination many of Dr. Nezhat's techniques, innovations, and, most importantly, thought processes. All of the characteristics necessary for an excellent textbook of surgery are included. The text is well written, provocative, and clear, and it demonstrates editorial consistency. The illustrations are superb and would provide the novice in endoscopic surgery enough information to carry out many of the procedures proposed.

I have chosen as an illustrative chapter the chapter on endometriosis. It demonstrates many of the things that have been conjured up by Dr. Nezhat and have become part of what we do as endoscopic surgeons. These include hydrodissection, ureteric resection, and reanastomosis with a stapler. If one could learn all of the techniques suggested in the chapter on endometriosis, one could become, as Dr. Nezhat has, a master endoscopic surgeon.

The book is encyclopedic in that it covers not only all surgical techniques, but also various kinds of equipment, laser and electrosurgical physics, adhesion formation, and, most importantly, complications.

Dr. Nezhat has synthesized his years of experience in this text. It will become a classic in the field and is a testimony to his skill, intelligence, and perseverance.

Alan H. DeCherney, MD
Louis E. Phaneuf Professor and Chairman
Department of Obstetrics and Gynecology
Tufts University
Boston, MA

Excellence in any human activity always commands admiration and respect. In the case of surgical techniques, excellence commands not only the admiration and respect of professional colleagues, but the gratitude of patients as well. Those who have had the opportunity to see the "Nezhat Orchestra" operate and simultaneously conduct the endoscopic operating team, recognize that they have seen a performance of excellence. It is a unique combination of manual dexterity, innovation, creativity, and teamwork.

The rapid proliferation of laparoscopic procedures in the last two decades originated in gynecology, but crossed the borders of this discipline to several other applications below and above the diaphragm. Many new devices have been introduced into the armamentarium of the endoscopic operating room. However, if there was a single factor that contributed to the increased interest, quality of patient care, and education of new generations of surgeons, it was the incorporation of video equipment as an integral part of the standard endoscopic set. This was promulgated and pioneered by Dr. Camran Nezhat. In so doing, the secrets behind the curtain of the "single eye–single hand" procedures were revealed and broadened the horizons of operative laparoscopy.

In this book, "the Nezhats" review the instrumentation and general principles of laparoscopy and elucidate the management of various procedures in gynecology and gastrointestinal and genitourinary surgery. The uniformity of text and illustration format of this book contribute to the clear message that comes from the "Nezhat School of Laparoscopic Surgery," and is complementary to the high-quality educational video library that originated in the same school.

I regard it as an honor to have this opportunity to be associated with this special project that will find an important place in the literature of our specialty.

Yona Tadir, MD
Department of Surgery
Beckman Laser Institute & Medical Clinic
Irvine, CA

Preface

This is an exciting time to be a surgeon. The field of reproductive medicine has undergone many changes over the past three decades. Gynecologic endoscopic surgery, in particular, has seen tremendous advances during this period. Breakthroughs in video technology, instrumentation, adhesion prevention, and computer-enhanced technology have certainly allowed surgeons to routinely perform a number of procedures endoscopically rather than by laparotomies. These innovations have contributed to faster recovery time, smaller scars, less adhesion formation, fewer complications, lower cost, and, most importantly, better results.

The editors deemed it necessary to update their previous edition due to popular demand and to reflect the rapid advancement in this field. With the contributions of authoritative figures in their respective areas of expertise, many new additions can be found in this book. The inclusion of hysteroscopy in the title and the dedication of a new section on hysteroscopy are meant to emphasize the importance of such surgery in the gynecologic practice today. A new section on fertility treatment and procedures reflects the rapid development in this area. As minimally invasive surgery and natural orifice surgery are becoming more and more accepted and applied in the management of gynecologic malignancy, a significant portion of the book is devoted to this topic to bring the latest information and controversies to our readers. New chapters have also been added on the emerging technologies in simulation and robotic surgery that have brought thought-provoking changes to the practice of surgery in general.

As predicted by the editors more than two decades ago, advanced laparoscopic procedures, which originated in gynecology, have now proliferated into other disciplines such as general surgery, urology, and cardiothoracic surgery. The expansion of such boundaries into the use of laparoscopy in pediatric and vascular surgery arenas is featured in this edition.

The compilation of *Nezhat's Operative Gynecologic Laparoscopy and Hysteroscopy* would certainly not have been possible without the tremendous enthusiasm and support of the contributors. The editors are deeply indebted to them for making this project successful. It is the editors' hope that this book would be able to impart to our readers both the depth and breadth of the experts' knowledge in the exciting field of minimally invasive gynecologic procedures.

Progress in medicine is made when different disciplines collaborate. The work of the editors would not have been possible without the selfless, dedicated support of the following friends and colleagues at Stanford University Medical Center: Drs. Christopher Payne, Harcharan Gill, and Thomas Hsu of the Department of Urology; Drs. Mark Welton and Andy Shelton of the Division of Colorectal Surgery; Drs. Myriam Curet and John Morton from the Department of General Surgery; Drs. Amin Milki and Ruth Lathi of the Department of Obstetrics and Gynecology; and Drs. Mary Lake Polan and Jonathan Berek, past and present Chairmen of the Department of Obstetrics and Gynecology, respectively.

The editors would like to thank their colleagues in New York for their assistance and encouragement: Dr. Carmel Cohen from Columbia University; Dr. Michael Brodman, Chairman of the Department of Obstetrics and Gynecology; and Dr. Joel Bauer of the Department of Colorectal Surgery at Mount Sinai Medical Center, as well as Dr. Perkash Saharia from Mercy Medical Center.

The editors would also like to express their gratitude to their collaborators in Atlanta for their tremendous support for this work: Dr. Earl Pennington, colorectal surgeon, and Dr. Howard Rottenberg, urologist.

We would like to thank our current Fellows: Drs. Radamila Kazanegra, Madeleine Lemyre, Senzan Hsu, Connie Liu, and Vadim Morozov.

The editors thank all the clinical Fellows in Advanced Laparoscopy, especially Drs. Eve Zaritsky and Jaime Ocampo, for their diligence and patience in completing this project. Eve and Jaime each spent one year reviewing, updating, and critiquing the chapter manuscripts. Without their help, this project would certainly be unfinished still. We are immensely grateful to Dr. Senzan Hsu for his enormous contribution and dedication in making this project a reality. We would also like to recognize Mr. Nat Russo, for his enthusiastic support of this project since it started more than 15 years and 2 editions ago. Without his foresight, these volumes would not have been published. The editors greatly appreciate the exceptional efforts of Ms. Barbara Walthall at Aptara Inc. and Mr. Marc Strauss at Cambridge University Press in making the publishing process as smooth as it could be. The editors would like to thank Dr. David Stevenson, Senior Dean at Stanford University Medical School, and Dr. Linda Giudice, Chairman of the Department of Obstetrics and Gynecology at the University of California at San Francisco, with whom they have enjoyed a long and fruitful collaboration. Finally, the editors are very grateful to Dr. Thomas Krummel, Professor and Chairman of the Department of Surgery at Stanford University Medical Center, and Susan B. Ford Surgeon in Chief, Lucile Packard Children's Hospital, for his continuous and unwavering support and friendship.

1 HISTORY OF MODERN OPERATIVE LAPAROSCOPY

Barbara J. Page, Jaime Ocampo, Mario Nutis, and Anthony A. Luciano

UNREASONABLENESS REDEFINED

The reasonable man adapts himself to the world; the unreasonable one persists in trying to adapt the world to himself. Therefore all progress depends on the unreasonable man. –George Bernard Shaw

One of the greatest transformations within the history of surgery has been the paradigmatic shift away from open surgery and into the realm of operative video-laparoscopy, an approach that truly captured all that minimally invasive surgery was meant to mean. Many have described the advent of operative video-laparoscopy as a change to surgery as "revolutionary to this century as the development of anesthesia was to the last century."[1]

Indeed, video-endoscopy is today the most common surgical procedure performed by gynecologists, colonoscopists, and gastroendoscopists.[2] As for our own discipline, gynecologic laparoscopists were some of the earliest believers in the new way. Indeed, by 1986, it was estimated that more than 1 million laparoscopic sterilizations were being performed in the United States alone.[3] Today, gynecologic operative video-laparoscopy has freed millions of women from the era when debilitating, multiple laparotomies were the norm for even mild pelvic pathologies.

NEZHAT AND THE ADVENT OF ADVANCED OPERATIVE VIDEO-LAPAROSCOPY

However, getting to this point of general acceptance – a process that is not even complete yet – actually took years of persistent insistence and ingenuity. To actually breathe life into video-laparoscopy, an entirely new way of operating had to be envisioned and accepted into the fold of convention. Yet, to convince an entire surgical discipline to relearn how to perform surgery was no walk in the park. We all know, of course, that attempting to convince surgeons to do anything against their will is a headache in the making. But especially to force upon their heads a change so radical – that of shifting their sacred line of vision – was like courting a collision with catastrophe.

An outsized catalyst was needed to rend surgeons loose from the mighty clasp of custom. It was Camran Nezhat, considered the "founding father" of operative video-laparoscopy, who would use his visionary foresight and virtuoso surgical skill to bring this concept clamoring out of its dream-state and headlong into the realm of reality.

To achieve this, Nezhat rigged together video cameras intended for other uses and began operating off the monitor in the late 1970s, which then allowed him to perform advanced procedures never before done by the laparoscope. For the first time, laparoscopic treatment of extensive endometriosis involving extragenital organs was shown to be possible when Nezhat presented his work at the Annual Meeting of the American Fertility Society in 1985. A year later, his early clinical results on the subject were published in the *Journal of Fertility & Sterility* under the title of "Surgical treatment of endometriosis via laser laparoscopy." After demonstrating the safety and feasibility of performing these complicated surgeries laparoscopically, Nezhat predicted that if such a complicated and extensive disease as endometriosis could be treated laparoscopically, then almost all other pathologies could be managed in that way, too, as long as a cavity existed or could be created in the body.

When all was said and done, Nezhat's conceptual breakthrough would revolutionize modern abdominal and pelvic surgery, overturning in its wake almost 200 years of endoscopic tradition. Talk about rocking the boat; boy would there be dues to pay before this uber-idea could claim its place at the helm of the minimally invasive movement.

THE NATURAL ORDER OF THINGS?

Of course, today all of this may seem so natural, so evolutionarily inevitable, like the story of man walking upright. Yet, operative video-laparoscopy, a concept that now seems almost prosaic in its self-evident appeal, was not so obvious a solution during the late 1970s, nor was it an idea that came gently into being.

Looking back, one actually finds that the opposite was true. Rather, the birth of operative video-laparoscopy was more like a case of gravity defied. It was like suggesting a baseball player look the other way right when the ball is pitched, totally counterintuitive.

To get a feel for just what Nezhat was up against in trying to convince the surgical world to believe in his ideas, let us take a quick trip back in time to review the status of operative laparoscopy as it stood in the 1970s, in terms of the types of procedures being performed, available technologies, and cultural mindsets that hindered its development.

MAROONED IN MEDIOCRITY: THE EARLY 1970S JUST BEFORE VIDEO-LAPAROSCOPY

Powerful indeed is the empire of habit. –Publilius Syrus

Operative Procedures Achieved by the 1970s

The late 1970s skepticism concerning gynecologic operative laparoscopy is not so clearly spelled out in other historical accounts. Many have made the inaccurate claim that gynecologists had "fully embraced" laparoscopy as a standard modality by the 1970s.[4,5] While there is a grain of truth in this with respect to diagnostic laparoscopy, for advanced operative procedures, the story was quite different. This can be established by reviewing the literature and textbooks of this era, where one can plainly see that operative laparoscopic procedures being performed were essentially no more advanced than those which had been introduced nearly 50 years earlier by endoscopy's early-20th-century pioneers: draining cysts, lysis of adhesions, taking biopsies, electrocautery, and tubal ligations.

Aspiration of Ovarian Cysts – But Not Their Removal

The history of draining cysts laparoscopically serves as a perfect example to track these operative plateaus. As early as the 1920s, the American laparoscopic pioneers Ordnoff and Bernheim were some of the first to demonstrate how successful the "peritoneoscope" (aka, laparoscope) was for this procedure. Jacobaeus was also able to drain ascites in the abdomen in the 1910s, a laparoscopic procedure similar in nature. Yet, more than 50 years later, some of the most popular manuals and textbooks of the 1970s and 1980s – Frangeheim's *Endoscopy and Gynecology*, TeLinde's *Operative Gynecology*, AAGL *Manual of Endoscopy*, Hulka's *Textbook of Laparoscopy*, Baggish's *Atlas of Contract Hysteroscopy and Endoscopy*, Wheeless' *Atlas of Pelvic Surgery* – all specifically direct laparoscopists to focus only on aspiration as the standard practice.[6–11] Surgical removal was made possible as a routine practice as a result of video-laparoscopy. Today, of course, clinical data demonstrate that up to 40% of these cysts do refill, indicating, therefore, that surgical removal is the preferred standard.[12]

Tubal Sterilizations

As for the endoscopic superstar of the 1970s – tubal sterilizations – it actually got its start back in 1936, when Boesch performed the world's first documented laparoscopic tubal sterilization using electro-cauterization.[13] Naturally, the technique has been perfected over the years. Yet, by the 1970s, conceptually the procedure had not changed much from its 1930s debut.

Indeed, with the exception of contributions from the era's few virtuosos, such as Palmer, Semm and Mettler, Steptoe, Cohen, and Gomel, our entire discipline seemed stalled for what felt like was going to be forever at tubal sterilizations, as if it were the final frontier.

Figure 1.1. Surgeon with old laparoscopic setup still being published in laparoscopic books in the 1980s. Picture adopted from *Textbook of Laparosopy* by Jaroslav Hulka, 1985.

Близок локоток, да не укусишь – *Blizok lokotok, da ne ukusish*

Impossible, you might say! Fifty years without a new operative procedure? How could this be? After all, eye-popping technological advances were proliferating at an astonishing clip during this era; fiber optics, automatic insufflators, electronically controlled thermo-coagulators. Yet, here we were, in the late 20th century, with men and monkeys flying to the Moon and back, while we laparoscopists were still stuck back at the farm, doing mainly routine diagnostics. It seemed to be a clear case of *Blizok lokotok, da ne ukusish*. This old Russian proverb, translated as "your elbow is close, yet you can't bite it," was an apt description for the times because, with the new technologies enabling video-laparoscopy even more, we were so elbow-close to breaking through and past the old ways. Yet, paradoxically, we were so far away from the "bite" because, as Nezhat and other pioneering laparoscopists of this era soon discovered, confronting psychological resistance to change was the far more difficult task to overcome.[14]

ANOTHER CONUNDRUM

There was another conundrum to overcome: New surgical techniques had to be invented that could accommodate being done in the new closed, video-laparoscopic manner. Doing a procedure endoscopically that was actually designed to be done via laparotomy presented one of the most formidable problems. In short, there were essentially no textbooks or protocols established that would have demonstrated how to make these procedures feasible laparoscopically. Some innovations were beginning to pour through the pipeline; Semm and Mettler's extracorporeal Roeder's loop was one such example.[15,16] Yet these contributions still did not resolve the majority of the problems having to do with achieving more advanced procedures.

In short, each procedure normally done via laparotomy would have to be re-invented. This process was naturally one of trial and error, a factor that especially exposed Nezhat and other laparoscopic pioneers to some harsh criticism in the early days.

An Overview of the Times – TV, Video, and Light Source Technologies

As for the nature of endoscopic technologies, many precursors to video had been established for many years prior to the 1970s. Cinematography and television had actually been used modestly in a handful of surgical centers since the late 1930s. By the 1950s, Japanese pioneers from Hayashida Hospital, Uji, Fukami, and Suginara, developed one of the earliest endoscopic cameras, the gastrocamera,[17] while in 1953 Cohen and Guterman introduced their Cameron cavicamera.[18]

Some of the most sensational moments in endoscopy's history came with the debuts of the world's first television and color film broadcasts by French pioneers; Palmer's 1955 color film debut of the first live laparoscopy; and, in the same year, the world's first television broadcasts of live bronchoscopies, achieved separately by the French bronchoscopists Soulas and Dubois de Montreynaud.[19] Within a few years, Frangenheim of Germany would produce his famous 1958 color film of a gynecologic laparoscopic surgery, a feat that reverberated throughout the world of gynecologic laparoscopists for years to come.[20]

By 1960, Inui, Berci, and others had either invented or collaborated with industry to bring miniaturized video endo-cameras into endoscopy. However, all of these systems were definitely not designed with advanced operative video laparoscopy in mind. For instance, Berci's 1962 article was one of the earliest to mention both "TV" and endoscopy" in the title. While this article did an excellent job of delineating the latest TV technologies, nevertheless its singular focus was on the ways in which the new imaging technologies would enhance documentation and teaching capabilities; there is no mention of changing the method of performing endoscopic procedures, with the goal of advancing laparoscopy's operative potential.[21]

Even as late as 1977, Berci revisited the role of TV and video devices – referred to as "teaching attachments" – as technologies to enhance teaching only.[22,23] Figures 1.1 through 1.5 from this same 1977 article also clearly show that the most recent camera-equipped endoscopes were still designed to be used in the old way, with endoscopists peering awkwardly through the scope. A similar attachment, called a "multiple tube medical television camera," highlighted in a 1977 American Association of Gynecologic Laparoscopists (AAGL) conference also demonstrates this well-entrenched trend.[24–25]

In other words, while some of the technological rudiments to support video-laparoscopy had been in existence for at least 40 years, the most crucial missing link was not technological in nature, but rather was an issue of missing imagination. The conceptual idea of combining these technologies and using them in an entirely different way had been entirely overlooked until Nezhat's unique contribution.

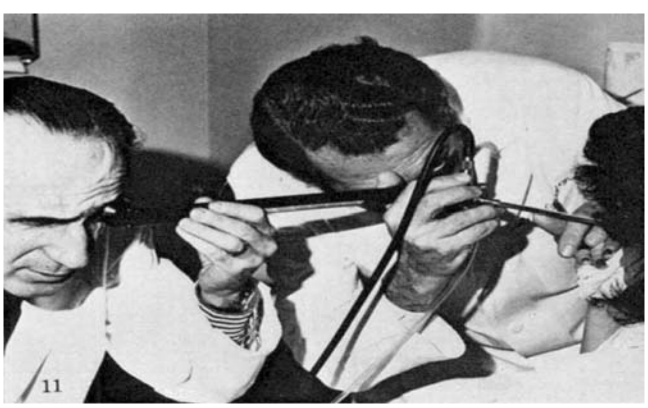


Figure 1.2. Dr. Berci peering through a teaching attachment in 1977. Although Dr. Berci had very innovative ideas, Dr. Nezhat was the first person to operate off a videomonitor. Photo adopted from Berci, G. (1977). Present and future developments in endoscopy. Proceedings of the Royal Society of London.

A PARADOX – POOR RESOLUTION ALMOST FOILS THE THOUGHT

This background review has missed one vital but paradoxical point: Even with these newly emerging optic and video technologies, Nezhat's idea was still too advanced for the era's technologies to support. At the time of Nezhat's awakening to the magic of operating upright, operating off the monitor was barely feasible. The early generation optics and video systems (before digital was perfected) did not yet produce the level of high pixel resolution that we have become accustomed to today. And, despite the superior illumination afforded by the most recent fiber optics and Hopkins lens systems, the quality of light had not advanced to a level where images could be efficiently split toward the monitor. As recently as 1977, Berci made a point to mention the inadequate nature of light sources, stating that "Illumination sources are in a chaotic state."[26] These combined technical deficiencies meant that the images shown on the monitor were so grainy that for most they proved to be indiscernible; definitely not clear enough to support the notion of operating off images. This is why so many surgeons were initially against the idea, because it was quite disorienting to view barely discernible images emanating from a low-resolution, two-dimensional screen positioned several feet away from both surgeon and patient!

BACKLASH TO LAPAROSCOPY FOR SECOND TIME IN THE 20TH CENTURY

As if these obstacles were not enough, gynecologic laparoscopy in the United States was experiencing another season of discontent, just beginning to surface in the late 1970s. Of course, as usual with the story of laparoscopy, this is completely paradoxical, for the discipline did experience some very dramatic leaps forward during this era, at least symbolically. For example, by the mid-1970s training in laparoscopy had been added to "all major gynecologic residency programs" in Europe.[27] By 1981, the American Board of Obstetricians and Gynecologists followed suit and made laparoscopic training a required component of U.S. residency programs. The number of procedures being performed annually also skyrocketed. By about 1973, some sources state that between 6 million and 7 million endoscopic procedures were being performed annually in the United States alone.[28] Other reports show that from 1971 to 1976, laparoscopic sterilizations increased from a mere 1% to an astonishing 60%. [29] Although such statistics on the quantity of surgical procedures are notoriously difficult to verify, based on our research these appear to be reasonable estimates.

Yet at the end of the day, the majority of operative procedures were still limited to simple tasks, which translated to millions of female patients continuing to be subjected to multiple laparotomies for even mild cases of endometriosis. This stall in the progression toward more advanced procedures was, in part, caused by growing concerns about complication rates associated with out-patient laparoscopic sterilizations, which had rapidly grown in popularity in just a few short years.

A growing backlash toward all things laparoscopic developed in earnest, and articles forewarning of high complication rates began to seep into the literature. One of the first such articles to gain national attention was published by the well-respected

Figure 1.3. One of the first cameras used for video-laparoscopic surgery by Cameron Nezhat, MD.

founder of the AAGL, Jordan Phillips, whose 1977 report outlining in stark detail the estimated complication rates associated with laparoscopic tubal sterilizations struck a raw nerve within surgical communities and served for a time to temper enthusiasm.[30] Indeed, failed sterilizations became the second leading cause of lawsuits for ob-gyns in the United States, only after those associated with pregnancy complications.[31]

Another example of the ambivalence over the scope's role in more advanced operative procedures can be found in one of AAGL's most memorable meetings, at which Semm had been invited to demonstrate the types of operative procedures he envisaged for his "pelviscopy." "Kurt Semm's pelviscopy presentation struck people in that meeting as going too far," recalls Soderstrom, one of the founding members of AAGL. The title of this debate, called "Laparoscopy is replacing the clinical judgment of the gynecologist," also perfectly captured the unease about allowing the scope to advance beyond diagnostics.[32]

Soon thereafter, urgent congressional hearings and other governmental advisory panels were called into session to address concerns about the rapid technological changes affecting endoscopic medical devices, in particular, and medical technologies, in general. Symbolic actions were taken against laparoscopy, beginning most conspicuously with the Congressional Health Device Act passed in 1976. Later, in 1981, the Centers for Disease Control (CDC) in Atlanta issued a very strong public rebuke over patient deaths apparently linked to unipolar laparoscopic sterilization procedures.[29] Because the medical community tends to err on the side of caution, such adverse reports – whether exaggerated or not – were nearly the death-knell for laparoscopic innovation in those days.

THE FROZEN TUNDRA OF BUFFALO – THIS IS YOUR BRAIN ON IMAGINATION

Necessity knows no law except to conquer. – Publilius Syrus

And thus it unfolded that, for the second time in the 20th century, interest in laparoscopy had soared to the heights of unfathomable popularity, only to plunge back down to Earth once its inherent limitations were revealed after the veil had been lifted. An epic tale indeed was in the making, as it seemed our laparoscope's once rising star of shiny, happy brilliance was on the verge of being reduced to a garish glare. The revivalist hey-day that American laparoscopists had so enjoyed from 1965 to 1975 had been nearly neutralized by the end of the 1970s. [32]

In other words, the timing could not have been worse to introduce such a radically new concept as that of advanced operative video-laparoscopy!

All the same, Nezhat remained imperturbable. These heavy realities were no match for his hidden reserves of moxie; he boldly pushed past the raucous ramble of naysayers, forcing a reckoning with minimally invasive surgery as the new reality. So, how did it all begin?

Amidst the frozen tundra that is Buffalo, New York, in midwinter, there was a kindling mind, ablaze with great visions that soon would take the surgical world by storm. But how did video-laparoscopy develop from the imagination of this young physician just starting his residency? And, by the way, what audacity! How did he find the courage to disagree with senior surgeons – at risk to his own just-blooming career – and take on the entire surgical world? Very gracefully, of course.

