SHAWN TSUDA
OMAR YUSEF KUDSI
EDITORS

Robotic-Assisted Minimally Invasive Surgery

A Comprehensive Textbook

Springer

Shawn Tsuda • Omar Yusef Kudsi
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A Comprehensive Textbook

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Editors
Shawn Tsuda
School of Medicine
Department of Surgery
University of Nevada
Las Vegas, NV
USA

Omar Yusef Kudsi
Department of General Surgery
Tufts University School of Medicine
Boston, MA
USA

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Preface

Robotic-Assisted Minimally Invasive Surgery: A Comprehensive Textbook is a one-of-a-kind book which covers all fields of surgery that currently use robotic platforms to facilitate a minimally invasive approach to procedures. The advantages of robotic surgery including improvements in instrumentation, three-dimensional optics, and computer-assisted motion have jump-started the implementation of more than 4000 systems worldwide and over 7000 peer-reviewed research studies. A textbook that comprehensively covers this evolution of surgery is timely and necessary.

The target audience for this book spans a wide breadth, including surgeons using, or planning to use, robotic platforms; general, specialty, and gynecologic residents; medical students; nurses; surgical technologists; hospital administrators; and even patients seeking to understand more about their options for the robotic-assisted surgical management of disease.

Most texts on the topic of robotic surgery are limited to a specific field. *Robotic-Assisted Minimally Invasive Surgery: A Comprehensive Textbook* in addition to the background, training, and economics of robotic surgery covers procedural details of general surgery, gynecology, urology, cardiothoracic surgery, plastics, otolaryngology, military surgery, and future robotic platforms. Included are disease-specific procedures that have been described and published in the peer-reviewed medical literature. Each chapter includes a literature review, preoperative planning, setup, procedural steps, and postoperative care of each surgical disease that has been managed with robotics.

Established experts and pioneers in the area of robotic surgery authored the chapters of this book. The latest knowledge and techniques are presented in a concise manner, with figures and photos to supplement the text. For the fastest-growing method of surgery across all fields, *Robotic-Assisted Minimally Invasive Surgery: A Comprehensive Textbook* is the authoritative resource.

Las Vegas, NV, USA — Shawn Tsuda, MD, FACS
Boston, MA, USA — Omar Yusef Kudsi, MD, MBA, FACS

Contents

Contributors

Abbas E. Abbas, MD, MS, FACS Thoracic Medicine and Surgery, Temple University Hospital, Philadelphia, PA, USA

Micahel Argenziano, MD Department of Surgery, New-York Presbyterian Hospital, New York, NY, USA

Michael M. Awad, MD, PhD, FACS Department of Surgery, Section of Minimally Invasive Surgery, Barnes-Jewish Hospital, Saint Louis, MO, USA

Bilgi Baca, MD Department of General Surgery, Acibadem Mehmet Ali Aydinlar University, School of Medicine, Istanbul, Turkey

Charles T. Bakhos, MD, MS, FACS Thoracic Medicine and Surgery, Temple University Hospital, Philadelphia, PA, USA

Conrad Ballecer, MD, MS Department of Surgery, Abrazo Arrowhead Hospital, Peoria, AZ, USA

Ovunc Bardakcioglu, MD FACS FASCRS Department of Surgery, University of Nevada Las Vegas Medicine, Las Vegas, NV, USA

Richard C. Baynosa, MD, FACS Division of Plastic Surgery, Plastic Surgery Residency Program, UNLV School of Medicine, Las Vegas, NV, USA

Eren Berber, MD, FACS Department of Endocrine Surgery, Cleveland Clinic, Cleveland, OH, USA

Costas Bizekis, MD Division of Thoracic Surgery, New York University Medical Center, New York, NY, USA

Jeffrey A. Cadeddu, MD Department of Urology, University of Texas Southwestern, Dallas, TX, USA

Abdullah Erdem Canda, MD Koc University, School of Medicine, Department of Urology, Istanbul, Turkey

Robert Cerfolio, MD Department of Cardiothoracic Surgery, New York University NYU Langone Health, New York, NY, USA

