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Robotic-Assisted Minimally Invasive Surgery

A Comprehensive Textbook

Robotic-Assisted Minimally Invasive Surgery

Shawn Tsuda • Omar Yusef Kudsi
Editors

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 Springer

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ISBN 978-3-319-96865-0 ISBN 978-3-319-96866-7 (eBook)

<https://doi.org/10.1007/978-3-319-96866-7>

Library of Congress Control Number: 2018958625

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The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

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.

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Part I

Surgical Robots

Intuitive Surgical: An Overview

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

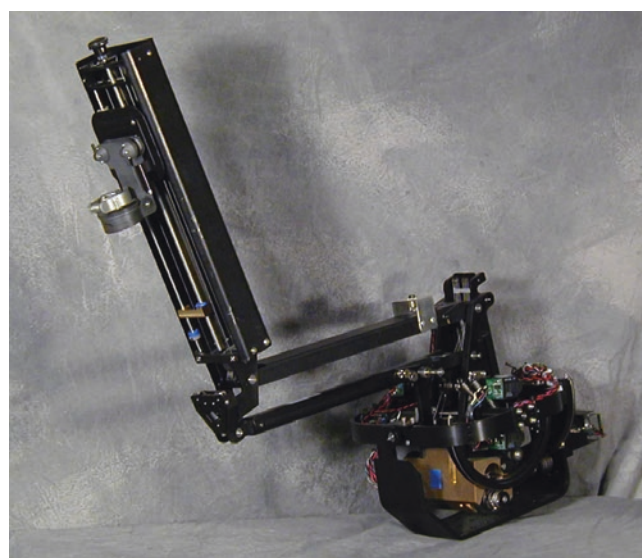


Fig. 1.1 *da Vinci*[®] Mona prototype. (With permission ©2018 Intuitive Surgical, Inc.)

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Fig. 1.2 Zeus prototype.
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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