More than anything, the "how" came from the "why": Nezhat was driven to help ease the pain of his patients, who had been forced to endure 6- to 12-inch incisions into their abdomens for even the mildest of pathologies. In witnessing the extreme pain and suffering of his patients, their long convalescence, and the serious and numerous complications arising out of laparotomies, Nezhat believed that with just minor alterations almost all of this unnecessary suffering could be averted. It seemed clear to Nezhat that one of the most significant hindrances was the positioning of the surgeon in relation to the scope. The whole contraption left him contorted in the most unnatural of positions: bent-over sideways, with an assistant blindly holding the scope in place while the surgeon tried in vain to verbally direct its positioning.

He knew that if only he could find a way to circumvent the physical limitations posed by peering through the scope's singular eyepiece that the scope's surgical capabilities could then be extended into more advanced operative procedures. Practicing in the lab late at night, he realized that one might be able to perform surgery standing upright by watching the monitor.

With the concept now firmly in his head, Nezhat began the art of rigging together whatever equipment he could find to make this vision come true.

Nezhat recounts those early days:

> Early on, vascular and neurosurgeons had had success using cameras for microsurgery. So, hoping to learn from their successes, I approached my colleagues in these disciplines. Their willingness to spend time demonstrating this technology was very fruitful. Of course, we ran into unusual logistical dilemmas trying to adapt this technology. Many strange configurations were attempted before achieving any degree of success. [Eventually though], we were able to convert an old camera used in their disciplines into an awkward but nevertheless functioning addition to the scope. – Nezhat, C, Presidential Speech, September 2005, JSLS (Figure 1.3)

Despite this precarious start, Nezhat was able to collaborate with other disciplines, a factor which became crucial in further developing these ideas.[34] Nezhat attributes this multidisciplinary facet as having been a vital source of endless inspiration. Endometriosis especially led him to work with other specialties because it commonly affects many different organs, especially the gastrointestinal (GI) and genitourinary (GU) tracts. The contributions of Dr. Earl Pennington, a pioneering colorectal surgeon, and Drs. Rottenberg and Green, both urologists, were especially noteworthy, as they guided Nezhat through very challenging procedures that had never been achieved laparoscopically before.[34] Nezhat recalls, "Colorectal surgeon, Earl Pennington, and urologist, Howard Rottenberg, were always at our side." Also, patients with endometriosis have high rates of endometriomas that sometimes can have the appearance of malignancy. Therefore, from the very beginning, contributions from colleagues in gynecologic oncology were of critical importance. In this area, the guidance of Drs. Benedict Benigno and Matthew Burrell was absolutely invaluable. Through their vision and willingness to share their expertise, a better understanding of how to recognize and manage malignancies laparoscopically was achieved.[35]

As for new suturing methods, only a few modifications were needed. For the most part, Nezhat was able to convert the same microsurgical techniques for open surgeries as were taught by pioneers in treating endometriosis such as Drs. Robert Frankling of Houston, Texas, and Ron Batt of Buffalo.[37] Before switching to video-laparoscopy, suturing laparoscopically was a feat extraordinarily difficult to achieve while hunched over the scope. In fact, this factor was one of the main hindrances that had made earlier attempts at operative laparoscopy so awkward, unsuccessful, and, ultimately, unpopular.

"FOREVER-SCOPY"

Operative video-laparoscopy was certainly not without its flaws. And we would not want to delude the reader by providing only the pretty pictures of its past. Indeed, one of its least attractive features initially was the extra time it took to perform some of the advanced procedures. As Nezhat recalled, "They used to call laparoscopy 'forever-scopy.'" For instance, laparoscopic ectopic pregnancy surgeries were taking 4–5 hours initially, while Nezhat recalls that his first – and also the world's first – radical hysterectomy and paraeortic and pelvic lymphadenectomy by video-laparoscopy actually took 7 hours. This added time factor was not helping convince anyone that the video-laparoscopic method was better or safer than open surgery.[36] Of course, even some laparotomies took up to 7 hours. But, the new method naturally was judged more harshly than classical standards.

Because of this time factor stemming from the very steep learning curve, the effectiveness of video-laparoscopy was difficult to assess at first. Early reports showed laparoscopy to have higher complication rates than laparotomies, although these results were attributable mainly to inexperience.

COLLABORATION WITH INSTRUMENT MAKERS

To overcome these inherent deficiencies standing in the way of the new technique, Nezhat began a fruitful relationship of collaboration with Karl Storz and other surgical instrument companies.

Figure 1.4. Camran Nezhat doing videolaparoscopy in early 1980.

Using those same old clunky cameras borrowed from the neuro and vascular surgeons, Nezhat was able to show the company representatives that operating off the monitor could work. After hours in the operating room, eventually Storz and other company representatives were also convinced of the scope's greater potential and they began producing new cameras and light sources customized for operative video-laparoscopy.

Today, working together with companies in this fashion might be discouraged. Yet, without this early support and free-spirited exchange of ideas between engineers and surgeons, poor visualization and other technological hindrances certainly would have persisted as formidable conceptual and technological divides.[37]

DELAYS IN PUBLICATIONS

Despite collecting verifiable clinical proof to the safety and efficacy of video operative laparoscopy, at first no journal would accept Nezhat's early manuscripts on the subject.[12]

It took several years, but finally his debut articles on these never-before-seen laparoscopic surgeries were published in 1986.[13,38] From this point, Nezhat was able to continue to demonstrate –this time to a larger audience – that other complex surgeries were finally possible (Figure 1.4). Indeed, between the years of 1984 and 1989, Nezhat forced a reconsideration of all that was thought possible when he and his colleagues became the first to successfully perform such complex surgeries as:

- the first laparoscopic treatment of multi-organ, extensive, stage iv endometriosis, affecting the GI and GU;[39–49]
- the first laparoscopic bowel surgery and resection with Pennington;[39,42, 44, 45, 49, 50]
- the first laparoscopic ureter resection and ureterouretrostomy with H. Rottenberg and B. Green;[43, 45, 48]
- the first laparoscopic radical hysterectomy with paraortic and pelvic node dissection with M. Burrell and B. Benigno;[51, 52]
- the first laparoscopic bladder resection with H. Rottenberg;[43, 45, 48]
- the first laparoscopic vesicovaginal fistula repair with H. Rottenberg;[53]
- the first laparoscopic rectovaginal fistula repair with J.A. Bastidas;

- the first laparoscopic ovarian cystectomy in second and third trimesters of pregnancy;[54]
- the first laparoscopic-assisted surgery (laparoscopically assisted myomectomy);
- the first laparoscopic Burch procedure;[55]
- the first laparoscopic treatment of ovarian remnant with E. Pennington and H. Rottenberg;[56]
- the first laparoscopic sacral colpopexy;[57]
- the first laparoscopic treatment of diaphragmatic endometriosis lesions with H. Brown;[58]
- the first laparoscopic management of a leaking inferior mesenteric artery with C. Zarins;[59]
- the first laparoscopic coronary reanastomosis in a porcine model;[49]
- and the first laparoscopic management of dermoid cyst.[60]

Acceptance and publications on these firsts by Nezhat and his colleagues often faced numerous rejections and/or lagged 3 to 5 years after the initial procedures were performed, due to either resistance from journal editors to such new-fangled ideas, or for preference to publish the work of those in academia rather than those in private practice. In any case, before 1990, Nezhat and his colleagues had already performed laparoscopically nearly all the major procedures involving the bowel, bladder, and ureter, which in the past had only been accomplished via laparotomy.

"AGONY IN THE GARDEN" – THE ERA OF HOSTILITY

Scandal has ever been the doom of beauty. – book ii, properties

Like a rite of passage, the quintessential pioneer story would not be complete without an element of abject suffering to startle us out of our imaginative reverie. Like Semm, Muhe, and others, Nezhat endured many years of doubt before his ideas became accepted. In terms of endoscopy's long history, this was not surprising. There had always existed an element of resistance since the time of Bozzini, if not earlier. Resistance to operative video-laparoscopy was especially fierce for it forced surgeons – for the second time in the 20th century – to lose two vital sensory mechanisms: tactile and direct visualization.[61] These changes seemed to be the tipping point that drove the final stake into ancient surgical practices, bringing to the fore a 21st-century approach that few were actually ready to embrace. Indeed, so suspect was the new surgical revolution that Nezhat and his brothers had their academic integrity called into question.

Just a few years ago, in 2002, a lay media frenzy went so far as to label Nezhat's work "bizarre," "barbaric," and akin to "medical-terrorism." Forced now to answer to this misinformed media frenzy, Stanford University was essentially left with no choice but to act in the most politically expedient manner by launching a highly publicized, formal investigation of Nezhat's work, issuing in the process a temporary suspension to appease the public outcry. After lengthy investigations – and to the surprise of no one in the know – Nezhat's work was found to be free of any misconduct whatsoever, cleared by the highest authorities from Stanford University, the U.S. State Supreme Court, and the California and Georgia State Medical Boards. How ironic it is today that, quietly, all the studies are pouring forth which confirm Nezhat's initial impressions of the advantages of operative video-laparoscopy. Those same procedures, pioneered by Nezhat and his team considered so controversial just a few years ago, are now encouraged to be performed by the most prestigious journals. A 2004 editorial from the *New England Journal of Medicine* states, "Surgeons must progress beyond the traditional techniques of cutting and sewing . . . to a future in which . . . minimal access to the abdominal cavity [is] only the beginning."[62]

CONCLUSION

History may be servitude, history may be freedom – from "Little Gidding," TS Eliot

Sometimes history can become an unbearable weight. Operating off the monitor and inventing the accompanying advanced procedures were the crucial links which allowed our discipline to be set free from hundreds of years of history, peering directly through a tube, specula, or scope. By demonstrating the scope's boundless potential, Nezhat hit the groundbreaking grand slam that drove laparoscopy home toward its true operative potential.

Perhaps of even more lasting significance, switching to the monitor set off an intense scientific and philosophical debate about just where the upper bounds – if any – of operative laparoscopy should end. It forced a reconsideration of the entire field of surgery, a change that called for every aspect of surgical methodologies to be thoroughly scrutinized. And it was not strictly the category of surgery that was reevaluated. Rather, questions arose having to do with a wide range of aspects concerning medicine, patient rights, and disease-states. New concepts relating to pain management for patients emerged as one of the most important changes to have come about due to the minimally invasive movement. As well, an eventual rethinking in expectations about surgical outcomes arose. Complications once considered unavoidable in the days of open surgery were suddenly reevaluated and revised in the minimally invasive era.

Still, as gynecologic laparoscopists, our advocacy work to perfect and promote minimally invasive surgery is not done. There are still too many patients who are enduring needless open procedures. For example, in 1997 66.8% of hysterectomies performed in the United States were done via laparotomy. Nevertheless, humankind is closer than ever to truly being able to perform the most advanced operative surgeries through the least traumatic incisions. For this reason, the nearly complete triumph of minimally invasive surgery – with video-laparoscopy leading the way – has turned out to be one of the greatest achievements of 20th-century medicine. More than that, it transformed into one of the world's most important human rights movements by insisting on greater and more democratized standards in healthcare, a change that touched the lives of millions of patients who had suffered too long in the shadows of silence.

REFERENCES

1. www.sls.org, Marelyn Medina, MD, Rio Grande Regional Hospital (McAllen, TX).
2. www.sls.org, Marelyn Medina, MD, Rio Grande Regional Hospital (McAllen, TX). The trouble with trocars, quote from M. Kavic in Nov 2001.

3. Gomel, V. Surgical textbook introduction.
4. Sgambati, SA & Ballantyne, GH. Minimallyinvasive surgery in the diseases of the colon and rectum: the legacy of an ancient tradition. In: Jager RM Wexner S, *Laparoscopic Colectomy*, Churchill & Livingstone. New York. 1995. pp 13–23.
5. Gunning, JE. The history of laparoscopy. *Jour of Repr Med*, 1974, 12:6.
6. Frangeheim H. Endoscopy and gynecology. In *The Range and Limits of Operating Laparoscopy in the Diagnosis of Sterility*, Phillips, JM, ed. Downey, CA: AAGL, 1978.
7. TeLinde's Operative Gynecology, Lippincott Williams & Wilkins,
8. Martin DC, ed. *AAGL Manual of Endoscopy*. , 1988.
9. Hulka, JF *Textbook of Laparoscopy*, Orlando, FL:Grune and Stratton, Inc., 1985.
10. Baggish, MS. *Atlas of Contact Hysteroscopy and Endoscopy*. Urban & Schwarzenberg, 1982.
11. Wheeless, CR. *Atlas of Pelvic Surgery*, Lippincott Williams & Wilkins, 1988.
12. Nezhat C, Crowgey S, Garrison C. Surgical treatment of endometriosis via laser laparoscopy. *Fertility and Sterility*, 1986; Vol 25, No 6, pp 778–783.
13. Boesch PF. Laproskopie. *Schweiz Z Krankenh Anstaltw* 1936; 6:62.
14. Bruhat MA, Mage G, Manhes H.: Use of CO_2 laser by laparoscopy. In Laser Surgery III. *Proceedings of the Third International Congress on Laser Surgery*, I. Kaplan, editor. Tel Aviv, Jerusalem Press, 1979, p 225.
15. Semm K, Mettler L. Technical progress in pelvic surgery via operative laparoscopy. *Am J Obstet Gynecol*. 1980;138(2):121–7.
16. Semm K: The endoscopic intra-abdominal suture. *Geburtshilfe Frauenheilkd*. 42:56, 1982.
17. Uji T, Shirotokoro T and Hayashida T: Gastrocamera. *Tokyo Med. J.*, 61:135, 1953 *J. Japan Med. Ass.*, 1954; 31:681.
18. Cohen M. *Laparoscopy, Culdoscopy, and Gynecolography*. Philadelphia:WB Saunders, 1970.
19. Soulas A.: *Televised bronchoscopy*. Presse Med. 1956; 64:97.
20. Frangenheim H. *Laparoscopy and Culdoscopy in Gynaecology*. 1972; London: Butterworth, 1972.
21. Berci G., Davids J.: Endoscopy and television. *B.M.J*.1962; 1: 1610.
22. Berci G. Present and future developments in endoscopy. Proc. R. Soc. *Lond*. 1977. B. 195, 235–242
23. Olsen V, Berci G. *Teaching attachments. Endoscopy*. 1976. New York: Appleton-Century-Crofts.
24. Phillips, JM. Endoscopy in Gynecology. *AAGL* Proceedings of the Third International Congress on Gynecologic Endoscopy, 1977; 488–489.
25. Berci G. Flexible fiber endoscopes, Figure 2, *Endoscopy Today*. Mar 1972; 111–113.
26. Berci G. Present and future developments in endoscopy. Proc. R. Soc. *Lond*. 1977. B. 195, 235–242.
27. Litynski GS. *Highlights in the history of laparoscopy*.1996; Barbara Bernert Verlag.
28. Berci G. *Endoscopy Today*, 1972; vol 51, Nos 2 and 3: 64–70.
29. Soderstrom RM. A history of the American Association of Gynecologic Laparoscopists. *The Journal of the American Association of Gynecologic Laparoscopists*; 2001;Vol 8(4).
30. Phillips JM. Complications in laparoscopy. *Int J Gynaecol Obstet*. 1977;15:157–162.
31. Hulka JF. Foreword to Textbook of Laparoscopy. 1985; Grune & Stratton.
32. Nezhat C. Personal correspondence files; rejection letters for the technique of video-laparoscopy and operating off the monitor.
33. Mahnes H. A History of Laparoscopy, Acceptance Speech, *Recipient of SLS Excel Award*, 2003.
34. Nezhat F, Nezhat C, Pennington E, Ambroze W, Jr.: Laparoscopic segmental resection for infiltrating endometriosis of the rectosigmoid colon: a preliminary report. *Surg Laparosc Endosc*, 1992, 2(3):212–216.
35. Journal of Society of Laparoendoscopic Surgeons, Presidential Speech, C. Nezhat, Sept 2005.
36. Shushan A, Mohamed H, Magos AL. How long does laparoscopy surgery really take? Lessons learned from 1000 operative laparoscopies. *Hum Reprod*. 1999; 14(1):39–43.
37. Nezhat C. Videolaseroscopy: A new modality for the treatment of endometriosis and other diseases of reproductive organs. *Colposcopy & Gynecologic Laser Surgery*, 1986, 2(4): 221–224.
38. Nezhat C, Crowgey S, and Nezhat F. Videolaseroscopy for the treatment of endometriosis associated with infertility. *Fertility and sterility*. 1989; 51(2): 237–40.
39. Nezhat C, and Nezhat FR. Safe laser endoscopic excision or vaporization of peritoneal endometriosis. *Fertility and sterility*, 1989; 52(1), 149–51.
40. Nezhat CR, Nezhat FR, and Silfen, SL. Videolaseroscopy. *The CO_2 laser for advanced operative laparoscopy. Obstetrics and gynecology clinics of North America*. 1991; 18(3), 585–604.
41. Nezhat F, Nezhat C, & Pennington E. Laparoscopic proctectomy for infiltrating endometriosis of the rectum. *Fertility and sterility*, 1992;57(5), 1129–32.
42. Nezhat CR, and Nezhat FR.. Laparoscopic segmental bladder resection for endometriosis: a report of two cases. *Obstetrics and gynecology*, 1992; 81(5 (Pt 2)), 882–4.
43. Nezhat C, Nezhat F, Pennington E, et al. Laparoscopic disk excision and primary repair of the anterior rectal wall for the treatment of full-thickness bowel endometriosis. *Surgical endoscopy*. 1994;8(6), 682–5.
44. Nezhat, Camran. A safe approach to Laparoscopic Excision of Serosal and Subserosal Endometriosis, Endometriosis of the Bladder, Ureter, Rectovaginal Septum and Rectum. Annual Meeting of AAGL September 1989.
45. Nezhat C. Advanced Laparoscopic Treatment of Endometriosis. *Annual Meeting of AAGL*, Sept 1989.
46. Nezhat F, Nezhat C, Videolaseroscopy for the treatment of infiltrative rectovaginal septum, *endometriosis and posterior cul-de-sac nodularity. Annual Meeting of AAGL*, Nov 1990.
47. Nezhat CR, Nezhat F, Nezhat CH. Operative Laparoscopy (minimally invasive surgery): State of the art. J. *Gynecol Surg* 1992;8:111–141.
48. Seidman DS, Nezhat C. Letter-to-the-Editor: Is the laparoscopic bubble bursting? *The Lancet*, Feb 24 1996.
49. Nezhat, C, Nezhat, F, Ambroze, W, et al. (1993). Laparoscopic repair of small bowel and colon. *A report of 26 cases. Surgical endoscopy*, 7(2), 88–9.
50. Nezhat, CR, Nezhat, FR, Burrell, MO, et al. (1993). Laparoscopic radical hysterectomy and laparoscopically assisted vaginal radical hysterectomy with pelvic and paraaortic node dissection. *Journal of gynecologic surgery*, 9(2), 105–20.
51. Nezhat, CR, Burrell, MO, Nezhat, FR, et al. (1992). Laparoscopic radical hysterectomy with paraaortic and pelvic node dissection. *American journal of obstetrics and gynecology*, 166(3), 864–5.
52. Nezhat, CH, Nezhat, F, Nezhat, C, et al. (1994). Laparoscopic repair of a vesicovaginal fistula: a case report. *Obstetrics and gynecology*, 83(5 Pt 2), 899–901.
53. Nezhat, F, Nezhat, C, Silfen, SL, et al. (1991). Laparoscopic ovarian cystectomy during pregnancy. *Journal of laparoendoscopic surgery*, 1(3), 161–4.
54. Nezhat C, Nezhat F, Nezhat CH. Laparoscopic Burch procedure. *Operative laparoscopy (minimally invasive surgery): state of the art. J Gynecol Surg*. 1992; 8:111–141.

55. C Nezhat, F Nezhat. Videolaseroscopy for the treatment of ovarian remnant attached to bowel and ureter Annual Meeting of AAGL November 1990.
56. Nezhat F, Nezhat C, Nezhat CH. Laparoscopic sacral colpopexy for vaginal wall prolapse. *Obstet Gynecol*. 1994; 84:885–888.
57. Nezhat F, Nezhat C, Levy JS. Laparoscopic treatment of symptomatic diaphragmatic endometriosis: A case report. *Fertil Steril*. 1992;58:614–616.
58. Nezhat C, Childers J, Nezhat F, et al. Major retroperitoneal vascular injury during laparoscopic surgery. *Hum Reprod*. 1997; 12:480–483.
59. Nezhat C, Winder WK, Nezhat F. Laparoscopic removal of dermoid cysts, *Obst Gynecol*. 1989;73(2):278–281.
60. Seidman DS, Nezhat C. Letter-to-the-Editor: Is the laparoscopic bubble bursting? *The Lancet*, Feb 24 1996.
61. Pappas, Joacobs, NEJM, May 2004.

2 EQUIPMENT

Jaime Ocampo, Mario Nutis, Camran Nezhat, Ceana Nezhat, and Farr Nezhat

Successful operative laparoscopy requires the proper basic and specialized equipment to make difficult procedures technically possible and safe. Most operations can be done with two or three forceps, a suction–irrigator probe, a bipolar electrocoagulator, and a CO_2 laser. With the rapid growth of operative laparoscopy, disposable, semireusable, and reusable instruments have become available. In selecting the appropriate instruments, their cost and effectiveness should be considered because too many instruments clutter the field and increase operative time.

With videolaseroscopy, the operation is observed by the surgeon and operating room staff on video monitors. The CO_2 laser is used through the operative channel of the laparoscope for cutting and establishing hemostasis of small blood vessels.[1] Electrocoagulation with a bipolar forceps is used to control bleeding from larger vessels. These instruments enable surgeons to increase the diversity of laparoscopic procedures. Some of them have multiple functions, whereas others are specialized. Most are designed to fit through trocar sleeves between 2 mm and 33 mm in diameter.

THE BASIC INSTRUMENTS

The Laparoscope

The endoscope allows one to view the abdominal and pelvic cavities and is the most important piece of equipment. It must be in optimal condition. Although the diameter of laparoscopes varies from 2 to 12 mm and the angle of view varies from 0° to 90°, the most commonly used laparoscopes are straight diagnostic (Figure 2.1A) and angled operative laparoscopes (Figure 2.1B,C). A direct 10-mm, 0° diagnostic laparoscope and an 11-mm, 0° operative laparoscope with a channel for the CO_2 laser are preferable (Figure 2.2A,B). The image transmitted by the diagnostic scope is better. The operative channel requires a reduction in the size of the lens system and the number of fiberoptic bundles. With a Hopkins rod lens system, the shaft of the laparoscope contains quartz rods with concave ends that provide excellent clarity. This type of lens rarely is dislodged during handling. Endoscopes are either rigid or flexible. Most rigid scopes are focused with the camera coupler. With a videoscope (camera and scope together), either there will be a focus control on the scope or the focus will occur automatically inside the camera. The image is magnified and appears larger on the monitor.

Flexible scopes rely on many fiberoptic bundles. As the image is magnified, so are the bundles, making the ends of the bundles visible along with the image. The scopes are relatively fragile, and small cracks allow water to seep through the lens and distort the image.

Another breakthrough in medical cameras is “chip-on-a-stick,” a technology that combines the camera and the scope in one piece of equipment. The camera chip is taken out of the camera head and placed at the distal end of the scope. This technology does away with the optical lenses an image passes through when the chip is in the camera head. Chip-on-a-stick cameras require less light than do standard cameras because light is not lost in the light cord and rod lens.

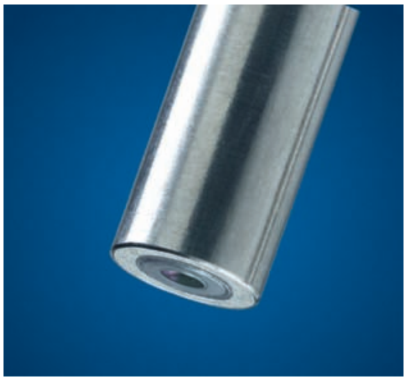
There are multiple manufacturers of laparoscopes, all of which have slightly different variations. We recommend that you try laparoscopes from different manufacturers so that you can find the most comfortable one for you.