Myriam Curet, MD Intuitive Surgical, Inc., Sunnyvale, CA, USA

Peter S. Dahlberg, MD, PhD Department of Surgery, Allina Health, United Hospital, St. Paul, MN, USA

Giovanni Dapri, MD, PhD, FACS Saint-Pierre University Hospital, European School of Laparoscopic Surgery, Department of Gastrointestinal Surgery, Brussels, Belgium

Scott C. DeRoo, MD Cardiothoracic Surgery, Columbia University/New-York Presbyterian Hospital, New York, NY, USA

Erica Dolph Department of Surgery, Center for Advanced Surgical Technology, University of Nebraska Medical Center, Omaha, NE, USA

Matthew Dong, MD, MPH Department of Surgery, The Mount Sinai Hospital, New York, NY, USA

Darrell Downs, BS Surgical Surgery, Florida Hospital Tampa, Tampa, FL, USA

Kemal Ener, MD Umraniye Training and Research Hospital, Department of Urology, Istanbul, Turkey

Jared Rocky Funston, MD Department of Surgery, Huntington Hospital, Pasadena, CA, USA

Antonio R. Gargiulo, MD Department of Obstetrics, Gynecology and Reproductive Biology, Harvard Medical School, Center for Infertility and Reproductive Surgery, Brigham and Women's Hospital, Boston, MA, USA

Center for Robotic Surgery, Brigham and Women's Hospital, Boston, MA, USA

William Gerull, BA Department of Surgery, Section of Minimally Invasive Surgery, Barnes-Jewish Hospital, Saint Louis, MO, USA

Fahri Gokcal, MD Department of Surgery, Good Samaritan Medical Center, Brockton, MA, USA

University of Health Sciences Istanbul Bakirkoy Dr. Sadi Konuk Training and Research Hospital Bakirkoy, Istanbul, Turkey

Daniel Groves, MD Department of Urology, Cleveland Clinic, Akron, OH, USA

Elizabeth M. Hechenbleikner, MD Department of General Surgery, Mount Sinai Hospital, New York, NY, USA

Department of General Surgery, Garlock Division of Surgery, Mount Sinai Hospital, New York, NY, USA

Daniel M. Herron, MD Department of Surgery, The Mount Sinai Hospital, New York, NY, USA

Juan José Hidalgo Diaz Department of Hand Surgery, SOS Main, CCOM, University Hospital of Strasbourg, FMTS, University of Strasbourg, Illkirch, France

Brian P. Jacob, MD Department of General Surgery, Mount Sinai Hospital, New York, NY, USA

Icahn School of Medicine at Mount Sinai, Laparoscopic Surgical Center of New York, New York, NY, USA

Brett A. Johnson, MD Department of Urology, University of Texas Southwestern, Dallas, TX, USA

Bora Kahramangil, MD Department of Endocrine Surgery, Cleveland Clinic, Cleveland, OH, USA

Daniel M. Kirgan, MD Department of Surgery, Division of Surgical Oncology, UNLV School of Medicine, Las Vegas, NV, USA

Crystal Krause, PhD Department of Surgery, Center for Advanced Surgical Technology, University of Nebraska Medical Center, Omaha, NE, USA

Jayram Krishnan, DO Department of Urology, Cleveland Clinic, Akron, OH, USA

Omar Yusef Kudsi, MD, MBA, FACS Department of Surgery, Good Samaritan Medical Center, Tufts University School of Medicine, Boston, MA, USA

Robert B. Lim, MD Uniformed Services University of the Health Sciences, Bethesda, MD, USA

Department of Surgery, Tripler Army Medical Center, Honolulu, HI, USA

Philippe Liverneaux, MD, PhD Department of Hand Surgery, SOS Main, CCOM, University Hospital of Strasbourg, FMTS, University of Strasbourg, Illkirch, France

Joshua MacDavid, MD UNLV School of Medicine, Department of Surgery, University Medical Center, Las Vegas, NV, USA