Primary Trocars

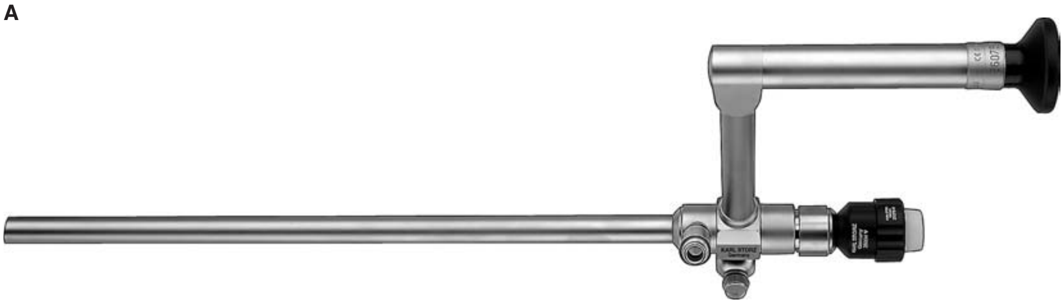
Reusable and disposable trocars are constructed of a combination of metal and plastic (Figure 2.3A,B). A feature common to all of them is a flapper or trumpet valve that is designed to prevent gas leakage as the laparoscope or other instruments are removed from the abdomen. With reusable trocars, this mechanism creates friction on the laparoscope. After a prolonged procedure, the trocar moves with the laparoscope. This phenomenon causes inadvertent removal of the trocar from the abdominal cavity and a loss of pneumoperitoneum. When the spring is removed from the valve, there is less friction and that problem can be avoided. A feature of disposable cannulas is a new stability thread design that provides greater fixation of the abdominal wall. A radially expanding outer sheath has been developed to allow safer trocar insertion (Step, InnerDyne, Sunnyvale, CA). The radially expanding dilation is supposed to leave a 50% smaller scar while securely anchoring the cannula and virtually eliminating abdominal wall bleeding (Figure 2.4).

Another approach to improving the safety of primary trocar insertion is the observing or optical trocar (Ethicon; Figure 2.3B). The obturator of this trocar is hollow except for a clear plastic conical tip with two external ridges. The trocar–cannula assembly is passed through tissue layers to enter the operative space under direct vision from a 10-mm or a 5-mm 0° laparoscope placed into the trocar. Initial experience suggests that this technique represents a safe alternative to Veress needle placement when laparoscopic access could be hazardous or difficult.[2,3] The optical device requires some additional training so that the operator can identify the various anatomic layers upon entry into the abdomen through the contact view. This device is no substitute for proper training, and its cost-effectiveness for an experienced laparoscopist is doubtful.

A fiberglass optic–equipped safety needle has been developed for visually controlled access in laparoscopic procedures. This device can allow immediate diagnosis of small bowel perforation by endoscopy.[4]



A



B

C

Figure 2.1. (**A**) A 5-mm straight diagnostic laparoscope. (**B**) A 10-mm diagnostic laparoscope. (**C**) Angled laparoscopes.

Figure 2.2. (**A**) The laser laparoscope has two channels: one for the CO_2 laser and one for the light source. (**B**) The CO_2 laser is connected to the operative channel of the laparoscope.

Figure 2.3. (**A**) A reusable 11-mm trocar with a 10-mm laparoscope. (**B**) A 5-mm and 10-mm trocar with a bladeless obturator (Ethicon). Both of these trocars also allow for the insertion of the camera in order to have visualization on insertion of the trocar.

Various disposable trocar tips are available. Spring-loaded safety shields (Ethicon) retract into the cannula as the trocar is inserted into the abdomen. This exposes the sharp trocar for entry and automatically releases the plastic shield inside the peritoneal cavity to cover the sharp tip and protect intra-abdominal organs. Another trocar uses the same principle as the Veress needle. The trocar tip has a hollow core with a spring-loaded blunt stylet (Dexide). After the peritoneal cavity is penetrated, the blunt stylet moves beyond the tip to prevent injury. Bullet blunt-tip disposable trocars (Ethicon) lessen the possibility of tissue being caught between the trocar and the sleeve. In the presence of adhesions to the anterior abdominal wall, under the umbilicus, the reusable devices have no proven advantage.

There has been great debate over the decreased risk of trocar injury with radially expanding (blunt) trocars versus sharp trocars. Both these types of trocars are available on the market today. Bhoyrul et al. [5] compared the complication rates in two groups of patients who had procedures using sharp trocars versus blunt trocars. There was a decrease in the rate of intraoperative cannula site bleeding and operative wound complications in the blunt trocar group. Pain scores were lower in the blunt trocar group, but these did not reach statistical significance. In these studies, the investigators opted for no closure of the 12-mm trocar sites when using blunt trocars. No incisional hernias were reported during a follow-up period of 18 months. Decreased risk of incisional hernias, even in nonapproximated port sites of 12 mm, was also shown by a study done by Johnson et al.[6] In this retrospective review, 747 patients with 3735 trocar sites were studied. There were no incisional hernias reported with the use of the VersaStep blunt trocars. These results were compared to the 1.2% rate of incisional hernias when the Hassan trocar was used.

Whether or not blunt trocars decrease the risk of vascular injury remains unknown. The Office of Surveillance and Biometrics, U.S. Food and Drug Administration keeps records through the Manufacturer and User Facility Device Experience (MAUDE) database.[6] In most cases of vascular injury, the trocar involved was either a shielded trocar (which has a retractable shield that covers the trocar blade before and after insertion to help protect abdominal and pelvic organs from inadvertent puncture) or an optical trocar (which allows the laparoscopist to view the cutting tip as it penetrates the tissues). However, no studies looking at this issue have been done.

Secondary Trocars

Reusable and disposable accessory trocars and sleeves come in a variety of lengths and range in diameter from 2 to 30 mm; the most common size is 5 mm. Some are threaded and are screwed into the abdominal wall, making them relatively immobile during manipulation. The use of "fascial screws" is associated with an increased incidence of omental and bowel herniation after laparoscopy.[7]

Veress Needle

Disposable and reusable Veress needles consist of a blunt-tipped, spring-loaded inner stylet and a sharp outer needle (Figure 2.5). A lateral hole on this stylet enables CO_2 gas to be delivered. As the needle passes through the abdominal layers, the stylet retracts to allow penetration into the peritoneal cavity. The absence of tissue resistance allows the blunt stylet to protrude intra-abdominally. The disposable Veress needle has several added safety points, related mainly to the sharp tip of the outer needle and the smooth operation of the spring mechanism.

Many laparoscopists continue to use the Veress needle to create pneumoperitoneum, mainly because of preference for and comfort with this technique. They also claim that a vascular or organ injury would be less severe with a smaller-caliber instrument. However, multiple studies have shown that direct trocar insertion is a safe alternative to Veress needle insertion technique for the creation of pneumoperitoneum; it has lower complication rates, has less cost/instrumentation, and allows rapid creation of pneumoperitoneum.[8,9]

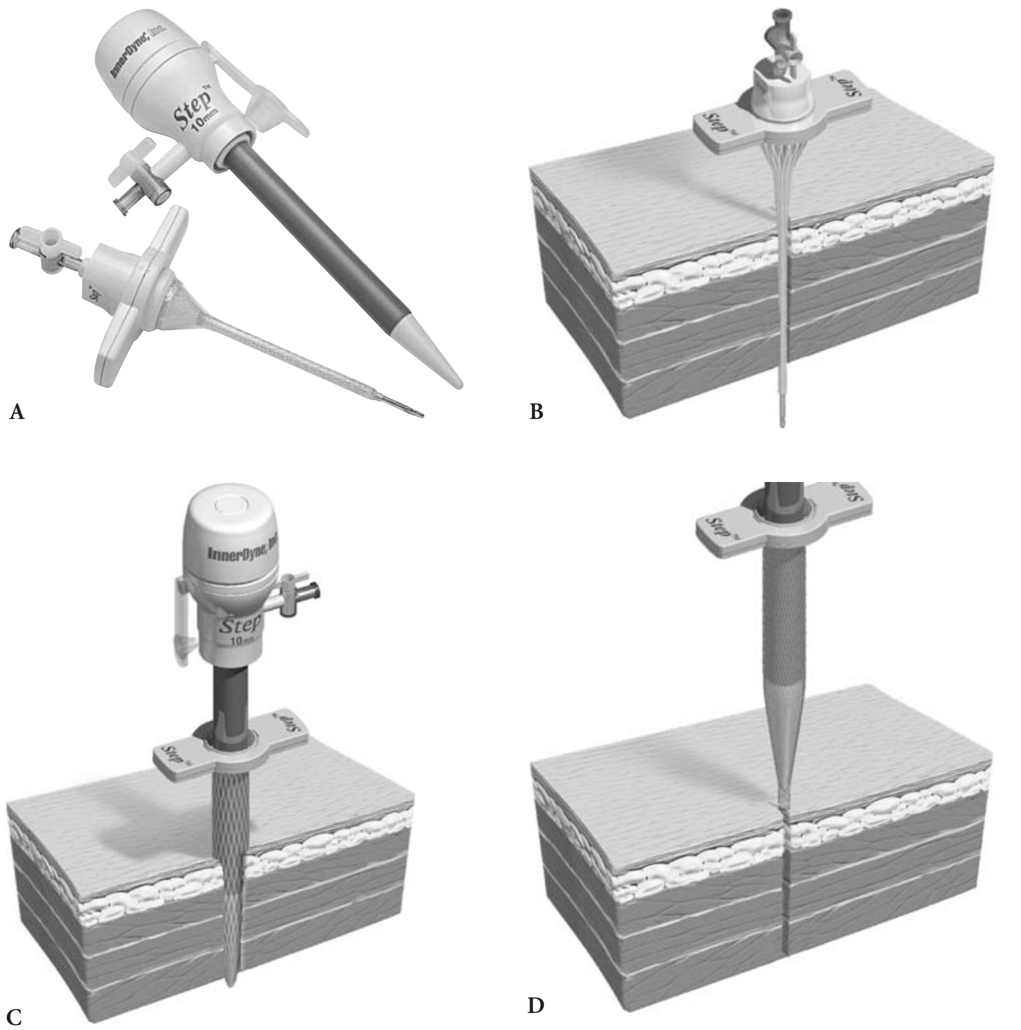


Figure 2.4. (**A**) A radially expanding 10-mm cannula/dilator. (**B**) After insufflation, intra-abdominal entry is made by using an insufflation and access needle with a radially expandable sleeve. The needle is withdrawn, leaving the expandable sleeve in place. (**C**) A tapered blunt dilator is inserted, expanding the sleeve and tissue tract. Radial dilation of the tract splits each layer of tissue along a path of least resistance. (**D**) After the cannula is removed, a small slit-like defect remains when the layers of muscle in the abdominal wall collapse.

Insufflator

To adequately observe the contents of the abdominal and pelvic cavity, the abdomen is distended with insufflated CO_2. Some operations require an automatic electric insufflator that can deliver up to 40 L of gas per minute. The insufflator compensates for changes in intra-abdominal pressure. To avoid complications such as subcutaneous emphysema, intra-abdominal pressures should not exceed 15 mm Hg. The Stryker Endoscopy Insufflator (Stryker Corporation, Kalamazoo, MI) (Figure 2.6) uses heated carbon dioxide (37°C/99°F) immediately before it enters the patient's abdominal cavity, and this may help maintain body temperature, decrease the risk of hypothermia, and reduce endoscope fogging.

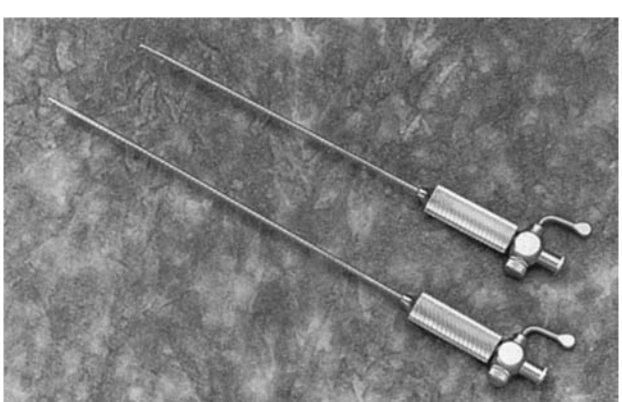


Figure 2.5. Reusable Veress needles.

The Light Cord

The light cord is as important as a high-resolution camera and a precision scope. If light does not move properly from the light source to the scope through the cord, the value of the camera is limited and images are poor. Light dispersed evenly across the cord's diameter is preferred. Light cords are either fiberoptic or liquid filled. Fiberoptic cables are available in varying lengths (6, 8, and 10 ft) with little light loss. Light cords are fragile and should not be wound into small bundles. Liquid-filled light guide cables transmit more light and are more durable than fiberoptic cables.

Figure 2.6. High flow insuflattors (like this Stryker unit) warm CO_2 gas(37°C/99°F) immediately before it enters the patient's abdominal cavity. These insufflators can provide flow up to 40 L /min.

They are more expensive, produce more heat at their connection to the endoscope, and are limited to a standard 6-ft length.

Light Sources

All light sources use xenon, halogen, or mercury bulbs. Each type generates light of a different color and intensity. The most common bulbs are halogen and xenon, with xenon available in 150, 175, and 300 W (Figure 2.7). Xenon bulbs generate a higher intensity of light, last longer, and are more expensive to replace. They provide consistent levels of light intensity and can generate even higher levels of light as needed.

Suction–Irrigator Probe and Hydrodissection Pump

A suction–irrigator probe is a versatile instrument. Controlled suction and irrigation enhance observation and improve operative technique. This device serves as an extension of the surgeon's fingers, serves as a backstop for the CO_2 laser, and helps with hydrodissection, division of tissue planes and spaces, lavage, blunt dissection, and smoke and fluid evacuation. A properly designed suction–irrigation system has the following characteristics:

1. The trumpet valve is designed ergonomically and is versatile, so electrosurgical accessories, lasers, and hand instruments can be inserted through the probe (Figure 2.8A,B)
2. The trumpet valve is easy to use and provides constant control of fluid or suction, including valve regulation, rather than an on/off mechanism.
3. The internal valve diameters are large enough to allow blood and tissue to pass easily through the canister and provide sufficient irrigation flow.
4. Probe tips are smooth, strong, and nonreflective so that they can be used for blunt dissection and serve as a backstop for the CO_2 laser (Figure 2.9).
5. The irrigation pump provides precise and variable irrigation pressures.

A trumpet valve can incorporate a metered adjustment feature, allowing smoke evacuation without manual intermittent

Figure 2.7. Xenon light source by Stryker.

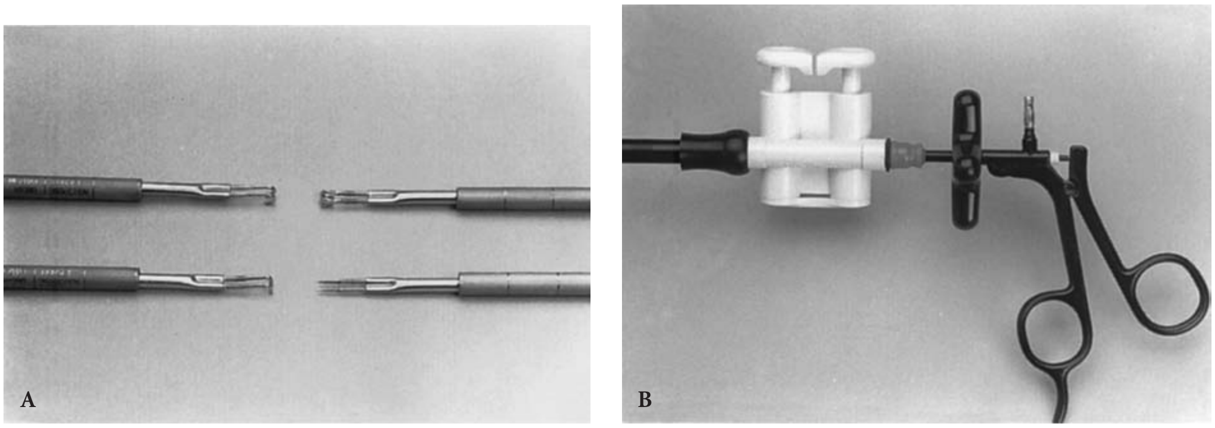


Figure 2.8. (**A**) Nezhat-Dorsey hydrodissection suction–irrigator probes with different electrosurgical accessories. (**B**) A hydrodissection probe can accommodate hand instruments.

depression of the suction piston. To begin smoke evacuation, a control pad is rotated counterclockwise by the surgeon, allowing variable evacuation up to 10 L per minute (Figure 2.10). Additional suction capability can be accessed by depressing the suction piston button. Laser or electrosurgical accessories inserted through the rear access port simultaneously can be combined with smoke evacuation, maintaining a clear field of vision. Several probe tips are available in various lengths and shapes (Figure 2.11). A quick mechanism-disconnect probe tip speeds the changing of the tips. An aspiration–injection needle accessory with nonfenestrated 5-mm/28-cm probe tips allows precise closed-chambered aspiration of ovarian cysts or injection of fluid (Figure 2.12). This system has reusable probe tips. Although the pump can deliver fluid with a pressure up to 775 mm Hg, 300 mm Hg is used for routine irrigation. Higher pump pressures are used to dissect areas near the bowel, bladder, major blood vessels, and ureters. The irrigation fluid consists of warmed 1-L bottles of lactated Ringer's solution (Travenol Laboratories, Deerfield, IL), and wall suction is used as the aspirated material initially enters a Vac-Rite canister. A laser plume filter removes particles that might clog the wall suction. A higher pneumatically powered pump pressure with adjustable pulsations has been developed (Davol X-Stream Irrigation System [previously American Hydro-Surgical Instruments]). It incorporates the effectiveness and convenience of bag irrigation with the precision and effective delivery of pressurized pump irrigation (Figure 2.13). It does not use electric current, electronics, or any type of computer software but offers irrigation control. It has a "pump cartridge chamber" into which a disposable cartridge is inserted. As compressed gas does not contact the irrigation fluid at any time, this design eliminates the potential for procedural contamination during setup and the possibility of inadvertently entering the abdominal cavity. Irrigation bags replace bottled solutions. As the bag is depleted, it collapses on itself, stopping the pump and alerting the staff to switch to the second fluid supply. The fluid is delivered in a continuous flow or in a pulsed irrigation mode. The rates of pulsation and irrigation pressure are adjustable. The latter setting ranges from 0 to 2500 mm Hg. Pulsatile irrigation cleanses the surgical site more effectively than does normal continuous flow, enabling a more thorough removal of blood clots and char. The use of irrigation fluid warmed to 39°C has been advocated to decrease the drop in core temperature commonly observed in laparoscopy.[10]

Forceps

Atraumatic and grasping forceps with jaws are available in sizes from 3 to 10 mm (Figure 2.14). Atraumatic stabilization of structures is important in many procedures, and several types of forceps are available for this purpose. The preferred type is medium sized, with a rounded tip and serrated jaws. It can grasp tissue for exposure, act as a blunt probe with the jaws closed, affect traction

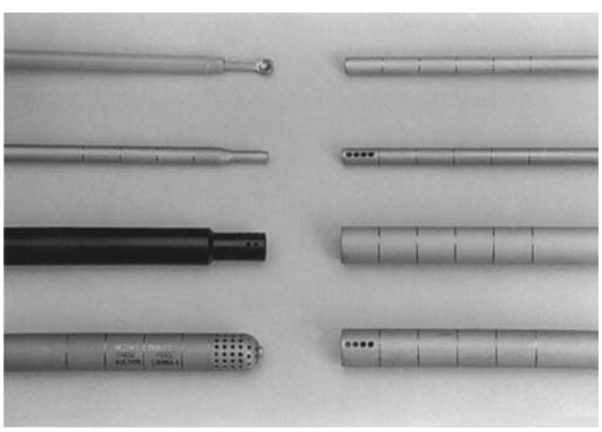


Figure 2.9. Different size probe tips are smooth and nonreflective and can be used for blunt dissection and as laser backstops.

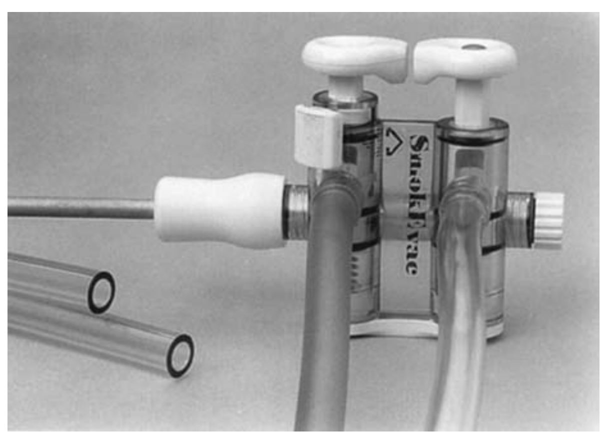


Figure 2.10. A trumpet valve has a control-metered adjustment pad that permits smoke evacuation.

Figure 2.11. Designed specifically for use with the Nezhat-Dorsey hydrodissection system, the "Quick-Disconnect" probe tip set contains one 5-mm probe tip without irrigation holes, one Micro-Probe tip, one 10-mm probe tip with irrigation holes, one suction cannula, one instrument insert probe, 12 instrument insert adapters, and six "Quick-Disconnect" adapters. All probe tip sets are available in 23-cm, 28-cm, and 33-cm lengths.

with the jaws open for more tissue surface area, serve as a needle holder, and tie sutures (Figure 2.15A).

Forceps can grasp tissue and remove tissue from the peritoneal cavity. Those made of titanium with a polished finish can serve as a backstop for the CO_2 laser, whereas others have monopolar electrocoagulating ability. The Remorgida 3-in-1 bipolar forceps (Karl Storz, Culver City, CA) features two jaws of atraumatic grasping teeth and a scalpel-like blade between the forceps, enabling surgeons to grasp, cut, and coagulate tissue with one instrument (Figure 2.15B). Creating a neosalpingostomy in a hydrosalpinx requires two grasping forceps for traction and countertraction. Fine forceps are used for delicate work such as ovariolysis, fimbrioplasty, and tubal exploration during salpingostomy for ectopic pregnancy (Figure 2.16).

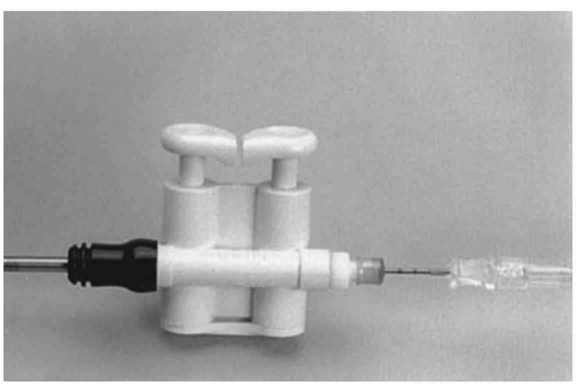


Figure 2.12. The aspiration–injection needle is inserted through the back of the trumpet valve. At the distal end of the needle, there is a Luer-Lock that allows connection to a syringe so that suction and irrigation are not interrupted.

Figure 2.13. The X-Stream Irrigation System (Davol Inc., New Jersey) uses bag irrigation. It uses a "pump cartridge chamber" into which a disposable cartridge is inserted.

Scissors

Scissors are curved, straight, or hooked (Figure 2.17). Some have an electrical adaptor so that they can be combined with unipolar or bipolar electrocoagulation (Figure 2.18). Scissors are inserted into the secondary trocar under direct observation to avoid injury to pelvic structures. Hooked scissors have overlapping tips and can cause damage even when closed. Scissors can lyse adhesions, divide coagulated tissue, cut sutures, and open a fallopian tube for salpingostomy. If they become dull, they are discarded because sharpening is ineffective. Disposable scissors are particularly useful for patients who have extensive adhesions.

Biopsy Forceps

Biopsy forceps can sample suspected endometrial implants, ovarian lesions, and peritoneum (Figure 2.19). The jaws should be sharp and overlap when closed to avoid tearing tissue and causing unnecessary bleeding. Some have a small tooth on the upper or lower jaw and are ideal for taking a tissue sample from hard or slippery surfaces (Figure 2.20). Bleeding from the biopsy site is controlled by a defocused laser or bipolar electrocoagulation.