Christopher Francis McNicoll, MD, MPH, MS Department of Surgery, University of Nevada, Las Vegas School of Medicine, Las Vegas, NV, USA

Heidi J. Miller, MD, MPH Department of Surgery, University of New Mexico, Albuquerque, NM, USA

Kyle Miller, MD, MBA Intuitive Surgical, Inc., Sunnyvale, CA, USA

Brian Minh Nguyen, MD San Diego, CA, USA

Yuri W. Novitsky, MD Department of Surgery, Columbia University, New York, NY, USA

Dmitry Oleynikov, MD Department of Surgery, University of Nebraska Medical Center, Omaha, NE, USA

Department of Surgery, Center for Advanced Surgical Technology, University of Nebraska Medical Center, Omaha, NE, USA

Sean B. Orenstein, MD, FACS Oregon Health & Science University, Department of Surgery, Division of Gastrointestinal and General Surgery, Portland, OR, USA

Volkan Ozben, MD Department of General Surgery, Acibadem Mehmet Ali Aydinlar University, School of Medicine, Istanbul, Turkey

Ankit D. Patel, MD Department of General and GI Surgery, Emory University, Atlanta, GA, USA

Jasmine Pedroso, MD MPH Obstetrics and Gynecology, Mountain View Hospital, Centennial Hills Hospital, Las Vegas, NV, USA

Roman V. Petrov, MD, PhD, FACS Thoracic Medicine and Surgery, Temple University Hospital, Philadelphia, PA, USA

Alexander S. Rosemurgy, MD Department of Surgery, Florida Hospital Tampa, Tampa, FL, USA

Sharona B. Ross, MD Department of Surgery, Florida Hospital Tampa, Tampa, FL, USA

Nicola Santelmo, MD Department of Thoracic Surgery, University Hospital of Strasbourg, FMTS, Strasbourg, France

Peter Michael Santoro, MD, FACS Department of Surgery, Christiana Care Health System, Wilmington, DE, USA

Benjamin E. Schneider, MD Minimally Invasive and Bariatric Surgery, Department of Surgery, University of Texas Southwestern, Dallas, TX, USA

Keri Seymour, DO Department of Surgery, Duke University Medical Center, Durham, NC, USA

Anushi Shah, MD General Surgery, Maricopa Medical Center, Phoenix, AZ, USA

Shinil K. Shah, DO Department of Surgery, McGovern Medical School, University of Texas Health Science Center at Houston, Houston, TX, USA

Michael E. DeBakey Institute for Comparative Cardiovascular Science and Biomedical Devices, Texas A&M University, College Station, TX, USA

Beth-Ann Shanker, MD Department of Surgery, Saint Joseph's Mercy Hospital Ann Arbor, Ypsilanti, MI, USA

Mark S. Sneider, MD, FACS Department of Surgery, Allina Health, United Hospital, St. Paul, MN, USA

Mark K. Soliman, MD, FACS Colon and Rectal Surgery, Colon and Rectal Clinic of Orlando, Orlando, FL, USA

Charles R. St. Hill, MD, MSc Department of Surgery, Division of Surgical Oncology, UNLV School of Medicine, Las Vegas, NV, USA

Jamil Stetler, MD Department of General Surgery, Emory University, Atlanta, GA, USA

Erica Stockwell, DO Las Vegas Minimally Invasive Surgery, WellHealth Quality Care, a DaVita Medical Group, Las Vegas, NV, USA

Iswanto Sucandy, MD Department of Surgery, Florida Hospital Tampa, Tampa, FL, USA

Ranjan Sudan, MD Department of Surgery, Duke University Health System, Duke University Medical Center, Durham, NC, USA

Thomas Swope, MD, FACS Center for Minimally Invasive Surgery, Mercy Medical Center, Baltimore, MD, USA

Anthony R. Tascone, MD Department of Surgery, Christiana Care Health System, Wilmington, DE, USA

Sandeep S. Vijan, MBBS, FACS Sangre de Cristo Surgical Associates P.C., Parkview Medical Center, Pueblo, CO, USA