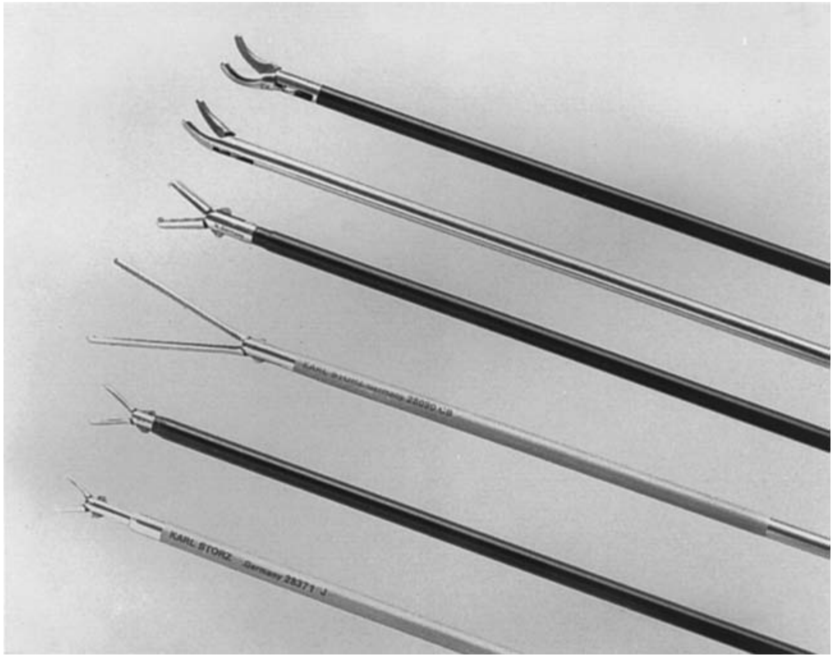


Figure 2.14. Straight and curved laparoscopic grasping forceps.

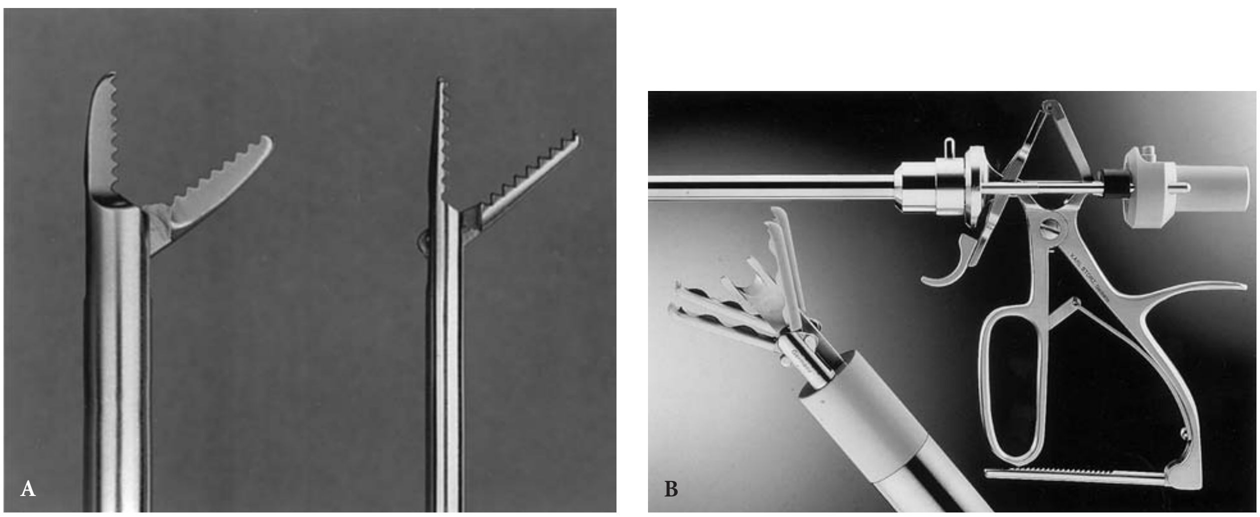


Figure 2.15. (**A**) Serrated jaws of 5-mm (left) and 3-mm (right) needle holders. (**B**) The Remorgida 3-in-1 bipolar forceps (Storz).

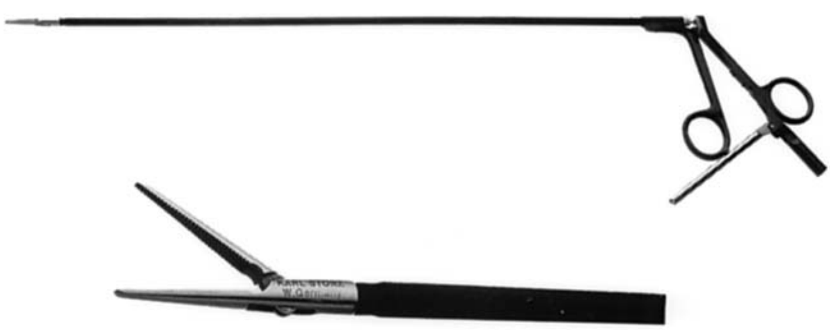
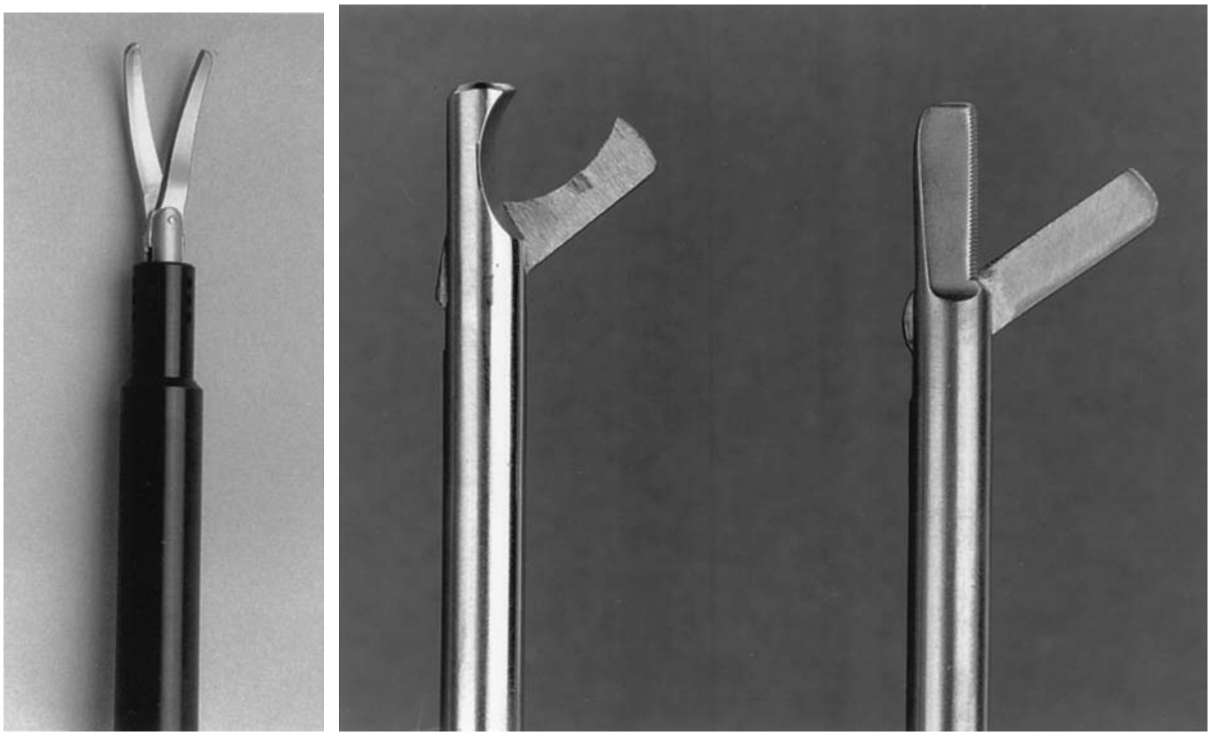


Figure 2.16. Fine forceps can be used for delicate procedures such as ovariolysis, fimbrioplasty, and tubal exploration for ectopic pregnancy.



A B C

Figure 2.17. Laparoscopic scissors. (**A**) Curved. (**B**) Hooked. (**C**) Straight.

Electrosurgical Generator and Bipolar Forceps

The primary instrument used for hemostasis during operative laparoscopy is the bipolar electrocoagulator (Figure 2.21). One should prepare and test this instrument before the operation begins because it is essential for hemostasis during oophorectomy, hysterectomy, or even bowel resection to desiccate the mesenteric artery. Several types of bipolar forceps are available (Figures 2.21, 2.22). Fine tips are used for coagulating small blood vessels during delicate operations involving the tubes, bowel, or ureter. Flatter jaws are appropriate for use on large blood vessels or pedicles, including the uterine artery and the infundibulopelvic ligaments. A 3-mm bipolar forceps is available and is useful for tubal coagulation under local anesthesia. The main advantage of bipolar energy to monopolar energy is more controlled spread of energy because energy travels only between the small space of the two jaws. The thermal spread of bipolar forceps has been reported to be between 2.0 mm and 3.5 mm when sealing arteries and 4.0 mm to 6.0 mm when sealing veins.[11] This thermal spread is the highest among devices using bipolar energy.

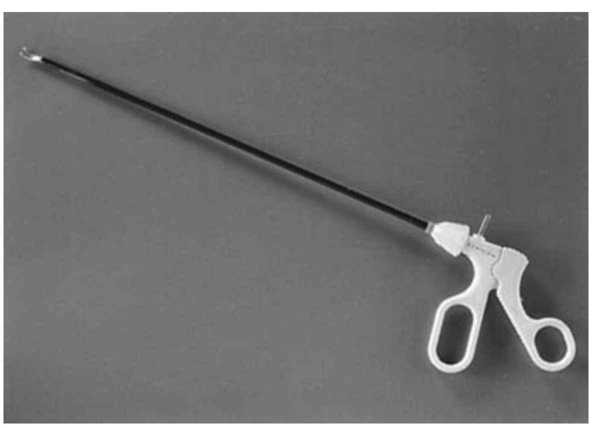


Figure 2.18. Laparoscopic scissors have unipolar electrocoagulation capability.

Vessel-Sealing Systems

The ever-present need to facilitate advanced laparoscopic procedures has brought about the invention of new modalities for achieving hemostasis. Besides titanium clips and laparoscopic stapling devices, there are two other modalities available on the market: bipolar vessel-sealing devices and ultrasonic energy.

Bipolar Vessel-Sealing Devices

Modern feedback-controlled bipolar devices include the LigaSure (LS) sealing device (Valleylab, Boulder, CO; Figure 2.23A,B)and the PlamaKinetics (PK) sealer (Gyrus Medical, Maple Grove, MN; Fig. 2.23C). Both of these devices use radiofrequency bipolar energy and both have an impedance-based feedback loop that modifies the bipolar energy delivered. Delivery of bipolar energy differs in that the LS device provides a continuous bipolar waveform whereas the PK sealer delivers a pulsed bipolar waveform, allowing for a cooling-off period for cooling of the blades.[12] These devices are recommended for sealing vessels up to 7 mm in diameter.

Both devices have been thoroughly tested and provide supraphysiologic burst pressures (burst pressure is the capacity to seal vessels) equivalent to the gold standard burst pressures of sutures and clips or staples.[11]

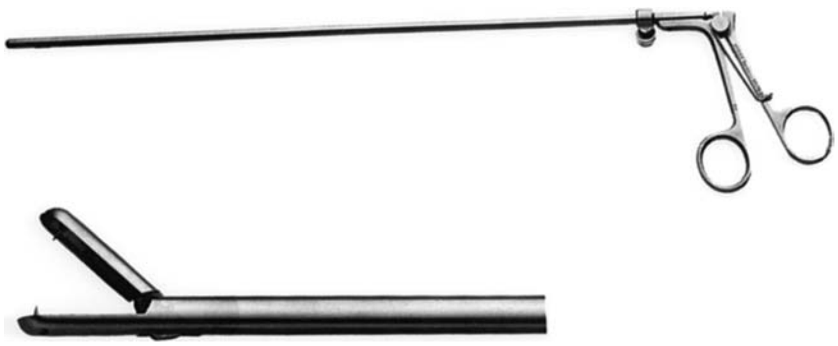


Figure 2.19. A 5-mm biopsy forceps is used to obtain tissue from endometrial ovarian implants.

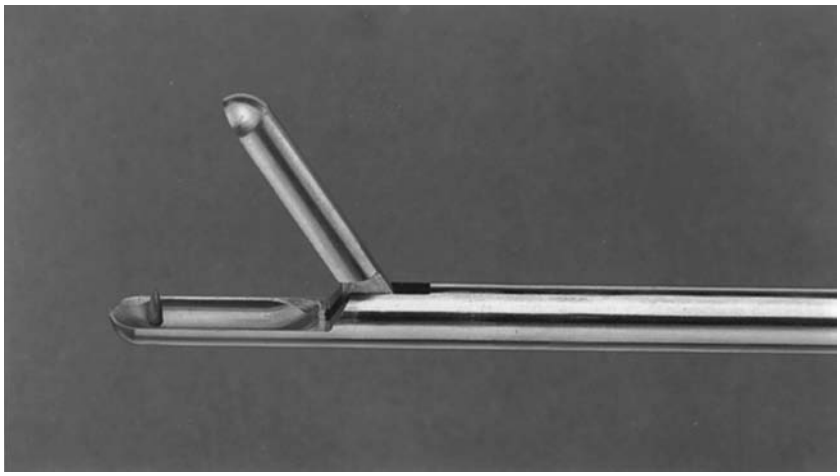


Figure 2.20. A biopsy forceps has small teeth on the upper and lower jaws to biopsy hard and slippery tissue surfaces.

Figure 2.21. An electrogenerator with different types of bipolar forceps.

Figure 2.22. Bipolar forceps with different tips are seen with a coagulating probe.

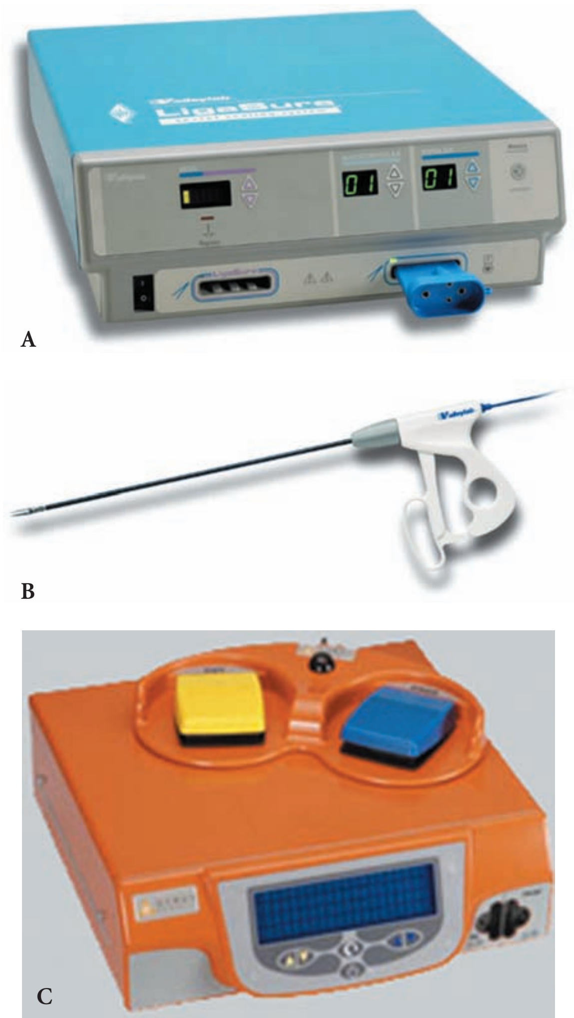


Figure 2.23. (**A**) LigaSure generator is shown along with (**B**) ligasure laparoscopic device (Valley Lab). (**C**) Gyrus generator.

In a study conducted by Carbonell et al. [12], the LS device was shown to provide significantly higher burst pressures. As vessel size increased, burst pressures became progressively weaker with the PK versus the LS (397 vs. 326 mm Hg in vessels 2 to 3 mm, 389 vs. 573 mm Hg in vessels 4 to 5 mm, and 317 vs. 585 mm Hg in vessels 6 to 7 mm). Although this difference was statistically significant, it is unclear whether this difference is clinically important because these burst pressures remain supraphysiologic and on par with the gold standard. Thermal spread with the LS system was not significantly different from that of PK (2.5 vs. 3.2 mm when sealing vessels 6 to 7 mm).

Ultimately, both instruments seem to be equally effective for achieving hemostasis, and choice of instrument will depend on the surgeon's preference.

Harmonic Scalpel

The ultrasonically activated vibrating blade of the harmonic scalpel (Ethicon) moves longitudinally at 55,000 vibrations per second, cutting tissue while simultaneously providing hemostasis. The vibration of the ultrasonic scalpel is thought to generate low heat at the incision site. This combination of vibration and heat causes the proteins to denature. The harmonic scalpel may limit the number of steps required for desiccation and transection of vascular pedicles such as the infundibulopelvic ligaments, reducing overall operating time. It is available in both 5-mm and 10-mm sizes. Several additional interchangeable tips, such as those useful during linear salpingotomy for the treatment of ectopic pregnancies, are available, allowing the surgeon to tailor the use of the harmonic scalpel to the specific task (Figure 2.24A,B,C).

A few studies have also compared the efficacy of the harmonic scalpel with bipolar vessel-sealing devices. Although the harmonic scalpel also provides supraphysiologic burst pressures, it has been found to be less effective in sealing vessels greater than 4 mm in diameter.[11] However, thermal spread of this device was found to be the least of the group, with a range of thermal damage of 0 to 2.4 mm.[11,13] Another advantage of the harmonic scalpel is that its active blade can be used as a surgical knife, which allows for transection of tissues that do not need to be desiccated.

SPECIALIZED INSTRUMENTS

Claw-Tooth and Spoon Forceps

Claw-tooth and spoon forceps are 10-mm graspers that require a 10- to 11-mm sleeve and are used during myomectomy to remove large pieces of tissue, such as a section of tube and ovary, or an ectopic pregnancy (Figure 2.25).

Clips

Laparoscopic clip applicators are used through 5- to 11-mm sleeves for reapproximation of peritoneal surfaces or hemostasis of medium-sized vessels. A disposable loaded applicator and reusable single-clip applicators are available (Figures 2.26, 2.27).

Linear Stapler

The stapler designed for gynecologic use is similar to the one used for bowel operations and fits through a 12-mm trocar sleeve (Figure 2.28). [14] Ethicon and U.S. Surgical produce endoscopic surgical staplers with different designs, but their function is essentially the same. The available staplers are disposable and can be reloaded with cartridges for use in gynecologic, general, and thoracic surgery (Figure 2.29). Each cartridge contains 54 (Ethicon) or 48 (U.S. Surgical) titanium staples that are arranged in two sets of triple-staggered rows. The instrument also contains a push-bar knife assembly, which cuts between the two sets of triple rows, ligating both ends of the incised tissue. The cut line usually is shorter than the staple line. For example, the laparoscopic linear cutter 35 (Ethicon) cut line is approximately 33 mm, with a staple line of 37 mm.

Tissue to be clipped is placed on stretch with grasping forceps, and the applicator's jaws are placed at the desired incisional site. When fired, it simultaneously places six rows of small titanium clips and cuts along the center, leaving three rows of clips on the edge of each pedicle (Figure 2.30). This instrument is used to seal blood vessels and cut pedicles, but it should be used with caution. Several complications have resulted from the use of this device.[15]

B

Figure 2.24. The harmonic scalpels (Ethicon). (**A**) Generator. (**B**) Interchangeable attachments. (**C**) Different tips.

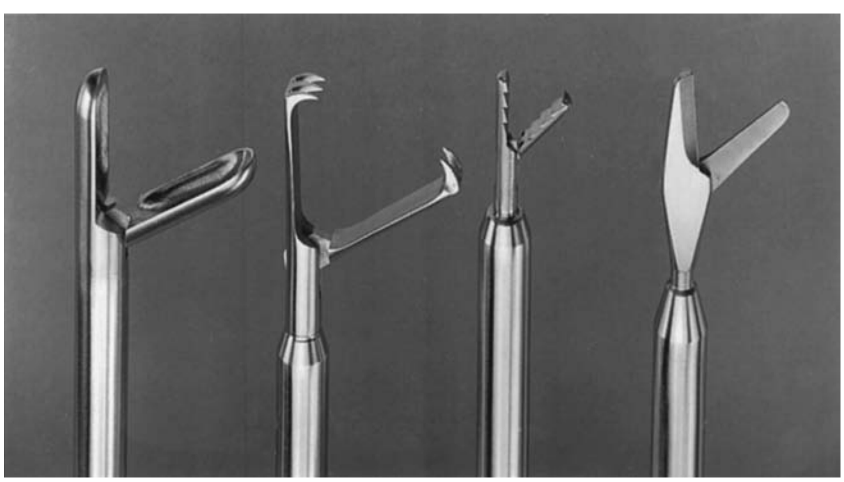


Figure 2.25. Different 10-mm instruments are used during operative laparoscopy. From left to right: spoon forceps, claw graspers, serrated grasper, and scissors.

Figure 2.26. A reusable 10-mm laparoscopic clip applicator with clips.

Myoma Screw

When one is doing a laparoscopic myomectomy, it is difficult to stabilize a smooth, hard fibroid. Five- and 10-mm myoma screws allow the surgeon to maneuver the myoma and apply traction with improved visibility and access (Figure 2.31).

Morcellator

Morcellators grasp, core, and cut the tissue to be removed into small bits. These fragments are forced into the hollow part of the instrument. The morcellator is designed for the removal of fragments of myomas and ovaries through 5- or 10-mm trocar sleeves or through a colpotomy incision. If the removal of a large myoma is attempted, the effort to morcellate it mechanically may outweigh the amount of time saved, particularly if the myoma is calcified.

Electromechanical morcellators, such as the Steiner electromechanical morcellator (Karl Storz, Tuttlingen, Germany), consist of a motor-driven cutting cannula that can be inserted directly into the peritoneal cavity or introduced through a standard trocar (Figure 2.32). Tissue is morcellated and removed by applying uniform traction and varying the speed and direction of the cannula's rotation. This technique facilitates the rapid removal of even large sections of tissue through the minimal access ports.

Carter and McCarus [16] compared electromechanical to manual morcellation in doing laparoscopic myomectomies. The use of the electromechanical morcellator reduced the average

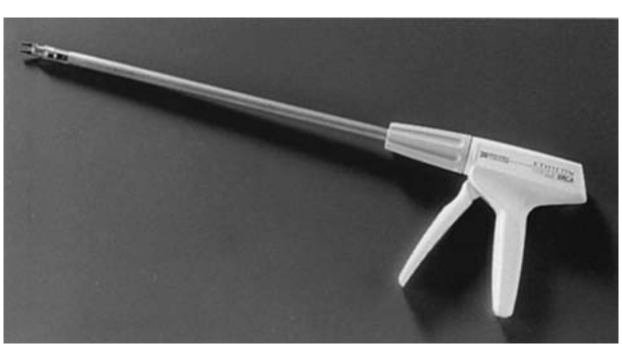


Figure 2.27. A disposable loaded 10-mm laparoscopic clip applicator.

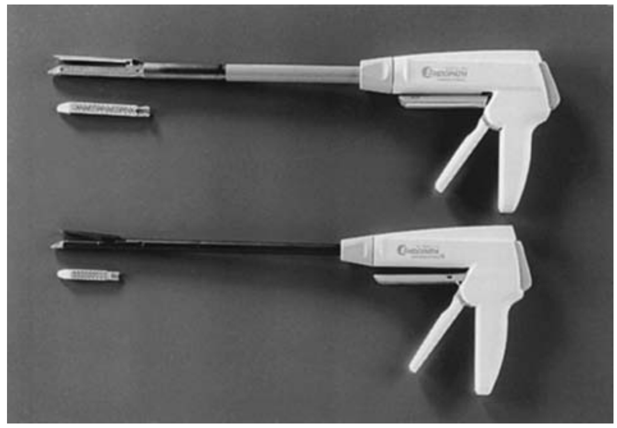


Figure 2.28. Endo-path linear cutters (Ethicon) are used in intestinal operations and gynecologic laparoscopy.

time for extraction of myomas less than 100 g by 15 minutes and 401 to 500 g by 150 minutes. The average time saved for all myomectomies was 53 minutes. It was estimated that with operating room charges of $10 per minute, the $14,000 cost of the morcellator was recovered by the 21st case. The authors concluded that electromechanical morcellation results in significant time savings compared with the manual technique, with financial savings accruing rapidly after the 21st case.

The serrated edged macro morcellator (SEMM) has been used during laparoscopic myomectomy.[17] It allows rapid morcellation of even large myomas, up to 418 g, and their removal by means of a 15-mm trocar. This morcellator has been used extensively in Germany to do endoscopic intrafascial supracervical hysterectomy.[18] It is available with a battery-operated motor (WISAP Moto-Drive) in diameters of 10, 15, 20, and 24 mm.

A powered disposable morcellator (Gynecare, Sunnyvale, CA) has been used successfully during laparoscopic supracervical hysterectomy to morcellate the entire uterus for easy removal through a 15-mm cannula (Figure 2.33).[19]

The use of the automatic tissue morcellator does not interfere with proper histologic evaluation of solid pediatric malignant tumors, in which accurate histologic assessment is important for prognosis and staging.[20]

Specialized Graspers

Three-pronged forceps specifically designed to atraumatically immobilize adnexal structures [21] hold the ovary, whereas four-pronged forceps are designed to hold fallopian tubes. The force applied by the prongs is adjustable and is maintained by tightening a screw in the handle. Three-pronged graspers with teeth also are available. Large spoon forceps are used to extract tissue excised during the procedure.

Laparoscopic Specimen Retrieval Bag

To simplify the retrieval of specimens from the abdominal cavity and avoid contamination of the abdominal and pelvic cavities with cyst contents, a disposable retrieval bag (Endopouch, Ethicon) has been developed (Figure 2.34). It is composed of a flexible plastic bag with a cannula, introduction sleeve, and introduction cap (Figures 2.35–2.41). The bag is pushed by hand

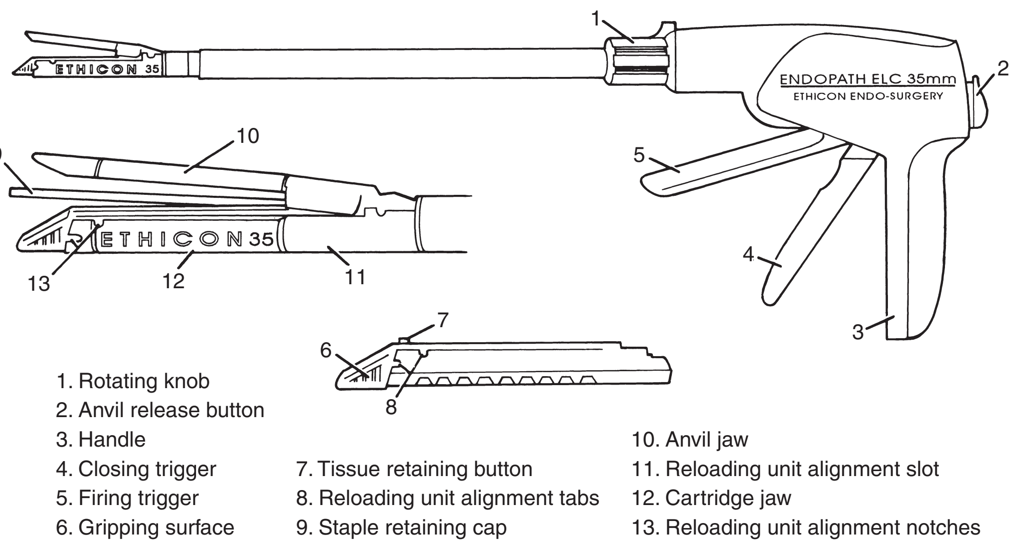


Figure 2.29. Schematic representation of the Endo-path linear cutter 35 (ELC 35, Ethicon).

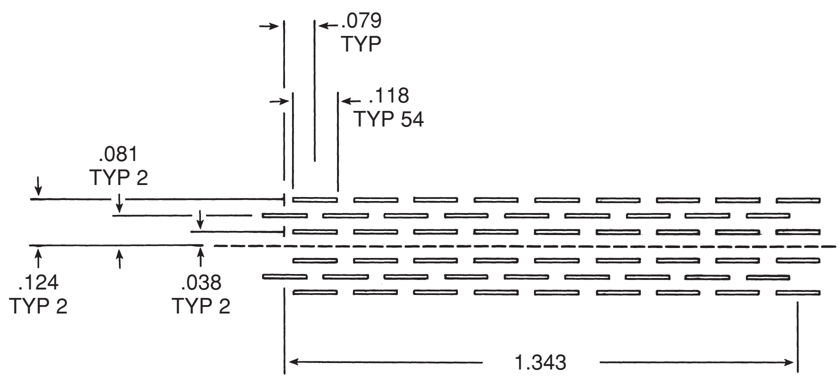


Figure 2.30. The stapler can place six rows of small titanium staples (54 staples).

Figure 2.31. A myoma screw (Circon).

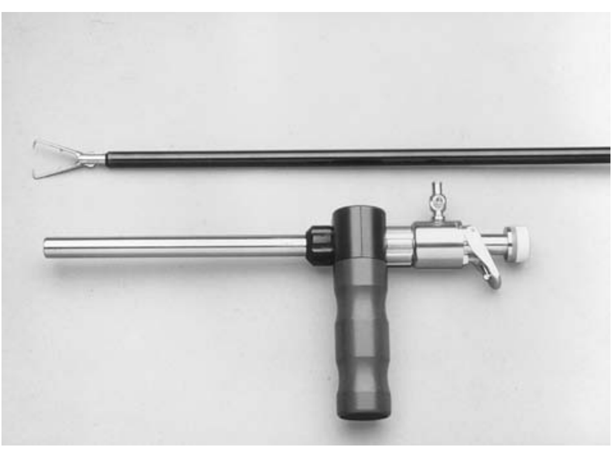


Figure 2.32. Steiner electromechanical morcellator (Storz).

Figure 2.33. The Gynecare disposable morcellator (Gynecare).

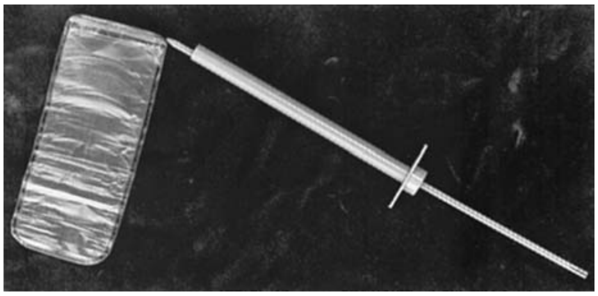


Figure 2.34. Specimen retrieval bag (Endopouch, Ethicon).

into the introducer before being loaded into a 10-/11-mm trocar (Figures 2.35 and 2.36A). During loading, the cannula should not be pulled to retract the Endopouch bag. The introducer cap and introducer sleeve are inserted into the abdomen through the trocar (Figure 2.36B). The introducer cap should remain flush against the top of the trocar. The cannula is pushed until the bag is exposed fully. A closed grasper is used to expand the bag opening (Figure 2.37). A specimen is placed in the bag (Figure 2.38A) and the cannula is broken at the scored point (Figure 2.38B), allowing the suture to be pulled through the cannula and closing the top of the bag (Figure 2.39). The bag is retracted to the base of the trocar sleeve by carefully pulling the suture strand. Small masses are retracted into the introducer and extracted through the trocar sleeve. If the bag and contents cannot be extracted, the bag is pulled into the trocar until resistance is felt (Figure 2.40). The trocar is removed, and the bag is brought to the incision. The contents are aspirated or removed with forceps (Figure 2.41). A larger incision may be required to remove the bag with its contents from the body.

Instruments for Trocar Port Dilation

Occasionally a 10- or 12-mm instrument must be inserted through incisions made for 5-mm instruments. Dilator rods for this purpose allow the placement of a 10- or 12-mm trocar. The operator withdraws the smaller trocar and replaces it with a larger one.

Aspiration–Injection Needle

A 16- or 22-gauge calibrated aspiration–injection needle can be used to precisely aspirate and inject fluids (Figure 2.42). When it is used with a 28-cm probe tip without fenestrations, close-chambered ovarian cyst aspiration can be done. When the suction

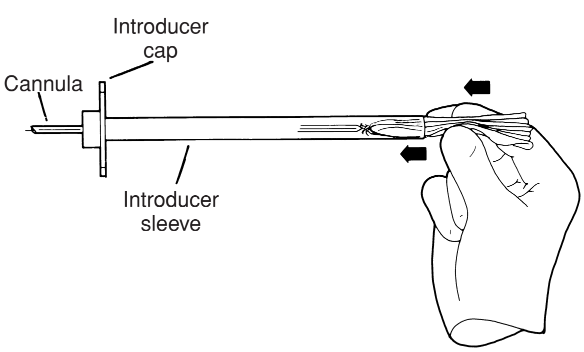


Figure 2.35. The bag is put into the introducer.

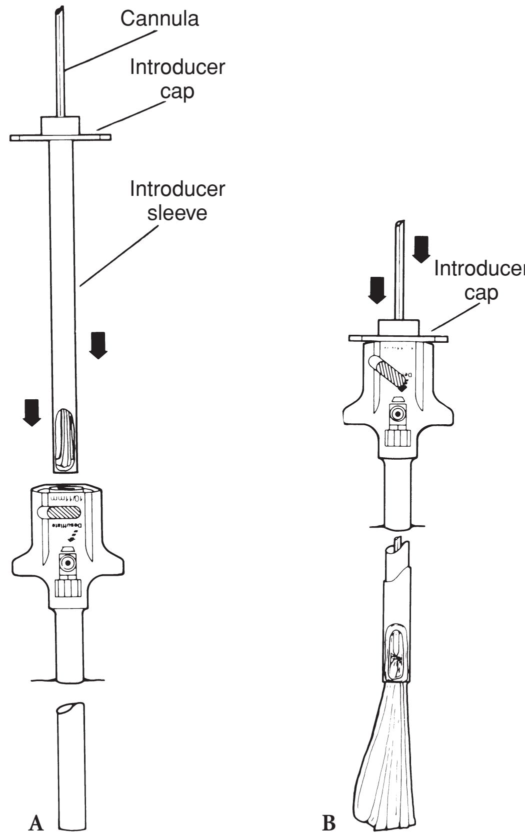


Figure 2.36. (**A**) The introducer is placed into the trocar. (**B**) The bag can be pushed into the abdominal cavity.

is started and the probe tip is placed on tissue, suction–retraction of that tissue results. The needle is inserted into the cyst, and leakage of contents is avoided. The 2.0-cm exposed portion of the needle is etched with 0.5-cm markings to accurately gauge tissue penetration. When a 60-mL syringe is attached to the needle, the fluid from the aspirated cyst is sent for cytologic examination.

This needle also is used to inject dilute vasopressin into the base of fibroids before myomectomy or into the mesosalpinx or tube before salpingostomy for tubal pregnancy. A syringe is attached to the needle by a connecting tube before injection to verify that intravascular injection does not occur.

Uterine Manipulators

Safe, effective endoscopy requires adequate mobilization and stabilization of the uterus and associated organs. Various combinations of uterine sounds, cannulas, and dilators are available. The most useful types of manipulators are the HUMI (Unimar, Wilton, CT) and the Cohen cannula in combination with a single-toothed tenaculum applied to the anterior cervical lip (Figure 2.43). The HUMI has a balloon at its tip to minimize the chance of uterine perforation, but when uterine manipulation is vigorous, the HUMI can twist within the uterine cavity, making it difficult to stabilize the uterus. The Cohen cannula is inserted as far as the internal os and is rigid, allowing excellent control of the uterine position. Although a large acorn tip limits its uterine entry, the cervix may dilate, resulting in uterine perforation by the acorn tip. It is crucial to monitor the position of uterine manipulators continually.

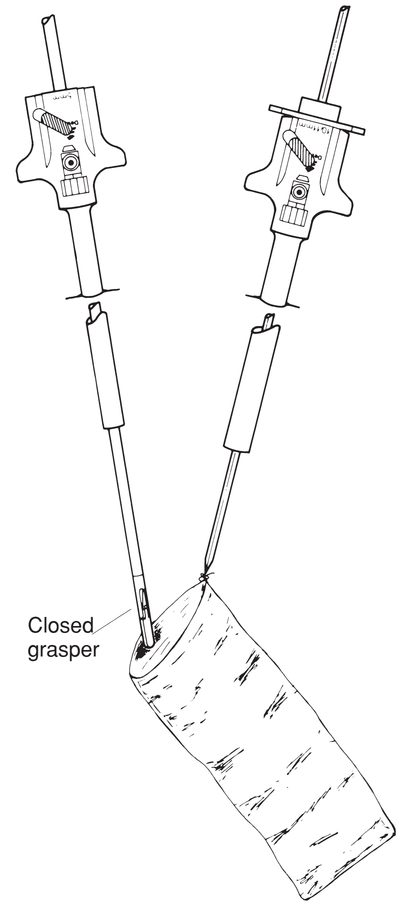


Figure 2.37. A closed grasper is used to open the bag.

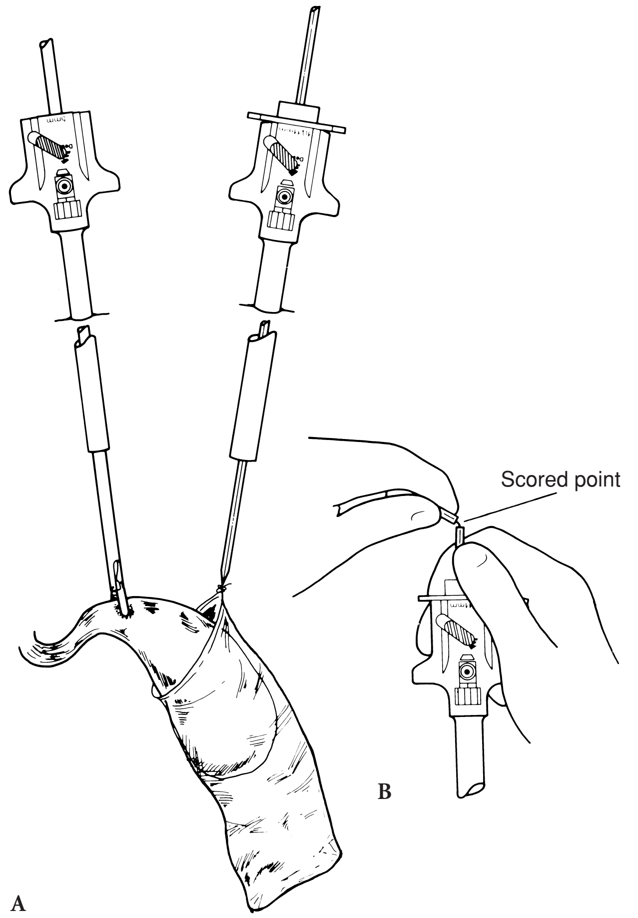


Figure 2.38. (**A**) The specimen is placed in the bag. (**B**) The cannula is broken at the scored point.

Valtchev and Papsin (Conkin Surgical Instruments, Ltd., Toronto, Canada) [22] devised an instrument consisting of an acorn-shaped head with a cannula connected to a rod by an articulation point. This arrangement allows the angle between the rod and the cannula to be changed, providing various degrees of uterine anteversion, which is adjusted with a screw. The Hulka tenaculum and sound combination is a good uterine manipulator but lacks a channel for chromopertubation.

More elaborate systems specifically designed to simplify total laparoscopic hysterectomy are available. For instance, the Koh Colpotomizer system (Cooper Surgical) is designed to be used with the RUMI uterine manipulator and consists of a vaginal extender to delineate the vaginal fornices and a pneumo-occluder (Figure 2.44).[23]

Another uterine manipulator that includes a vaginal cup to define the dissecting plane of colpotomy, as well as to prevent the loss of pneumoperitoneum, is the Vcare uterine manipulator (ConMed, Utica, NY; Figure 2.45).

Ceana Glove

Laparoscopic procedures that involve incision of the vaginal apex result in the loss of the pneumoperitoneum. A simple cost-effective technique has been developed by Ceana Nezhat that effectively preserves pneumoperitoneum. Two 4-inch by 4-inch sponges are folded (Figure 2.46) and submerged in sterile water or saline for several seconds. The sponges are placed in a latex

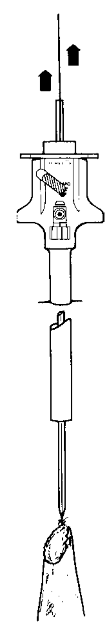


Figure 2.39. The bag is closed around the specimen.

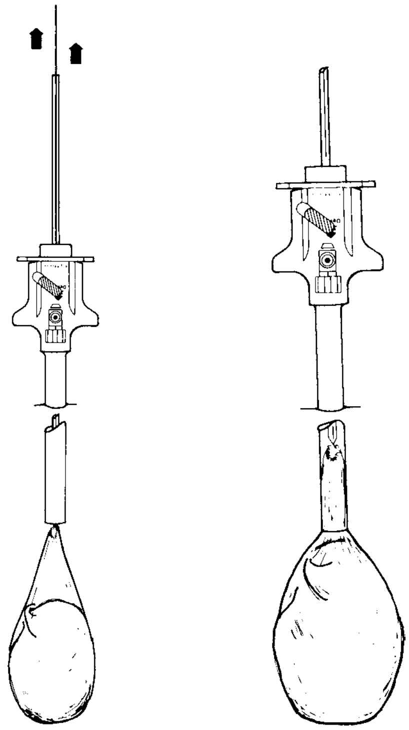


Figure 2.40. The bag is pulled to the base of the trocar sleeve until resistance is felt.

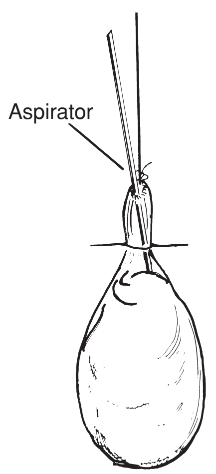


Figure 2.41. The specimen is pulled to the abdominal wall and aspirated.

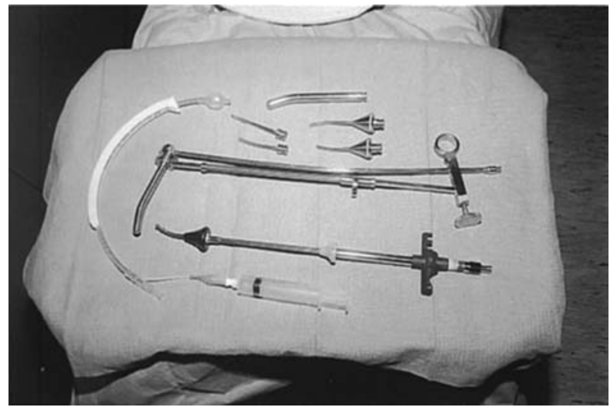


Figure 2.43. Three different uterine manipulators: HUMI, Cohen cannula, and Valtchev cannula.

Figure 2.44. The Koh Colpotopmizer system.

Figure 2.42. A laparoscopic aspiration–injection needle is used for aspiration of ovarian cysts (16- or 18-gauge), injection of diluted vasopressin in the base of a myoma, or hydrodissection (22-gauge).

Figure 2.45. The Vcare uterine manipulator.

surgical glove, usually trapping some air in the glove fingers (Figure 2.46B,C).[24–28] The top of the glove is tied shut and placed in the vagina or minilaparotomy incision, acting as a flexible air block for preservation of pneumoperitoneum (Figure 2.46D). This device, which is called the Ceana glove, can be prepared in any operating room and has been found to be both safe and effective in numerous laparoscopic procedures.

Instruments for Port Closure

The use of a new device for the closure of subcutaneous tissue in laparoscopic sites was reported by Airan and Sandor.[29] The use of such instruments is gaining in popularity with the widening recognition of the risk of incisional hernia at trocar sites. These instruments are similar to the device described as the Carter–Thomason device.[30] Both instruments operate as a needle and a grasper that serve as a suture passer. The conical suture passer guide frequently aids in introducing the suture at the proper angle for the closure of fascia, muscle, and peritoneum. The conical guide has the additional benefit of maintaining pneumoperitoneum once the laparoscopic trocar has been removed. The Carter–Thomason suture passer (Figure 2.47) has been recommended for use without the guide if that is deemed more appropriate, for instance, in ligating epigastric arteries. Because the proper closing of the abdominal layers occasionally presents a challenge, the growing interest in instruments designed to assist

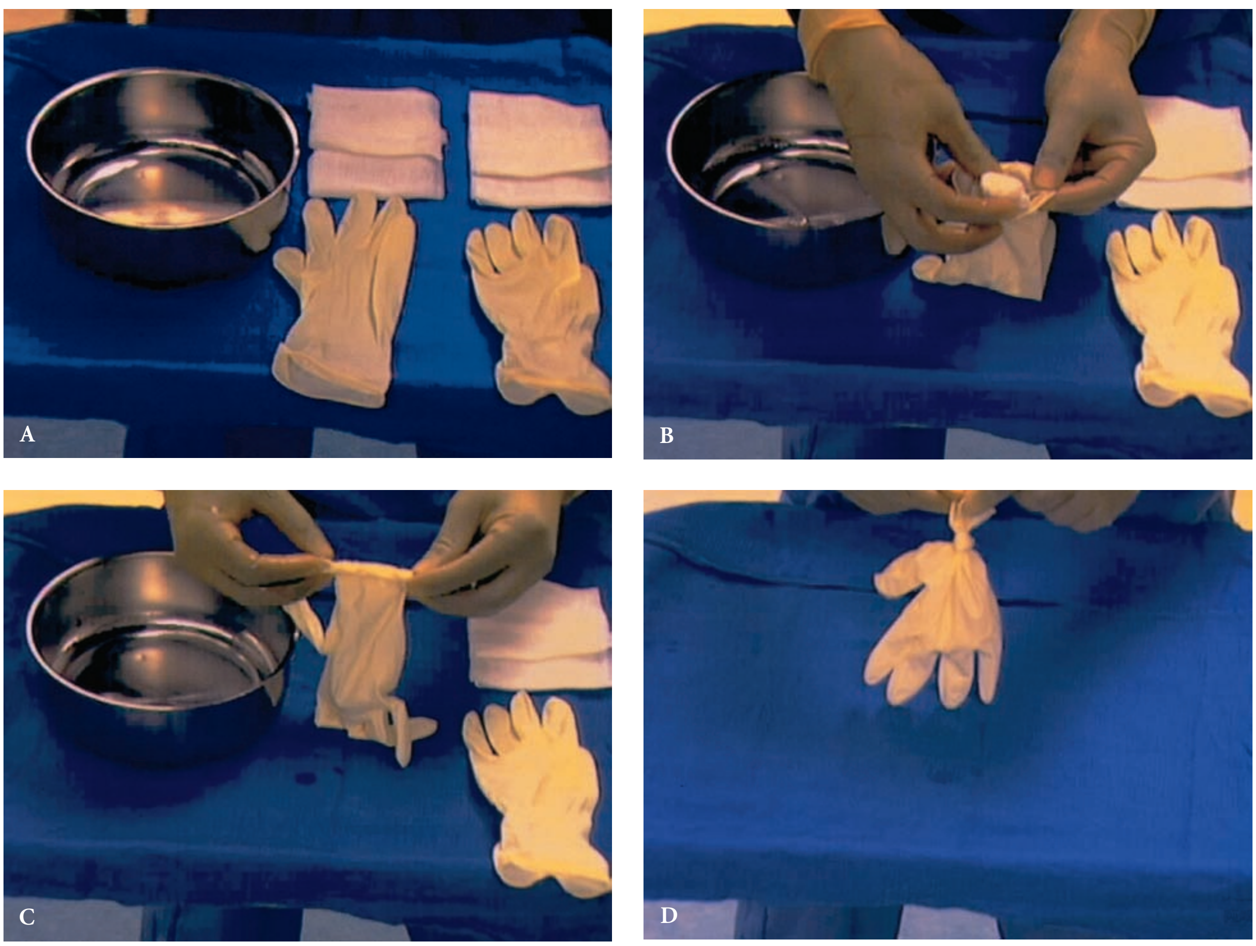


Figure 2.46. The Ceana glove. (**A**) The materials for a Ceana glove are available in the operating room and can be prepared easily. (**B**) Two 4 × 4 sponges are folded and emerged in sterile water. (**C**) They are inserted inside a sterile glove. (**D**) The glove is closed at the top, and is placed in the vagina to block the loss of pneumopertioneum.

Figure 2.47. The Carter–Thomason device.

Figure 2.48. J-needle.

the surgeon is encouraged. The J-needle allows for port closure that incorporates all layers of the abdominal wall under direct observation (Figure 2.48).