K. Warren Volker, MD, PhD Las Vegas Minimally Invasive Surgery, WellHealth Quality Care, a DaVita Medical Group, Las Vegas, NV, USA

Peter A. Walker, MD Department of Surgery, McGovern Medical School, University of Texas Health Science Center at Houston, Houston, TX, USA

Health First Medical Group, Rockledge, FL, USA

Benjamin Wei, MD Division of Thoracic Surgery, New York University Medical Center, New York, NY, USA

Erik B. Wilson, MD Department of Surgery, McGovern Medical School, University of Texas Health Science Center at Houston, Houston, TX, USA

Yanghee Woo, MD, FACS Department of Surgery, City of Hope National Medical Center, Duarte, CA, USA

Fred Xavier, MD, PhD Orthopedic Surgery, Biomedical Engineering, Cincinnati, OH, USA

Spine Surgery, Dalhousie University, Halifax, NS, Canada

Anusak Yiengpruksawan, MD, FACS, FRCST (Hon.) The Valley Minimally Invasive and Robotic Surgery Center, The Valley Hospital, Ridgewood, NJ, USA

Minimally Invasive Surgery Unit, Department of Surgery, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

Michael Zervos, MD Division of Thoracic Surgery, New York University Medical Center, New York, NY, USA

Department of Cardiothoracic Surgery, New York University NYU Langone Medical Center, New York, NY, USA

Ahmed Zihni, MD Department of Surgery, Section of Minimally Invasive Surgery, Barnes-Jewish Hospital, Saint Louis, MO, USA

Part I

Surgical Robots

Intuitive Surgical: An Overview

1

Kyle Miller and Myriam Curet

Company Background

Intuitive Surgical, Inc., with corporate headquarters in Sunnyvale, California, pioneered the rapidly expanding field of robotic-assisted minimally invasive surgery. Founded in 1995, the company initially aimed for adoption in cardiac surgery with its introduction of the *da Vinci*® Surgical System. However, as history would demonstrate, urologists were the first group to widely adopt robotic-assisted minimally invasive approaches for prostatectomies leading to a revolution in the field of surgery [1]. Intuitive Surgical now supports and serves customers throughout the USA and world, providing technology innovation in cardiac, thoracic, gynecology, colorectal, otolaryngology, urology, pediatric, and general surgery disciplines.

When Intuitive was first founded, the vision for the product revolved around four key specifications or product pillars for a surgical robotic system: (i) a reliable, fail-safe surgical device, (ii) a system providing intuitive control of the instrumentation, (iii) dexterous manipulation with six degrees of freedom, and (iv) three-dimensional stereo vision. The goal for the company with its formation was to provide surgeons with a minimally invasive approach while regaining key benefits of open surgery that were lost with the invention and adoption of laparoscopic surgery: virtual transposition of the surgeon's eyes and hands onto the surgical workspace. The *da Vinci*® System was appropriately named during the company's first month of existence for the renowned renaissance polymath, Leonardo da Vinci, given his lasting contributions in the fields of science, art, anatomy, and engineering.

The technology was initially licensed from SRI International, IBM, and MIT providing a foundation for the *da Vinci*® Surgical System. Dr. Fred Moll, Rob Younge, and John Freund co-founded Intuitive Surgical in 1995 by licensing telepresence surgery technology from SRI and began by hiring three engineers. The company developed two generations of technology prototypes (Lenny and Mona) that would be utilized in the first set of animal and human trials [2]. The Lenny prototype was completed and taken to animal trials during the summer of 1996 for a period of 6–9 months to demonstrate safety and feasibility around intuitive motion mapping and dexterity with six degrees of freedom with the wristed architecture. From this prototype, the team learned an extraordinary amount from the initial in vivo experiments. With lessons from the Lenny prototype, the Mona prototype was born with dramatic redesigns and improvement with the patient-side manipulators, interchangeable architecture, master-slave interface, and setup mechanisms [2]. The Mona prototype (Fig. 1.1), named after Leonardo's timeless masterpiece, the Mona Lisa, would be the first prototype tested in humans. These prototypes eventually led to the launch of Intuitive's flagship product, the *da Vinci*® Surgical System. The company began marketing the *da Vinci*® Surgical System initially in Europe in