ENDOSCOPIC ULTRASOUND

Intraoperative ultrasound has gained an established role in many surgical procedures. Laparoscopic ultrasound and thoracoscopic ultrasound are the latest modes of intraoperative sonography. They have been introduced mainly to overcome the two major drawbacks of laparoscopy: the ability to show only the surface of the organs and the lack of manual palpation of the anatomic structures. The technology, new indications, and results of intraoperative and laparoscopic ultrasound were reviewed by Bezzi and associates [31] during more than 500 operative procedures. Intraoperative ultrasound and laparoscopic ultrasound are helpful in confirming preoperative studies and acquiring new data not available otherwise. An important role of these techniques is to ascertain the anatomy of the involved organs, thus providing guidance for surgery. Both techniques play an important role in surgical decision making, particularly with respect to hepatic, biliary, and pancreatic malignancies. In some series, the rate of major changes in the surgical strategy can be as high as 38%. A relatively new application of intraoperative ultrasound is the ability to do interstitial therapy for tumors at the time of the initial surgery. This may be useful, for example, in patients undergoing liver resection when other unresectable lesions are found in a different segment or in the contralateral lobe. Finally, laparoscopic sonography plays an important role in staging abdominal neoplasms, providing more information than do preoperative imaging and laparoscopic exploration. This feature may be used to effectively stage gastrointestinal malignancies, pancreatic carcinomas, and abdominal lymphomas. It may be expected that a variety of open procedures will be done with videolaparoscopic monitoring and will need guidance from laparoscopic sonography. In the future, the staging of abdominal neoplasms may be improved by laparoscopy combined with laparoscopic ultrasound. A cost–benefit analysis of these techniques and a comparison with preoperative tests should be carried out. High-resolution images may be obtained to delineate abnormalities such as suspected ovarian cysts and uterine myomas. Endoscopic ultrasound is a new instrument that allows the surgeon to evaluate and define pelvic abnormalities suspected at laparoscopy. Endoscopic ultrasound may augment the diagnosis of subtle pathologic findings during laparoscopy.[32,33]

Laparotomy-Type Instruments

Babcocks, atraumatic bowel grasping forceps, Allis clamps, and Metzenbaum scissors have been adapted for laparoscopic use. The acquisition of these instruments depends on whether they will improve a procedure's efficiency.

Standard grasping forceps hold needles for most procedures, but stronger needle holders are necessary if precise placement is required and for suturing thick tissue (i.e., myometrium or periosteum). Some needle holders have handles similar to those used in laparotomy (Figure 2.49). Straight and curved narrow-tip needle holders are available for fine intra-abdominal suturing (Figure 2.50).

THE CAMERA

The camera includes the camera head with its cable and the camera control unit (CCU) or camera controller. The cable is plugged into the camera controller. The lens on the medical camera is

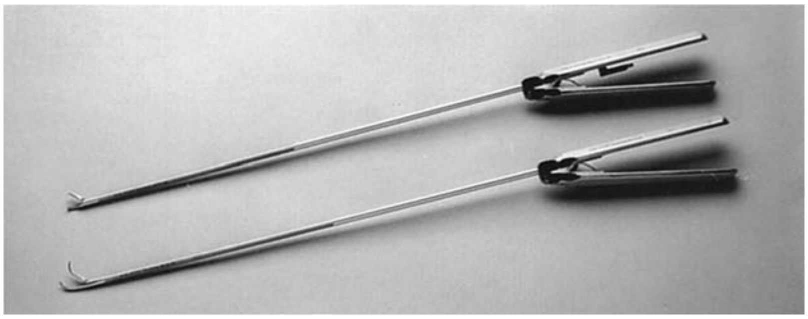


Figure 2.49. This needle holder is similar to that used at laparotomy with locking capability.

called a coupler. The coupler screws onto the camera head and is available in several sizes that magnify the image. A 24-mm coupler will produce a larger image on the monitor than will a 20-mm coupler. With a direct coupler, the image travels directly to the camera and is the most widely used style of coupler. A beam splitter coupler has a 90° angle; part of the image travels to the camera and part travels to a porthole or eye cup. The porthole allows the surgeon to view the image directly and is typically used in urology cases. In addition, urologists usually prefer the 20-mm coupler to prevent part of the anatomy from being cut off by the bottom of the monitor. One example is Stryker's new urology camera head, which has a built-in 20-mm rotating coupler with a beam splitter.

Couplers are mounted and fixed on the camera head. Removable couplers, also known as c-mount couplers, allow the purchase of a camera with interchangeable direct couplers and beam splitters. The removable coupler provides flexibility and economy. Being removable is a potential problem because the coupler is screwed to the camera head, and if it is not attached securely or if its O-ring is worn, liquids may seep between the coupler and the camera head, causing internal fog. A coupler with internal fog is not usable and must be repaired. A fixed coupler eliminates this problem.

Cameras are either single chip (red, green, and blue on the same chip) or three chip (each chip is dedicated to red, green, or blue). Three-chip cameras have better color separation and take in more information, which is beneficial in procedures in which color is important. The production of a unique video camera (Circon) has proprietary red–green–blue (RGB) 24-bit digital enhancement circuits. The signals coming from the charged coupled device (CCD) sensor are sampled at equal time intervals, and the amplitude of each sample is classified into a discrete level system and converted to a binary code. All the video information is encoded into a stream of noise-free digital numbers. These numbers are used as variables in mathematical equations (algorithms) to manipulate and shift in time and value through digital signal processing. Digital electronics are the leading edge in video technology and will be the new standard of performance just as digital compact discs have replaced LP records and audiocassettes. Digital signals take up less bandwidth than do the analog signals currently in use. Moreover, digitally processed signals can be applied to three-chip and high-definition television (HDTV).

Figure 2.50. Curved and straight fine serrated tips provide a better grip of straight or curved needles.

One camera on the market with high definition technology is made by Stryker (Figure 2.51A,B). It is a three-chip camera with a format of 1280 × 1024. This high-definition camera also uses progressive scan technology versus interlace technology. Progressive scan is a process in which a camera sends a complete picture back to the monitor 60 times per second. Interlace cameras take half a picture (every other line) and send the partial image back for a total of 30 complete pictures a second. Progressive scan is useful for sending a lot of information to the monitor at once and keeping pace with a live image; a high-definition camera is necessary when there is much more information being scanned.

One feature of the camera head is its ability to manipulate peripheral equipment by using buttons to accomplish a variety of tasks, including activation of the video printer and videocassette recorder (VCR). Some cameras have a single button to start both the video printer and the VCR. With a main control switch, several desired functions can be manipulated. Another variation includes separate buttons on the camera head to increase or decrease the camera gain level. With this arrangement, the first button can operate the video printer, the VCR, and additional components. An infrared remote control is required for all components to make the buttons operable. Another camera with two buttons on the camera head can control any two components. This system has cables running from the CCU (camera box) to two selected components, the video printer and VCR, or to the video printer and the still video recorder. With this system, infrared remote control is not required. The most prevalent camera sold on the market (Stryker) has a four-button design in which surgeons are able to control the gain, record video, take pictures, digitally zoom, and white balance. Another camera feature is field-replaceable camera cables. Because most camera problems occur in the camera cable, replacing cables at the hospital rather than sending a camera out for repair saves time and expense.

A

B

Figure 2.51. The Stryker camera provides a picture with a definition of 1280 × 1024 pixels. (**A**) Camera CCU. (**B**) Camera lens.

Camera Equipment

The first medical camera (Circon Corporation), which was developed in 1972, had three tubes and weighed 18 lb. It used a fiberoptic image guide to transfer a microscopic image to the camera that transferred the image to a video monitor. In 1973, a single-tube camera was designed weighing 3.8 lb (Figure 2.53). Although the weight was reduced, the camera remained heavy and counterweights were needed. This camera was attached directly to the endoscope without using a fiberoptic image guide. The single 1-inch tube had a specially striped filter to produce a full-color picture. Video camera manufacturers continued to make improvements in size, weight, and image quality. In 1975, a camera weighing 1.25 lb was developed, and in the following year, a low-light feature enabled it to be 10 times more light sensitive. In 1980, a new 6-oz camera was small enough to be held in the palm of the surgeon's hand. It produced excellent color separation and image resolution (Figure 2.53). Another milestone was achieved 2 years later with the first solid-state CCD camera. This camera weighed 3 oz, and with the change from tubes to solid-state CCD sensors, two major achievements were accomplished.

Figure 2.52. The Stryker capturing device digitizes video or picture images. These can then be transferred to a DVD/CD or downloaded directly into a portable hard drive.

Figure 2.53. The decrease in size of video cameras over the years is illustrated. The inset shows a contemporary camera head.

First, the camera could be disinfected in solutions so that there was no need to "bag the camera." Second, the colors produced by solid-state construction were more reliable than were colors produced by tube cameras (Figure 2.54).

Since 1982, all surgical camera manufacturers have switched to solid-state construction. Developments include low lux levels (enhancing the quality of the image in low-light situations), buttons on the cameras to start and stop VCRs, field-replaceable camera cables, and increased lines of resolution (S-Video and RGB signal output as opposed to National Television Systems Committee [NTSC]). Cameras also became more durable. The technologies of the 1990s added digitally processed signals, three-chip cameras, and chip-on-a-stick to surgical video. Currently digital technology has replaced VCRs in many operating rooms.

Basic Video Information

Within the camera is a CCD that "sees" an optical image through the lens and converts it into an electrical image. A CCD is composed of rows of tiny picture elements called pixels. Each pixel can sense red, green, or blue light to produce color. The more pixels, the better the picture. The most pixels on a camera to date are in the Stryker 1088 HD camera in which each CCD in the camera is in a format of 1280 × 1024 (pixels) (Figure 2.51A, B).

An image is sent through camera cables to the CCU to the monitor input. The monitor converts the electrical image to the original optical image seen by the human eye. The electrical image also is directed to components other than the monitor after leaving the CCU. It is relayed by a cable to a VCR or a digital capturing device (Figure 2.52), to a printer and onto a monitor.

Figure 2.54. Initial camera that Camran Nezhat used for video-laparoscopy in early 1980.

Scanning Formats

Video information is scanned to generate a signal frequency. The scanning is done at a rate of 525 lines per frame; there are 30 frames per second of video information, with the exception of the Stryker camera, which scans at 60 frames per second via the progressive scan technology. This scanning rate is like a television broadcast standardized by the National Television Systems Committee (NTSC). NTSC scanning rates are used in the United States, Canada, Japan, South America, and Asia. Russia and France use a different scanning rate called SECAM (*séquentiel couleur à mémoire*). PAL (phase alternation lines), a third type of scanning rate, is used in other European nations. These scanning rates are not compatible with NTSC standards. Videotapes made in the United States must be converted before they can be viewed in countries with non-NTSC scanning rates. The process of converting one scanning rate to another is expensive. When the NTSC scanning rates were created, technicians used a limited bandwidth to send the video signal to color and light information simultaneously. The first format of the NTSC signal is called a composite signal. There are inherent problems with this method of transference because a camera first processes color and light separately and then combines the two to create a signal. Cross-talk is a signal noise that generates grainy images with soft edges and causes colors to be less consistent. The signal-to-noise ratio is a measurement that differentiates between video noise (cross-talk) and useful video information. The higher the signal-to-noise ratio, the better the detail at the edge and the better the total image. Signal noise is measured in decibels. A quick way to evaluate noise is not to allow any light to reach the camera chip. With the absence of picture information, the image contains only noise. Another way to see picture noise is to adjust the camera to place color bars on the monitor screen. One selects first an NTSC signal, then a Y/C signal, and finally an RGB signal. One looks at the edge of each bar color and notes that movement from NTSC to Y/C to RGB makes the edges progressively sharper because NTSC has the most noise and RGB has the least. Specifications (lines of resolution, pixels, signal-to-noise ratios) set the parameters of the video components, but one should always test the monitor.

The second format, called a component signal, carries the color and light separately. There is less cross-talk, so pictures generated by component signals have sharper edges and truer colors than do pictures generated by composite signals. The Y/C format and NTSC format carry the video signal in a single cable. Y/C (Y stands for light brightness, and C refers to color) is the name for the format. SVHS and Super VHS are tape formats that accept this type of signal.

The third format, RGB, is also a component signal. Video information is separated into four signals: red, green, blue, and a timing signal. Each signal carries its own light. Separation occurs in the camera head and is done electrically. Because the colors and light are separate, this format requires less electronic processing. There are four separate cables from the camera box. A monitor that accepts RGB input is needed. Although these monitors are more expensive, they have higher resolution capabilities. Thus, of the three signal-carrying formats, the first format, NTSC, is the least desirable. The second and third formats carry much clearer signals with less noise.

Resolution

The clarity and detail of the video image depend on the number of horizontal lines of resolution, which are detected by the number of distinct vertical lines seen in a picture. Resolution is set forth by the camera's pixel count and by a formula used to achieve the resolution number. The HD camera made by Stryker has more than 1000 lines of resolution with a pixel. No resolution number can be higher than the pixel count. Each line of resolution is composed of pixels, and the more pixels per line, the better the image. Another way to understand the pixel effect is to compare a large-screen television with a small (13-inch) monitor. Smaller monitors have a sharper, crisper image, especially at the edges of an image, because pixels are placed closer together on a small screen. The ability of the video system to carry and process signals, the components that transmit signals, and the resolution numbers of the monitor together determine the ultimate picture quality. The industry standard is to measure horizontal resolution using 75% of the chip. However, some manufacturers have been known to use 100% of the chip, resulting in a higher resolution number.

The Camera Box (CCU)

The most common features include a color bar button and a white balance button. Some CCUs have manual and automatic white balance features. The most important feature for the CCU is to provide an automatic shutter because it adjusts each pixel's exposure time up to 1/15,000 of a second. The circuit can react to varying light conditions as fast as the human eye can. An electronic shutter is essential for a surgical video camera.

The Monitor and Accessories

The sizes of the screens vary from 19 to 20 inches. Over the past 5 years, the medical industry has adopted flat panel technology to accommodate the high-definition video cameras. The native resolution of the flat panel monitors should be no less than 1280 × 1024 and should accept a DVI (digital visual interface) video signal along with standard definition analog signals.

The preferred method of capturing both still and live images has been through digital capture devices. Stryker Endoscopy's SDC HD captures still images in native resolution 1280 × 1024 and can record videos in multiple mpeg formats. Digital capture devices allow surgeons to archive information to DVDs, USB hard drives, and hospital networks while printing pictures for medical records.

Equipment Problems and Troubleshooting

After the video system is moved to the operating room, it is plugged in and the components are tested. The following steps will reduce the chance of unexpected events:

1. Note the image, put color bars on the monitor screen, and evaluate the accuracy of the colors.
2. Look at the monitor, check the buttons, turn on the light source, and check the light cord for damaged light bundles.
3. Look through the scope before it is hooked up and illuminated because light hides defects.
4. Hold the scope with the distal end pointed at a normal ceiling light and then look through the eyepiece. Is the scope clear?
5. Check both the distal end and the eyepiece for cracks or other visible damage.

If a problem with the image occurs during an operation, the scope should be checked initially, then the light cord, and then the camera. If the picture is poor, the color and light level should be examined to search for the cause. If there is no picture, the operator should be certain that the light source is turned on. If none of the preceding steps solves the problem, the camera should be detached from the scope and focused on an object in the room. If the picture is good, the camera is functioning properly and the scope or the light cord is at fault. If the picture is poor, the camera may be defective or the lens may be fogged; a button on the CCU may have to be changed, or a new camera may be required. A methodical piece-by-piece examination of the components makes it easier to locate the fault so that it can be fixed or replaced.

ROBOTICS

Efforts to improve surgical efficiency have led to the development of robotically assisted laparoscopic procedures. The Animated Endoscopic System for Optimal Positioning (AESOP) was designed to hold and maneuver the laparoscope under the direct control of the surgeon. The elimination of the camera holder allows two doctors to do complex laparoscopic operations faster than they could without the robotic arm. This technology also may allow the surgeon to carry out some procedures without the aid of an assistant. The AESOP system can be activated by voice or by foot or hand control. For 50 patients undergoing routine gynecologic endoscopic procedures, the operating time

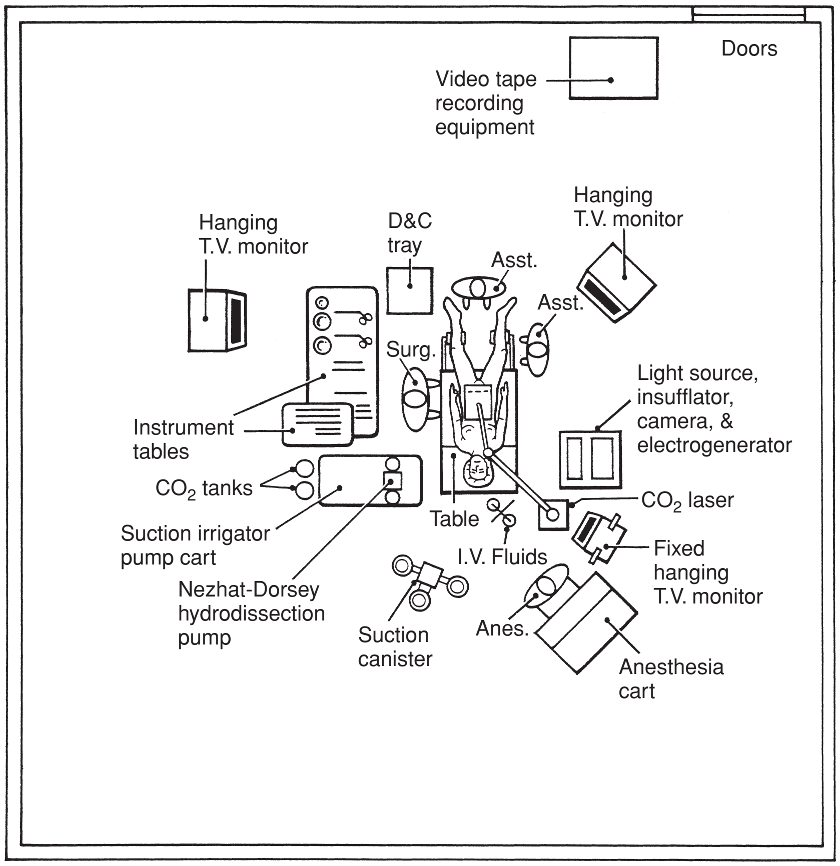


Figure 2.55. Positions of patient, assistants, surgeon, and equipment.

using voice control was compared with that using foot or hand control. The voice control worked more efficiently and faster than did hand or foot control.[34] In a comparison of the findings of five studies evaluating the need for a human camera holder assistant, the robotic man outperformed the human camera holder, and reduced laparoscopic operating time, resulting in efficiency and cost savings.[35] AESOP company is now part of intuitive surgical, which owns the da Vinci "Robotic Arm."

OPERATING ROOM SETUP

An organized and well-equipped operating room is essential for successful laparoscopy.[36, 37] The surgical team and the operating room staff should be familiar with the instruments and their functions. Each instrument is inspected periodically. Scissors, graspers, trocars, trocar sleeves, and the like are checked for loose or broken tips, even if the same instruments were used during a previous procedure. Before a new instrument is used, it is tested by the surgeon. Although the total cost of operative laparoscopy is decreased by the shortened hospital stay and recovery, the cost of the operating room is higher for operative laparoscopy because of the higher cost of instruments and the longer operating time.[38, 39]

Position of Equipment

Equipment positioning (Figure 2.55) varies according to the surgeon's preference. The following arrangements are suggested.

Operating Tables

Before the patient is brought to the operating room, the operating tables are set.

1. Mayo stand 1 contains a dilation and curettage setup with instruments for video-augmented hysteroscopy (videohysteroscopy). Included are a long-bladed weighted speculum, a double-or single-toothed tenaculum, dilators, a uterine sound, a small Kevorkian curette, a uterine manipulator, Raytec sponges (Baxter Healthcare, Deerfield, IL), Telfa pads, and a Foley catheter. The videohysteroscopy equipment includes a Circon (Circon-ACMI, Santa Barbara, CA) or a Storz (Karl Storz, Culver City, CA) diagnostic and operative hysteroscope along with its appropriate scissors and grasper. An adaptive sleeve is available for passing a scissors, grasper, or the fiber laser when it is used in the uterus. For more complicated procedures, such as resection of an intrauterine leiomyoma and endometrial ablation, electrosurgical wire loops and roller balls (Circon, Karl Storz) are added.
2. The back table is positioned behind the surgeon and next to the first assistant. The table contains a Veress needle, a scalpel, an Allis clamp, an 11-mm trocar and sleeve, a 10-mm laparoscope, a fiberoptic light cord, 5.5-mm secondary trocars and sleeves, a suction–irrigator probe (American Hydro-Surgical Instruments) with irrigation and suction tubing, tubing for the CO_2 insufflator with a CO_2 connector, atraumatic grasping forceps with teeth, bipolar forceps with cord, aspirating needles each with a 60-mL syringe, and Telfa pads and Raytec sponges. A small amount of dilute vasopressin (Pitressin, Monarch Pharmaceuticals) is made available (one ampule

in 100 mL of bacteriostatic sterile water). This solution (1 to 2 mL) is injected through the laparoscopic needle before the removal of a large fibroid or endometrioma to reduce bleeding. Vicryl suture (3–0) on a cutting needle for closing the primary trocar site, 1.5-inch Steri-Strips (3M) to be used with Mastisol (Ferndale Laboratories, Inc., Ferndale, MI), eye pads, and 3M tape for dressing care are placed on the back table.

3. Mayo stand 2 is positioned so that the surgeon and first assistant can reach the endoscopic scissors and grasping forceps with and without teeth.

Hydrodissection Pump

The Nezhat–Dorsey hydrodissection pump or any of the recent powerful suction irrigation pumps provide pressure during hydrodissection and is located behind the surgeon on a cart or specially designed stand. The plastic tubing is connected to the pump, brought to the operative field, and attached to the suction–irrigator probe.

Light Sources, Insufflator, and Electrogenerator

Other items kept on the side of the room opposite the surgeon include a storage table that holds the insufflator, electrosurgical equipment, camera boxes, and light sources. This equipment is stored in a specially designed stand opposite the surgeon and close to the patient, toward her head. This cart is placed so that it does not interfere with the assistants' position and does not obstruct the surgeon's view of the insufflator and light source. The camera is covered with a sterile cover, connected to the camera box, brought to the operative field, and attached to the laparoscope. Video cabinets are manufactured with removable backs, making adjustment of the machines easy.

Video Monitors

Video monitors should be positioned within view of the surgeon and the two assistants; one assistant stands between the patient's legs, and the other one opposite the surgeon. Three video monitors provide adequate views for the surgeon, the assistants, and other observers. The monitor provides the surgeon's view of the operative site and should be set for maximal clarity and true color transmission. The video monitors can be fixed to the ceiling, placed on a portable stand, or attached to a mobile stand with an articulating arm. The monitors are positioned for optimal viewing from any area in the operating room and are pushed from the operative area at the end of the day.

Video Recording

Depending on the surgeon's preference, the digital capture devices should be turned on at the start of the case. One capture device is sufficient as it will provide multiple ways to archive the information. The digital capture device is also ideal for surgeons who videotape procedures for educational purposes.

Lasers and Laser Equipment

Three different lasers are available in the operating room: a CO_2 laser (with a coupler), an argon or potassium titanyl phosphate (KTP) laser, and a neodymium:yttrium–aluminum–garnet (Nd:YAG) laser. They are used through the operative channel of the laparoscope or a suprapubic trocar. The CO_2 laser is on the patient's side, opposite the surgeon. The articulating arm is extended appropriately so that it does not weigh too heavily on the surgeon's hand. YAG and argon lasers are used less frequently than is the CO_2 laser and are located behind the first assistant, who stands between the patient's legs. This allows laser fibers to be passed from the back table through the second puncture site. Appropriate electrical outlets and special water connections are necessary when one uses fiber lasers. Typically, an outlet supplying a 220-V 30-A circuit is required. The YAG laser may be either three phase or single phase and air or water cooled, depending on the peak wattage required for a particular procedure. The CO_2 laser can be operated from a 100-V circuit supplied by any standard electrical outlet. Individually wrapped sterile fibers are kept with the fiber lasers, each with its own cleaver for sharpening fiber tips. Because the fibers break easily, they are handled carefully and checked repeatedly. Safety precautions are followed strictly when one is using lasers. One risk of fiber-equipped lasers that does not exist with a CO_2 laser is the possibility of fiber breakage in or outside the patient's abdomen. In the CO_2 laser, the beam is transmitted through and reflected by mirrors contained in the articulating arm. When fiber lasers are used, the appropriate tinted eye protection is worn by both the patient and the staff. Regular glasses may be worn when one is using the CO_2 laser but are not necessary during videolaseroscopy. The patient's eyes are covered with moistened eye pads when the CO_2 is used and with the appropriate tinted goggles when other lasers are used.