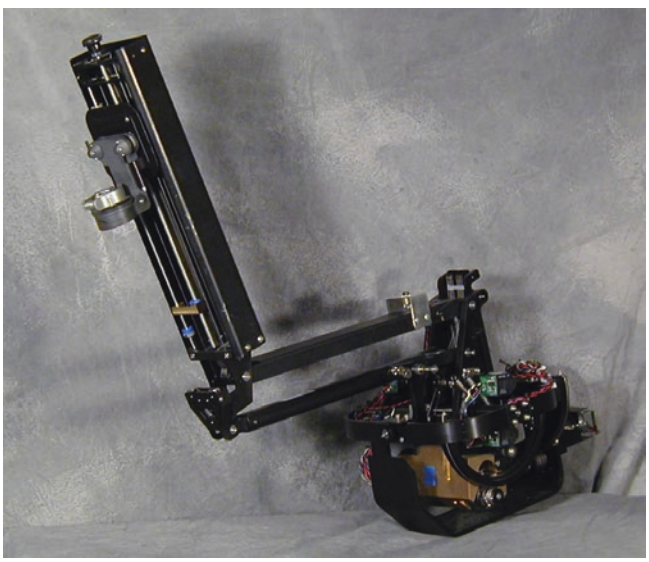

Fig. 1.1 da Vinci® Mona prototype. (With permission ©2018 Intuitive Surgical, Inc.)

K. Miller (✉) · M. Curet
Intuitive Surgical, Inc., Sunnyvale, CA, USA
e-mail: kyle.miller@intusurg.com

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Fig. 1.2 Zeus prototype. (With permission ©2018 Intuitive Surgical, Inc.)

1999. A month after the company's initial public offering in June of 2000, Intuitive received FDA clearance for applications in general surgery with clearance for thoracic and urological procedures a year later [3].

In the initial pursuit to launch a robotic-assisted surgical system, a competitor emerged with Computer Motion, makers of the Zeus Surgical System (Fig. 1.2). Launched in 1997, the Zeus system utilized a voice-controlled endoscopic manipulator aimed at providing laparoscopic surgeons with improved precision and tremor filtration. Competition between the two companies led to Zeus focusing primarily on adoption by traditional laparoscopists, and the Intuitive *da Vinci*® System marketed toward open surgeons. Various patent infringement lawsuits were filed between the two companies with a legal battle starting to impact growth for both start-up surgical robotic companies. In 2003, the two companies elected to merge. Following the merger, the *da Vinci*® System became the company's single system offering [3, 4].

In 2003, a fourth arm was added to the patient-side cart in the creation of the *da Vinci*® Standard System (Fig. 1.3) in order to provide the surgeon with more control in exposure and traction. In addition to a new arm, the instrumentation available on the system expanded from 6 to over 50 units. With continued improvements, the *da Vinci S*® product was released in 2006 (Fig. 1.4) with a focus on refining the ergonomics of the patient-side cart, which reduced the setup time by half [2]. With the *da Vinci S*® System, the side arms were lighter and smaller, improving the range of motion. Visualization improved with high-definition video, and TilePro™ was added for data interaction.

da Vinci Si® System (Fig. 1.5) was released in 2009 and focused on improvement for the surgeon console and vision cart building upon the patient cart improvements made in the *da Vinci S*® System [2]. With *da Vinci Si*® System, a higher-resolution 3D monitor was introduced along with improvements in ergonomic adjustability for the surgeon console. A wide-screen, higher-resolution touchscreen monitor was implemented into the vision cart. And finally, the *da Vinci Si*® System was developed to integrate two surgeon consoles to operate in unison with a patient-side cart. The introduction of the instrument "give-and-take" feature enabled advanced surgeon training and collaboration.

da Vinci Xi® System (Fig. 1.6) was introduced into the market in 2014 [2]. Advancements for the *da Vinci Xi*® System