Preparation and Termination of the Procedure

All the setup tables are brought close to the operating table, and both the hysteroscope and the laparoscope are connected to the light sources and cameras. After they are checked and functioning, they are placed over the patient. After the videohysteroscopy is completed and as the laparoscopic portion begins, the first Mayo stand is moved out of the way and the surgeon moves to the side of the patient for the laparoscopy.

The anesthesiologist covers the patient's eyes with moistened 4×4 pads when the laser is used and places a foam pad over her neck to protect her if lightweight camera equipment is placed on the sterile field during the procedure.

When the procedure is completed, instruments are handled carefully so that laparoscopes and other delicate equipment are not damaged. The disposable equipment is discarded, and the reusable instruments are given to the circulating nurses for cleaning. Care is taken to ensure that reusable instruments are not mixed with disposables and inadvertently thrown out.

The patient's abdomen is washed thoroughly, and her legs are lowered. Although the patient is not fully alert, she often can hear conversation as she is being extubated and while awakening. A professional demeanor is maintained, and conversation is limited.

MANAGED HEALTH CARE

New endoscopic procedures are done with increasing frequency, so hospitals need more video equipment to keep up with demand, and purchases must justify their cost. As medical services move from a large hospital-based facility to smaller community-based surgical centers, patients residing 2 hours from the main hospital could have a knee arthroscopy or laparoscopy done closer to home. The leading edge of technology includes three-dimensional (3-D) equipment, virtual reality, and HDTV. HDTV can expand the scanning rate from 525 lines of resolution to 1100 or 1200 lines per frame, and the quality of current pictures will more than double. One challenge is to reduce the cost to make it affordable for hospitals.

With virtual reality, a 3-D computer image is presented to the user through liquid crystal glasses. This technique is used in the United States by public institutions such as the Central Intelligence Agency and by architects so that clients can "see" a building inside and out before its construction. In a way, this is similar to a surgeon's use of virtual reality, but cost continues to be a major obstacle. The 3-D technology attempts to provide depth to the image that is not available with monocular endoscopic systems. The increased perception of depth of field enables the surgeon to locate instruments in relation to tissues and organs. These systems rely on special optical devices.

REFERENCES

1. Nezhat F, Nezhat C, Silfen SO. Videolaseroscopy for oophorectomy. *Am J Obstet Gynecol*. 1991;165:1323.
2. Wolf JS Jr. Laparoscopic access with a visualizing trocar. *Tech Urol*. 1997;3:34.
3. Kaali SG. Establishment of primary port without insertion of a sharp trocar. *J Am Assoc Gynecol Laparosc*. 1998;5:193.
4. Schaller G, Kuenkel M, Manegold BC. The optical "Veress-needle" – initial puncture with a minioptic. *Endosc Surg Allied Technol*. 1995;3:55.
5. Bhoyrul S, Payne J, Steffes B, et al. A randomized prospective study of radially expanding trocars in laparoscopic surgery. *J Gastrointest Surg*. 2000;4(4):392–397.
6. Fuller J, Ashar BS, Carey-Corrado J. Trocar-associated injuries and fatalities: an analysis of 1399 reports to the FDA. *J Minim Invasive Gynecol*. 2005;12(4):302–307.
7. Boike GM, Miller CE, Spiritos NM, et al. Incisional bowel herniations after operative laparoscopy: a series of nineteen cases and review of the literature. *Am J Obstet Gynecol*. 1995;172:1726.
8. Yerdel MA, Karayalcin K, Koyuncu A, et al. Direct trocar insertion versus Veress needle insertion in laparoscopic cholecystectomy. *Am J Surg*. 1999;177(3):247–249.
9. Nezhat FR, Silfen SL, Evans D, Nezhat C. Comparison of direct insertion of disposable and standard reusable trocars and previous pneumoperitoneum with Veress needle. *Obstet Gynecol*. 1991;78:148–150.
10. Moore SS, Green CR, Wang FL, et al. The role of irrigation in the development of hypothermia during laparoscopic surgery. *Am J Obstet Gynecol*. 1997;176:598.
11. Landman J, Kerbl K, Rehman J, et al. Evaluation of a vessel sealing system, bipolar electrosurgery, harmonic scalpel, titanium clips, endoscopic gastrointestinal anastomosis vascular staples and sutures for arterial and venous ligation in a porcine model. *J Urol*. 2003;169:697–700.
12. Carbonell AM, Joels CS, Kercher KW, et al. A comparison of laparoscopic bipolar vessel sealing devices in the hemostasis of small-, medium-, and large-sized arteries. *J Laparoendosc Adv Surg Tech A*. 2003;13(6):377–380.
13. Harold KL, Pollinger H, Matthews BD, et al. Comparison of ultrasonic energy, bipolar thermal energy, and vascular clips for the hemostasis of small-, medium-, and large-sized arteries. *Surg Endosc*. 2003;17(8):1228–1230.
14. Nezhat C, Nezhat F, Silfen SO. Laparoscopic hysterectomy and bilateral salpingo-oophorectomy using multifire GIA surgical stapler. *J Gynecol Surg*. 1990;6:287.
15. Nezhat C, Nezhat F, Bess O, et al. Injuries associated with the use of a linear stapler during operative laparoscopy: review of diagnosis, management, and prevention. *J Gynecol Surg*. 1993;9:145.
16. Carter JE, McCarus SD. Laparoscopic myomectomy: time and cost analysis of power vs. manual morcellation. *J Reprod Med*. 1997;42:383.
17. Mecke H, Wallas F, Brocker A, Gertz HP. Pelviscopic myoma enucleation: technique, limits, complications. *Geburtshilfe Frauenheilkd*. 1995;55:374.
18. Mettler L, Semm K, Lehmann-Willenbrock L, et al. Comparative evaluation of classical intrafascial-supracervical hysterectomy (CISH) with transuterine mucosal resection as performed by pelviscopy and laparotomy – our first 200 cases. *Surg Endosc*. 1995;9:418.
19. Kresch AJ, Lyons TL, Westland AB, et al. Laparoscopic supracervical hysterectomy with a new disposable morcellator. *J Am Assoc Gynecol Laparosc*. 1998;5:203.
20. Lobe TE, Schropp KP, Joyner R, et al. The suitability of automatic tissue morcellation for the endoscopic removal of large specimens in pediatric surgery. *J Pediatr Surg*. 1994;29:232.
21. Hasson HM. Ovarian surgery. In: Sanfilippo JS, Levine RL, eds. *Operative Gynecologic Endoscopy*. New York: Springer-Verlag;1989.
22. Valtchev KL, Papsin FR. A new uterine mobilizer for laparoscopy: its use in 518 patients. *Am J Obstet Gynecol*. 1977;127:738.
23. Koh CH. A new technique and system for simplifying total laparoscopic hysterectomy. *J Am Assoc Gynecol Laparosc*. 1998;5:187.
24. DesCoteaux JG, Tye L, Poulin EC. Reuse of disposable laparoscopic instruments: cost analysis. *Can J Surg*. 1996;39:133.
25. DesCoteaux JG, Blackmore K, Parsons L. A prospective comparison of the costs of reusable and limited-reuse laparoscopic instruments. *Can J Surg*. 1998;41:136.
26. DesCoteaux JG, Poulin EC, Lortie M, et al. Reuse of disposable laparoscopic instruments: a study of related surgical complications. *Can J Surg*. 1995;38:497.
27. Schaer GN, Koechli OR, Haller U. Single-use versus reusable laparoscopic surgical instruments: a comparative cost analysis. *Am J Obstet Gynecol*. 1995;173:1812.
28. Nezhat C, Bess O, Admon D, et al. Hospital cost comparison between abdominal, vaginal, and laparoscopy-assisted vaginal hysterectomy. *Obstet Gynecol*. 1994;83:713.
29. Airan MC, Sandor J. A simple subcutaneous tissue closure device for laparoscopic procedure. *Minim Invasive Ther Allied Technol*. 1996;5:35.
30. Carter JE. A new technique of fascial closure for laparoscopic incisions. *J Laparosc Surg*. 1994;4:143.
31. Bezzi M, Silecchia G, De Leo A, et al. Laparoscopic and intraoperative ultrasound. *Eur J Radiol*. 1998;27(suppl 2):14.
32. Nezhat F, Nezhat C, Nezhat CH, et al. Use of laparoscopic ultrasonography to detect ovarian remnants. *J Ultrasound Med*. 1996;15:487.
33. Hurst BS, Tucker KE, Awoniyi CA, Schlaff WD. Endoscopic ultrasound. A new instrument for laparoscopic surgery. *J Reprod Med*. 1996;41:67.
34. Dunlap KD, Wanzwe L. Is the robotic arm a cost effective surgical tool? *Am Oper Room Nurs J*. 1998;68:265.
35. Mettler L, Ibrahim M, Jonar W. One year experience working with the aid of a robotic assistant (the voice controlled optic holder, AESOP) in gynecological endoscopic surgery. *Hum Reprod*. 1998;13:2748.
36. Berguer R, Rab GT, Abu-Ghaida H, et al. A comparison of surgeon's posture during laparoscopic and open surgical procedures. *Surg Endosc*. 1997;11:139.
37. Nezhat C, et al. Reduce fatigue and discomfort: tips to improve operating room set-up. *Laparosc Surg Update.* 1997;5:97.
38. Hurd WW, Diamond MP. There's a hole in my bucket: the cost of disposable instruments. *Fertil Steril.* 1997;67:13.
39. Dorsey JH, Holtz PM, Griffiths RI, et al. Costs and charges associated with three alternative techniques of hysterectomy. *N Engl J Med.* 1996;335:476.

3 ANESTHESIA

Lindsey Vokach-Brodsky

Pneumoperitoneum and patient positioning during laparoscopy induce certain pathophysiologic changes. These must be understood for the anesthesiologist to provide the best perioperative care, particularly for patients with coexisting medical problems.

In this chapter, the changes induced by raised CO_2 pneumoperitoneum and head-down tilt are reviewed. The complications of laparoscopy that are of immediate concern to the anesthesiologist are discussed, followed by a brief description of anesthetic techniques and postoperative management. Recent research involving anesthesia for nongynecologic laparoscopy is included when relevant.

HEMODYNAMIC CHANGES DURING LAPAROSCOPY

The hemodynamic effects of gynecologic laparoscopy are the result of raised intra-abdominal pressure, insufflation of CO_2, and head-down positioning.

After CO_2 insufflation to an intra-abdominal pressure greater than 10 mm Hg, cardiac output falls 10% to 30%, arterial pressure increases, and both systemic and pulmonary vascular resistance increase.[1,2] Heart rate is unchanged. The fall in cardiac output is related to reduced flow in the inferior vena cava, pooling of blood in the legs, and an increase in venous resistance. Although venous return falls, cardiac filling pressures increase, which is consistent with the observed rise in intrathoracic pressure.[2,3] There is an increase in intrathoracic blood volume.[4] Systemic vascular resistance (SVR) increases because of an increase in the vascular resistance of intra-abdominal organs and increased venous resistance. This increase in SVR is reduced by a head-down tilt.[3] After pneumoperitoneum has been established, placing the patient in a 10° to 30° head-down position increases preload, pulmonary capillary wedge pressure (PCWP), and pulmonary artery pressure (PAP) while returning afterload toward normal.[2,3]

These hemodynamic changes appear to be more marked in patients with severe heart disease, particularly congestive heart failure. These patients require careful preoperative evaluation, more extensive intraoperative monitoring, and close hemodynamic control extending into the postoperative period.[5]

Vagal stimulation resulting in bradycardia and bradyarrhythmias may be provoked by mechanical distention of the peritoneum or manipulation of pelvic organs.[6] Surgery should be interrupted while atropine is administered and the level of anesthesia is deepened.

VENTILATORY CHANGES DURING LAPAROSCOPY

Pneumoperitoneum causes a cephalad shift in the diaphragm, stiffens the lower chest wall, and restricts lung expansion. There is a resultant 30% to 50% decrease in thoracopulmonary compliance, which occurs in all patients: healthy, obese, and American Society of Anesthesiology (ASA) class III and IV. A subsequent change in position does not affect compliance.[2,7–12] Functional residual capacity is also decreased. Physiologic dead space and shunt are unchanged in the absence of significant cardiac disease.

Peak inspiratory pressure (PIP) and mean airway pressure increase during pneumoperitoneum.[9] Mechanical ventilation may become difficult in the obese or in patients with lung disease.[10]

Pneumoperitoneum has been shown to shift the carina cephalad sufficiently to result in endobronchial intubation in some patients.[13,14] Increased PIP and decreased oxygen saturation (SaO_2) result. After positioning the patient, endotracheal tube placement should be rechecked by auscultation.

CO_2 is used commonly to provide a pneumoperitoneum. As CO_2 is absorbed from the peritoneal cavity, the CO_2 load increases over the first 20 minutes of pneumoperitoneum before reaching a plateau about 25% above preinsufflation values.[15,16] CO_2 absorption is probably limited by reduced peritoneal perfusion as the result of increased intra-abdominal pressure. An increase in minute ventilation of about 30% has been shown to maintain a normal end-tidal CO_2 partial pressure ($PetCO_2$).[7,16] Increasing respiratory rate rather than tidal volume tends to minimize the rise in PIP. Investigations of arterioalveolar CO_2 partial pressure differences have not shown a consistent change, but the differences may increase over time in prolonged operations. $PetCO_2$ therefore may not be a reliable measure of arterial CO_2 partial pressure ($PaCO_2$), particularly in prolonged procedures or in patients with underlying lung disease.[8,9,15]

METABOLIC AND RENAL RESPONSE TO LAPAROSCOPY

Endocrine responses to laparoscopy do not appear to differ from those seen with open surgery.[17,18] Increases in circulating catecholamines, cortisol, renin, and aldosterone are similar whether cholecystectomy is open or laparoscopic. However, the metabolic response to surgery is reduced. Acute phase proteins, hyperglycemia, and leukocytosis are lower following laparoscopic cholecystectomy, compared with an open procedure.[18,19]

Pneumoperitoneum is associated with a 50% reduction in the glomerular filtration rate and urine output. Urine output recovers promptly after release of the pneumoperitoneum.[20]

INTRAOPERATIVE COMPLICATIONS

CO_2 Embolism

CO_2 embolism is a rare but potentially fatal event.[21] It occurs most commonly during initial insufflation of gas as a result of inadvertent insertion of the trocar or Veress needle into a vessel or abdominal organ. The severity of the response depends on the volume of gas entering the circulation and the speed of entrainment. Small CO_2 emboli appear to follow a more benign and transient course than do air emboli because of the high solubility of CO_2 in blood and tissues and the large buffering capacity of blood, which leads to rapid elimination.[21] The lethal dose of CO_2 is about five times that of air (25 mL/kg for CO_2 and 5 mL/kg for air) in dogs.[22] The expansion of an air embolus caused by diffusion of nitrous oxide into the bubble of air does not occur with CO_2 emboli because CO_2 has a solubility similar to that of N_2O. Unlike air embolus, CO_2 embolus does not cause bronchospasm. Large volumes of gas injected under pressure, however, can cause an "air lock" in the vena cava or right atrium, causing sudden cardiovascular collapse.[21]

Paradoxic embolus occurs when gas passes through a patent foramen ovale into the systemic circulation, driven by high right atrial pressures.[2] About 25% of normal individuals have a probe patent foramen ovale.

Transesophageal echo and esophageal or precordial Doppler probes are the most sensitive detectors of CO_2 emboli. However, the low incidence of this complication during laparoscopy does not justify their routine use. Capnography is the most sensitive detector of CO_2 embolism normally in use during laparoscopy. In case reports, capnography showed an initial small sharp rise in end-tidal CO_2 concentration in expiratory air ($ETCO_2$) with a subsequent fall caused by an increase in dead space in the lung.[23,24] Saturation of peripheral oxygen (SpO_2) and mean arterial pressure (MAP) fall, with the magnitude of the fall depending on the size of the embolus. Bradycardia or other arrhythmia may occur, and a characteristic "mill wheel" murmur may be heard over the precordium. The alveolar–arterial CO_2 difference will increase. Treatment involves stopping insufflation, releasing the pneumoperitoneum immediately, and giving 100% oxygen. Turning the patient head down on the left side is recommended to displace the gas bubbles from the outflow tract of the right heart. Cardiopulmonary resuscitation should be instituted as necessary. Aspiration of gas through a central venous pressure (CVP) line may be attempted. Cardiopulmonary bypass has been used successfully after massive CO_2 embolus.[23] Hyperbaric oxygen has been recommended to treat suspected cerebral embolism.[25]

Pneumothorax, Pneumomediastinum, and Subcutaneous Emphysema

Although pneumothorax is a complication that is more commonly associated with upper abdominal laparoscopy, it has been reported during gynecologic procedures.[26] A congenital diaphragmatic defect may allow peritoneal gas to pass into the pleural cavity. An increase in PIP, a fall in SpO_2, and decreased breath sounds on one side point to the diagnosis, which should be confirmed by chest radiograph. The laparoscopist may be able to show abnormal motion of one hemidiaphragm. Reduced QRS amplitude in precordial ECG leads supports the diagnosis.[27] Falling MAP and SpO_2 suggests the presence of a tension pneumothorax that requires immediate decompression. In the absence of tension, unless there is a pulmonary cause (such as a ruptured bulla), pneumothorax resolves spontaneously after 30 to 60 minutes in the recovery period. If the patient is stable, Joris [27] suggests conservative intraoperative management. Chest tube drainage should be avoided during surgery because it will make it difficult to maintain the pneumoperitoneum. Increasing fraction of inspiratory oxygen (FiO_2), the addition of 5 cm of positive end-expiratory pressure (PEEP), and reduction of intra-abdominal pressure will maintain oxygenation and allow surgery to be completed.[29]

Subcutaneous CO_2 emphysema may accompany pneumothorax or occur in isolation. An abrupt and severe rise in $ETCO_2$ is characteristic. This occurs when CO_2 tracks into tissue planes, increasing the surface area for uptake into the circulation. A higher than normal increase in minute ventilation is required for control. $ETCO_2$ may increase to very high levels. Rarely, it may become necessary to discontinue surgery and release the pneumoperitoneum until control of $ETCO_2$ is achieved. The possibility of pneumothorax and pneumomediastinum always should be considered when subcutaneous emphysema is present. Subcutaneous emphysema resolves over several hours. Explanation and reassurance may be necessary for the patient in the postoperative care unit.

Nerve Injury

The common peroneal and sciatic nerves are at risk for injury during laparoscopy in the lithotomy position. Femoral neuropathy has also been reported.[30] The brachial plexus may be injured by pressure or stretching from shoulder restraints, especially in the steep head-down position. Meticulous care is necessary when positioning the patient to minimize the risk of injuring these vulnerable nerves. Lower limb compartment syndrome has complicated prolonged laparoscopy performed in the lithotomy position.[31,32]

Fluid Balance

A patient who has undergone a preoperative bowel preparation and a prolonged fast may be dehydrated on arrival in the operating room. Intraoperative blood loss may be difficult to assess during laparoscopy because of dilution in large volumes of irrigation fluid. Pulmonary edema has been described after the absorption of intra-abdominal irrigating fluid, resulting in dyspnea and hypoxemia in the recovery room.[33] Maintaining a careful record of irrigating fluid balance intraoperatively will alert the anesthesiologist when large deficits are accumulating.

Heat Loss

Postoperative hypothermia has been associated with an increased incidence of wound infection and prolonged hospital stay after laparotomy.[34] In patients with cardiac risk factors, perioperative myocardial events are increased in the presence of mild hypothermia.[35] Peritoneal gas insufflation and the use of large volumes of peritoneal irrigation predispose a patient to hypothermia during laparoscopy.[36] Warming of insufflation gas has not proved useful.[37] Warming of irrigation fluids and the use of a forced-air warming blanket reduce the incidence of the undesirable postoperative effects of hypothermia.

ANESTHESIA CONSIDERATIONS

Preoperative Evaluation and Premedication

Most patients for gynecologic laparoscopy are young, healthy women, requiring routine preoperative evaluation and few laboratory investigations.[38] A complete blood count and pregnancy test may be performed when indicated.

Patients with coexisting medical problems should be evaluated appropriately. In particular, patients with severe cardiac disease, particularly congestive heart failure, require careful workup. These patients may be unable to tolerate the cardiovascular changes of laparoscopy, and open procedure may be a better choice.

Laparoscopy has few contraindications, but pneumoperitoneum should be avoided in patients with raised intracranial pressure and in those with ventriculoperitoneal or peritoneojugular shunts.

Premedication with a small dose (1 to 2 mg) of the short-acting benzodiazepine midazolam allays anxiety without contributing to postoperative sedation. For patients with a history of severe postoperative nausea and vomiting, transdermal scopolamine is an effective adjunct to antiemetic medication given intraoperatively. It must be given at least 4 hours before the end of surgery to be effective.[39] In patients at risk for regurgitation of gastric contents, preoperative administration of a nonparticulate antacid increases gastric pH. Metoclopramide and H_2 receptor blockers may be given to reduce gastric volume and acidity.

Choice of Anesthesia

Although regional and local anesthesia have been used successfully for laparoscopy, they are suitable only for brief procedures with minimal intra-abdominal gas and few incisions. Operative gynecologic laparoscopy necessitates optimal surgical conditions, steep head-down positioning, muscle relaxation, a large pneumoperitoneum, and multiple incisions. These considerations make general anesthesia the safest and most comfortable choice. Similarly, although the laryngeal mask airway has been used successfully for laparoscopy [40], endotracheal intubation protects the airway from aspiration of gastric contents and facilitates the delivery of increased minute ventilation in the presence of increased airway pressures.[41]

Propofol anesthesia in outpatient surgery is associated with better postoperative recovery.[42] After the administration of the muscle relaxant, care must be taken during mask ventilation not to inflate the stomach with gas. Once the endotracheal tube is secured, an orogastric tube is passed to decompress the stomach. Balanced anesthesia with oxygen-enriched air, an inhalational agent, a muscle relaxant, and a narcotic such as fentanyl is suitable. Total intravenous anesthesia has also been used successfully. Intra-abdominal pressure can be kept as low as possible by controlled ventilation, maintaining muscle relaxation, and a relatively deep plane of anesthesia.

The role of nitrous oxide in anesthesia for laparoscopy remains controversial. Several studies have failed to show a difference in operating conditions or bowel distention during laparoscopy with and without nitrous oxide.[43,44] These procedures were less than 3 hours in duration. Studies of nonlaparoscopic colonic surgery lasting 3 hours or longer have demonstrated a deleterious effect on bowel function when nitrous oxide is used.[45] Avoidance of nitrous oxide may be most useful in procedures of long duration.

Continuous intraoperative monitoring should include pulse oximetry, ECG, $ETCO_2$, blood pressure, temperature, muscle relaxation, minute ventilation, and airway pressure. Patients with cardiac disease may benefit from transesophageal echo or invasive hemodynamic monitoring.[5]

RECOVERY FROM ANESTHESIA

Postoperative Nausea and Vomiting

Nausea with or without vomiting is a common postoperative occurrence and is distressing to patients. The incidence of postoperative nausea and vomiting (PONV) overall is about 30%; after laparoscopy, it is about 50%.[46] Younger, nonsmoking women with a history of motion sickness or previous PONV have the highest risk. The use of prophylactic antiemetic medication may be justified in laparoscopy because of this high probability of PONV. The optimal prophylactic regimen remains a matter of debate. Given the complex causes of vomiting, it seems likely that the use of a combination of medications will produce better results than will one alone. Several prophylactic and rescue algorithms have been proposed.[47,48]

Pain Management

Postoperative pain occurs in the abdomen, shoulders, and back. Shoulder pain, presumably from diaphragmatic irritation and phrenic nerve stimulation, tends to become more significant on the second postoperative day.[49] Many studies have examined the effect of nonsteroidal anti-inflammatory drugs (NSAIDs) on pain after laparoscopy. The intensity and duration of pain relief are improved by adding ketorolac to a short-acting opioid, but NSAIDs alone provide inadequate pain relief. There is evidence of increased postoperative bleeding associated with NSAIDs.[50] Various local anesthetic techniques have been used, including infiltration of the abdominal wounds and rectus sheath block. A combination of narcotics, local anesthesia, and an NSAID may offer the best relief.[51]

REFERENCES

1. Johansen G, Anderson M, Juhl B. The effect of general anesthesia on the hemodynamic events during laparoscopy with CO_2 insufflation. *Acta Anaesthesiol Scand*. 1989;33:132.
2. Hirvonen EA, Nuutinen LS, Kauko M. Hemodynamic changes due to Trendelenburg positioning and pneumoperitoneum during laparoscopic hysterectomy. *Acta Anaesthesiol Scand*. 1995;39:949.

3. Odeburg S, Ljungqvist O, Svenberg T, et al. Haemodynamic effects of pneumoperitoneum and the influence of posture during anaesthesia for laparoscopic surgery. *Acta Anaesthesiol Scand*. 1994;38:276.
4. Hofer CK, Zalunardo MP, Klaghofer R, Spahr T, Pasch T, Zollinger A. Changes in intrathoracic blood volume associated with pneumoperitoneum and positioning. *Acta Anaesthesiol Scand*. 2002;46:303.
5. Safran D, Sgambati S, Orlando R. Laparoscopy in high risk cardiac patients. *Surg Gynecol Obstet*. 1993;176:584.
6. Sprung J. Recurrent complete heart block in a healthy patient during laparoscopic electrocauterization of the fallopian tube. *Anesthesiology*. 1998;88:1401.
7. Hirvonen EA, Nuutinen LS, Kauko M. Ventilatory effects, blood gas changes, and oxygen consumption during laparoscopic hysterectomy. *Anesth Analg*. 1995;80:961.
8. Monk TG, Weldon BC, Lemon D. Alterations in pulmonary function during laparoscopic surgery [abstract]. *Anesth Analg*. 1994;76:S274.
9. Wahba RW, Mamazza J. Ventilatory requirements during laparoscopic cholecystectomy. *Can J Anaesth*. 1993;40:206.
10. Sprung J, Whalley D, Falcone T, Warner D, Hubmayr RD, Hammel J. The impact of morbid obesity, pneumoperitoneum, and posture on respiratory system mechanics and oxygenation during laparoscopy. *Anesth Analg*. 2002;94:1345.
11. Rauhr R, Hemmerling TM, Rist M, et al. Influence of pneumoperitoneum and patient positioning on respiratory system compliance. *J Clin Anesth*. 2001;13:361.
12. Oikkonen M, Tallgren M. Changes in respiratory compliance at laparoscopy: measurements using sidestream spirometry. *Can J Anaesth*. 1995;42:495.
13. Lobato EB, Paige GB, Brown MM, et al. Pneumoperitoneum as a risk factor for endobronchial intubation during laparoscopic gynecologic surgery. *Anesth Analg*. 1998;86:301.
14. Ezri T, Hazin V, Warters D, Szmuk P, Weinbroum AA. The endotracheal tube moves more often in obese patients undergoing laparoscopy compared with open abdominal surgery. *Anesth Analg*. 2003;96:278.
15. Puri GD, Singh H. Ventilatory effects of laparoscopy under general anaesthesia. *Br J Anaesth*. 1992;68:211.
16. Tan PL, Lee TL, Tweed WA. Carbon dioxide absorption and gas exchange during pelvic laparoscopy. *Can J Anaesth*. 1992;39:677.
17. Hirvonen EA, Nuutinen LS, Vuolteenaho O. Hormonal responses and cardiac filling pressures in head up or head down position and pneumoperitoneum in patients undergoing operative laparoscopy. *Br J Anaesth*. 1997;78:128.
18. Joris J, Cigarini I, Legrand M, et al. Metabolic and respiratory changes after cholecystectomy performed via laparotomy or laparoscopy. *Br J Anaesth*. 1992;69:341.
19. Karayiannakis AJ, Makri GG, Mantzioka A. Systemic stress response after laparoscopic or open cholecystectomy: a randomized trial. *Br J Surg*. 1997;84:467.
20. Hashikura Y, Kawasaki S, Munakata Y, et al. Effects of peritoneal insufflation on hepatic and renal blood flow. *Surg Endosc*. 1994;8:759.
21. Wahba RW, Tessler MJ, Kleiman SJ. Acute ventilatory complications during laparoscopic upper abdominal surgery. *Can J Anaesth*. 1995;43:77.
22. Graff TD, Arbegast NR, Philips OC, et al. Gas embolism: a comparative study of air and carbon dioxide as embolic agents in the systemic venous system. *Am J Obstet Gynecol*. 1959;78:259.
23. Shulman D, Aronson HB. Capnography in the early diagnosis of carbon dioxide embolism during laparoscopy. *Can J Anaesth*. 1984;31:31.
24. Diakun TA. Carbon dioxide embolism: successful resuscitation with cardiopulmonary bypass. *Anesthesiology*. 1991;74:1151.
25. McGrath BJ, Zimmerman JE, Williams JF, Parmet J. Carbon dioxide embolism treated with hyperbaric oxygen. *Can J Anaesth*. 1989;36:586.
26. Perko G, Fernandes A. Subcutaneous emphysema and pneumothorax during laparoscopy for ectopic pregnancy removal. *Acta Anaesthesiol Scand*. 1997;41:792.
27. Ludemann R, Krysztopik R, Jamieson G, Watson DI. Pneumothorax during laparoscopy. *Surg Endosc*. 2003;17:12.
28. Joris JL. Anesthetic management of laparoscopy. In: Miller RD, ed. *Anesthesia*. 4th ed. New York: Churchill Livingstone; 1994.
29. Chiche JD, Joris J, Lamy M. PEEP for treatment of intra-operative pneumothorax during laparoscopic fundoplication. *Br J Anaesth*. 1994;72:A38.
30. Gombar KK, Gombar S, Singh B, et al. Femoral neuropathy: a complication of the lithotomy position. *Reg Anaesth*. 1992;17:306.
31. Lydon JC, Spielman FJ. Bilateral compartment syndrome following prolonged surgery in the lithotomy position. *Anesthesiology*. 1984;60:236.
32. Montgomery CJ, Ready LB. Epidural opioid analgesia does not obscure diagnosis of compartment syndrome resulting from prolonged lithotomy position. *Anesthesiology*. 1991;75:541.
33. Healzer JM, Nezhat C, Brodsky JB, et al. Pulmonary edema after absorbing crystalloid irrigating fluid during laparoscopy. *Anesth Analg*. 1994;78:1207.
34. Kurz A, Sessler DI, Lenhardt R. Peri-operative normothermia to reduce the incidence of surgical wound infection and shorter hospitalization. *N Engl J Med*. 1996;334:1209.
35. Frank SM, Fleisher LA, Breslow MJ, et al. Perioperative maintenance of normothermia reduces the incidence of morbid cardiac events. *JAMA*. 1997;277:1127.
36. Moore SS, Green CR, Wang FL, et al. The role of irrigation in the development of hypothermia during laparoscopic surgery. *Am J Obstet Gynecol*. 1997;176:598.
37. Nelskaya K, Yli-Hankala A, Sjoberg J, Korhonen I, Kortila K. Warming of insufflation gas during laparoscopic hysterectomy: effect on body temperature and the autonomic nervous system. *Acta Anesthesiol Scand*. 1999;43:10.
38. Roizen MF, Cohn S. Preoperative evaluation for elective surgery – what laboratory tests are needed? *Adv Anesth*. 1993;10:25.
39. Kranke P, Morin AM, Roewer N, Wulf H, Eberhart LH. The efficacy and safety of transdermal scopolamine for the prevention of postoperative nausea and vomiting: a quantitative systematic review. *Anesth Analg*. 2002;95:133.
40. Maltby JR, Beriault MT, Watson NC, Liepert DJ, Fick GH. LMA-Classic and LMA Pro-Seal are effective alternatives to endotracheal intubation for gynecologic laparoscopy. *Can J Anaesth*. 2003;50:1.
41. Ho BY, Skinner HJ, Mahajan RP. Gastro-oesophageal reflux during day case gynaecological laparoscopy under positive pressure ventilation: laryngeal mask vs. tracheal intubation. *Anaesthesia*. 1998;53:910.
42. De Grood RM, Habers JB, van Egmond J, Crul JF. Anesthesia for laparoscopy: a comparison of 5 techniques including propofol, etomidate, thiopentone and isoflurane. *Anaesthesia*. 1987;42:815.
43. Brodsky JB, Lemmens HJ, Collins JS, et al. Nitrous oxide and laparoscopic bariatric surgery. *Obes Surg*. 2005;15:4.
44. Taylor E, Feinstein R, White PF, Soper N. Anesthesia for laparoscopic cholecystectomy. Is nitrous oxide contraindicated? *Anesthesiology*. 1992;76:541.
45. Akca O, Lenhardt R, Fleischman E, et al. Nitrous oxide increases the incidence of bowel distension in patients undergoing elective colon resection. *Acta Anesthesiol Scand*. 2004;48:894.

46. Beattie WS, Linblad T, Buckley DN, Forest JB. Menstruation increases the risk of nausea and vomiting after laparoscopy. *Anesthesiology*. 1993;78:272.
47. Habib AS, Gan TJ. Evidence-based management of postoperative nausea and vomiting: a review. *Can J Anaesth*. 2004;51:326.
48. Gan TJ, Meyer T, Apfel CC, et al. Consensus guidelines for managing postoperative nausea and vomiting. *Anesth Analg*. 2003;97:62.
49. Alexander JI. Pain after laparoscopy. *Br J Anaesth*. 1997;79:369.
50. Forrest JB, Camu F, Greer IA, et al. Ketorolac, diclofenac, and ketoprofen are equally safe for pain relief after major surgery. *Br J Anaesth*. 2002;88:227.
51. Michalolaikou C, Chung F, Sharma S. Preoperative multimodal analgesia facilitates recovery after ambulatory laparoscopic cholecystectomy. *Anesth Analg*. 1996;82:44.

4 LAPAROSCOPIC ACCESS

Section 4.1. Principles of Laparoscopy

Camran Nezhat, Ceana Nezhat, Farr Nezhat, and Roger Ferland

The modern era of laparoscopy began in 1954, when Palmer [1] reported the results of endoscopic procedures in 250 patients without sequelae. He produced a pneumoperitoneum with CO_2 at a rate of 300 to 500 mL/min and cautioned that the intra-abdominal pressure should not exceed 25 mm Hg. The claimed advantages of laparoscopy over culdoscopy were a decreased chance of infection, a better view of the pelvis, improved access to the pelvic organs and cul-de-sac, and easier application of surgical techniques.

Although the basic principles of laparoscopy are the same, the instruments and the complexity of operative procedures have changed significantly since 1954. This chapter presents information for residents learning laparoscopic operations and clinicians who are updating their knowledge of operative laparoscopy.

PREOPERATIVE EVALUATION

Advanced operative laparoscopy is a major intra-abdominal procedure. Careful preoperative evaluation optimizes the operative outcome and decreases the incidence of injuries and complications. Preoperative consultations with surgeons in other disciplines (colorectal, urologic, oncologic) sometimes are necessary. The patient is informed about the possible outcome and results of the planned operation, possible complications, and the surgeon's experience in doing the particular procedure. The following preoperative work-up is suggested:

1. History and physical
2. Complete blood count (CBC) with differential
3. Serum electrolytes
4. Urinalysis
5. Papanicolaou smear
6. Thrombin time, partial thrombin time, bleeding time
7. Transvaginal sonography (TVS)

In special situations, an endometrial biopsy, cervical culture, hysterosalpingogram, barium enema, intravenous pyelogram, blood type and screen or type and crossmatch, and bowel preparation are indicated.[2] Two bowel preparations are suggested (Tables 4.1.1 and 4.1.2).

Women who have had a previous laparotomy or have an adnexal mass, pelvic endometriosis, or adhesions are given instructions for the 1-day preparation. The 3-day regimen is used for a patient who may need an extensive laparoscopic procedure, such as a bowel resection.

PATIENT PREPARATION AND POSITION

The anesthesiology team and circulating nurses coordinate the patient's transfer onto the operating table. The operative site is cleansed and shaved preoperatively by an operating room (OR) nurse. Operating tables must be designed to provide a 25° Trendelenburg position. After the induction of endotracheal anesthesia, the patient's legs are placed in padded Allen stirrups to provide good support and proper position. Padding near the peroneal nerve is essential. To avoid nerve compression, no leg joint is extended more than 60°. The buttocks must protrude a few centimeters from the edge of the table to allow uterine manipulation. The patient's arms are placed at the side, padded with foam troughs, and secured by a sheet. This allows the surgeon and assistants to stand unencumbered next to the patient. The anesthesiologist should have easy access to the patient's arm (Figure 4.1.1).

Once the patient is positioned, her abdomen, perineum, and vagina are prepared with a suitable bactericidal solution and a Foley catheter is inserted. She is draped to expose the abdomen and perineum, and a pelvic examination is done. Diagnostic hysteroscopy may be indicated for patients undergoing diagnostic and operative laparoscopy. After withdrawal of the hysteroscope, a uterine manipulator is inserted into the cervical os to manipulate the uterus and for chromopertubation. Rectal and vaginal probes can help separate the tissue planes of the cul-de-sac. The assistant can do a simultaneous rectal and vaginal examination for the same purpose. A sponge on a ring forceps is placed in the posterior fornix to outline the posterior cul-de-sac or anteriorly to identify the vesicouterine space. In patients who are suspected of having rectosigmoid endometriosis, a sigmoidoscopic examination is suggested. The rectum is insufflated to look for bubbles as they pass into the posterior cul-de-sac filled with irrigation fluid.[3]

PLACEMENT OF THE VERESS NEEDLE

Insertion of the Veress needle, the primary trocar, and the secondary trocar is an important aspect of diagnostic and operative laparoscopy. Serious complications and injuries may occur during these procedures. The following factors increase the risk of injury:

1. Previous abdominal and pelvic operations
2. Body weight (whether patient is obese or very thin)
3. A large uterus and the presence of a large pelvic mass

Table 4.1.1: One-Day Bowel Preparation

1. Clear liquid the day before the operation
2. One gallon of GoLYTELY (Braintree Laboratories) consumed over 3 hours the evening before the laparoscopy or 45 mL of Fleet Phospho-Soda (C. B. Fleet Co.) orally at bedtime
3. One Fleet enema at bedtime and in the morning
4. 1 g metronidazole (Flagyl; Pfizer) by mouth at 11 PM
5. 1 g cefoxitin one-half hour before the procedure (intravenously)

The optimal location for the Veress needle and primary trocar is the umbilicus because the skin is attached to the fascial layer and anterior parietal peritoneum with no intervening subcutaneous fat or muscle (Figure 4.1.2). The transumbilical approach accounts for the shortest distance between the skin and the peritoneal cavity even in obese patients. These sites sometimes are modified. The primary trocar is inserted approximately 4 to 6 cm above the umbilicus in patients who have an enlarged uterus caused by a uterine leiomyoma or pregnancy or for para-aortic lymph node dissection.

Before the needle is inserted, a transverse or vertical cutaneous incision is made large enough to accommodate the primary trocar. A vertical umbilical incision provides better cosmetic results.[4] When one is incising the umbilicus, an Allis clamp or skin hook is used to grasp and evert the base of the umbilicus, raising it from the abdominal structures.

One should check the patency of the needle before it is inserted. Traditionally, the angle of insertion is approximately 45° for an infraumbilical placement while the patient is horizontal; a premature Trendelenburg position alters the usual landmarks (Figure 4.1.3). Transumbilical placement with a 90° angle of insertion is recommended after adequate training with this technique. Palpating the abdominal aorta and the sacral promontory is performed first. The patient is completely flat and the operating table is all the way down to maximize the surgeon's upper body control during insertion of the Veress needle (Figure 4.1.4). The Veress needle, held at the shaft, is directed toward the sacral promontory (Figure 4.1.5). The surgeon and assistants apply countertraction by grasping the skin and fat on each side of the umbilicus with a towel clip (Figure 4.1.6).[5] In obese patients, a 90° angle is necessary initially to enter the peritoneal cavity. In thin individuals, vital structures are closer to the abdominal wall, so the surgeon makes certain that the abdominal wall is elevated and only a small portion of the needle is inserted into the abdominal cavity. That is rarely more than 2 to 3 cm of the Veress needle or trocar. A prospective study involving 97 women undergoing operative laparoscopy showed that the position of the aortic bifurcation is more likely to be caudal to the umbilicus in the Trendelenburg position, compared with the supine position, regardless of body mass index.[6] Its presumed location may be misleading during Veress needle or primary cannula insertion. The physician must be careful to avoid major retroperitoneal vascular injury during this procedure.

Verification of Intraperitoneal Location

Failure to achieve and maintain a suitable pneumoperitoneum predisposes the patient to complications.

Table 4.1.2: Three-Day Bowel Preparation

Day 1
100 mL Fleet Phospho-Soda by mouth at bedtime

Day 2
Clear liquid diet

Day 3
Clear liquid diet
10 mg prochlorperazine by mouth at noon
Begin drinking 1 gallon of GoLYTELY at 2 PM
1 g neomycin by mouth at 6 PM and 11 PM
1 g erythromycin base by mouth at 6 PM and 11 PM
One Fleet enema at bedtime

Day of surgery
Two tap water enemas before reporting to the hospital

Hanging Drop Method

Correct needle placement is verified by the "hanging drop" technique. A drop of saline is placed on the hub of the Veress needle after insertion through the abdominal wall; lifting the abdominal wall establishes negative pressure within the abdomen, drawing the drop of fluid into the needle. Absence of this sign indicates improper placement of the Veress needle.

The Syringe Test

Alternatively, a 10-mL syringe with normal saline is attached to the Veress needle and aspiration verifies the absence of bowel contents or blood (Figure 4.1.7). The saline is injected into the peritoneal cavity, and if the needle placement is correct, the fluid cannot be withdrawn because it is dispersed intraperitoneally. If the needle is placed within adhesions or the preperitoneal space, the fluid usually is recovered by aspiration. If the needle has been placed intravascularly or in the intestine or bladder, characteristic contents are obtained. Additional methods of verifying proper placement of the Veress needle are summarized in Table 4.1.3. Once correct intraperitoneal placement of the Veress needle is assured, trocar-related injuries can be avoided by employing the technique of abdominal mapping before the insertion of the initial trocar. Mapping of the abdomen at the site of the trocar placement requires an 18-gauge spinal needle attached to a

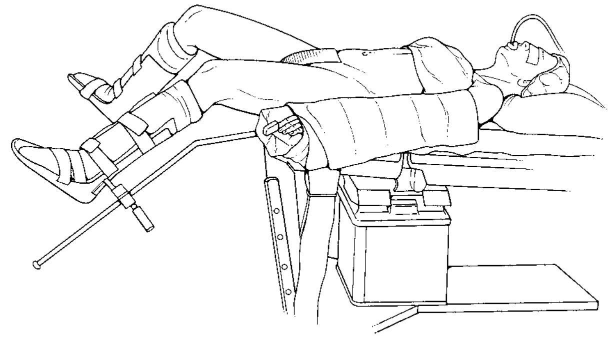


Figure 4.1.1. The patient is in a dorso-lithotomy position, but the thighs are not flexed so that the suprapubic trocars may be maneuvered.

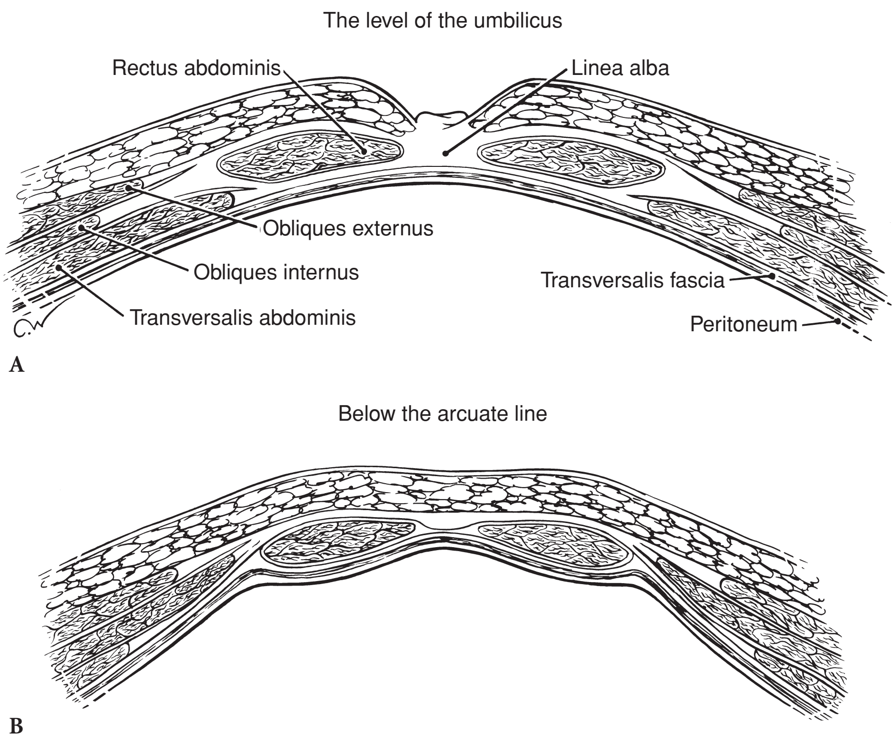


Figure 4.1.2. Transverse sections through the anterior abdominal wall. (**A**) Immediately above the umbilicus. (**B**) Below the arcuate line.

syringe partially filled with saline. Pneumoperitoneum is maintained through the Veress needle by using low-flow insufflation with CO_2 gas. The needle is placed transabdominally into the peritoneal cavity at several points surrounding the proposed trocar insertion site. Usually this is periumbilical. If the needle is placed in an area free of viscera or adhesions, bubbles of CO_2 gas should be seen rising through the fluid into the syringe. Mapping the abdomen will demonstrate the safest direction in which to place the primary trocar.

Alternative Sites for Insertion

Different sites may be used for insertion of the Veress needle (Figure 4.1.8), such as the left subcostal margin in the midclavicular line. This site is palpated and percussed to rule out splenomegaly or an insufflated stomach from a misplaced endotracheal tube. This site is useful, especially in patients who have had multiple previous laparotomies. The transvaginal approach is used through the posterior cul-de-sac as long as there is no evidence of pelvic thickening or masses in the cul-de-sac and the uterus is mobile.[7] This technique is effective in patients who have developed preperitoneal emphysema from unsuccessful attempts to insert the needle through the umbilicus or other abdominal sites.

Another technique is the transabdominal route through the uterine fundus.[8,9] The fundus is pushed up against the abdominal wall by using the uterine manipulator. A needle is passed through all layers of the abdomen and into the uterine fundus. As the uterus is pulled away from the tip of the needle, intraabdominal placement is achieved. Alternatively, the Veress needle is inserted transcervically through the fundus into the abdominal cavity. These alternative methods have uncertain margins of safety. Puncture of the uterus with this technique may result in persistent low-grade bleeding throughout the laparoscopy. Inadvertent perforation of the bladder, broad ligament perforation, and hemorrhage are possible. An intrauterine or intramyometrial position during insufflation may cause gas embolism. The technique is contraindicated if fundal adhesions are anticipated or chromopertubation is necessary.[10]

In an obese patient, proper placement of the Veress needle is difficult to achieve. If it is placed below instead of within the umbilicus at 45° to the abdominal wall, it can dissect into the preperitoneal space. It is preferable to insert the needle and trocar transumbilically and at 90°, using towel clips for traction and abdominal wall elevation (Figure 4.1.9).[11]

A survey of the existing data on the rates of failure and complications for each of the available methods of creating pneumoperitoneum showed that no technique was superior. Laparoscopists should be familiar with at least two of these techniques.[12]

PNEUMOPERITONEUM

A pneumoperitoneum is a prerequisite for laparoscopic observation and exposure to do intraperitoneal manipulations for endoscopic operations. Unless the surgeon is confident about the proper position of the Veress needle, the high flow is not used. The pressure recorded within the abdomen initially should be no greater than 9 or 10 mm Hg. If higher pressures are recorded, the needle has been placed improperly. The tip could be lodged in the omentum and can be dislodged by gently elevating and shaking the lower abdominal wall. If this maneuver fails, the needle hub is manipulated in a different direction because its distal