Jun Wang
Mark K. Ferguson
Editors

Atlas of Minimally Invasive Surgery for Lung and Esophageal Cancer

Springer

Atlas of Minimally Invasive Surgery for Lung and Esophageal Cancer

Jun Wang • Mark K. Ferguson
Editors

Atlas of Minimally Invasive Surgery for Lung and Esophageal Cancer

Springer

Editors
Jun Wang
Thoracic Surgery
Peking University People's Hospital
Beijing
China

Mark K. Ferguson
Thoracic Surgery Service
University of Chicago Medicine
Chicago
Illinois
USA

Deputy Editor
Xiao Li
Thoracic Surgery
Peking University People's Hospital
Beijing
China

ISBN 978-94-024-0833-1 ISBN 978-94-024-0835-5 (eBook)
DOI 10.1007/978-94-024-0835-5

Library of Congress Control Number: 2017940641

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer Science+Business Media B.V.
The registered company address is: Van Godewijckstraat 30, 3311 GX Dordrecht, The Netherlands

Contents

Contributors

Editors

Jun Wang, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Mark K. Ferguson, MD Thoracic Surgery Service, University of Chicago Medicine, Chicago, IL, USA

Deputy Editor

Xiao Li, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Authors

Mark F. Berry, MD Department of Cardiothoracic Surgery, Falk Cardiovascular Research Center, Stanford University, Stanford, CA, USA

Shanda H. Blackmon, MD, MPH Division of General Thoracic Surgery, Department of Surgery, Mayo Clinic, Rochester, MN, USA

Robert Cerfolio, MD, MBA Division of Cardiothoracic Surgery, University of Alabama-Birmingham Medical Center, Birmingham, AL, USA

Yin-Kai Chao, MD Department of Thoracic Surgery, Chang Gung Memorial Hospital, Taoyuan, Taiwan

Chun Chen, MD Department of Thoracic Surgery, Fujian Medical University Union Hospital, Fuzhou, Fujian, China

Jin-Shing Chen, MD Department of Surgery, National Taiwan University Hospital, Taipei, Taiwan

Ke-neng Chen, MD First Department of Thoracic Surgery, Beijing Cancer Hospital, Beijing, China

Kezhong Chen, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Ying Tai Chen, MD Department of Thoracic Surgery, Beijing Aerospace General Hospital, Beijing, China

Ya-Jung Cheng, MD Department of Anesthesiology, National Taiwan University Hospital, Taipei, Taiwan

Traves Crabtree, MD Department of Surgery, Washington University in St. Louis, St. Louis, MO, China

Mark J. Crye, MD Department of Cardiothoracic Surgery, Allegheny Health Network, Pittsburgh, PA, USA

Thomas A. D'Amico, MD Section of General Thoracic Surgery, Duke University Medical Center, Durham, NC, USA

K.J. Dickinson, MBBS, BSc, MD, FRCS Division of General Thoracic Surgery, Mayo Clinic, Rochester, MN, USA

Yi Feng, MD Department of Anesthesiology, Peking University People's Hospital, Beijing, China

Hiran C. Fernando, FRCS, FACS Division of Thoracic Surgery, Boston University, School of Medicine, Boston, MA, USA

Erin A. Gillaspie, MD Division of General Thoracic Surgery, Mayo Clinic, Rochester, MN, USA

Diego Gonzalez-Rivas, MD Department of Thoracic Surgery, Coruña University Hospital and Minimally Invasive Thoracic Surgery Unit (UCTMI), Coruña, Spain

Masatsugu Hiraki, MD, PhD Department of Surgery, Faculty of Medicine, Saga University, Saga, Japan

James Huang, MD Department of Surgery, Thoracic Service, Memorial Sloan Kettering Cancer Center (MSKCC), New York, NY, USA

Yuqing Huang, MD Department of Thoracic Surgery, Beijing Haidian Hospital, Beijing, China

Ming-Hui Hung, MD Department of Anesthesiology, National Taiwan University Hospital, Taipei, Taiwan

Gening Jiang, MD Department of Thoracic Surgery, Shanghai Pulmonary Hospital, Tongji University School of Medicine, Shanghai, China

Guanchao Jiang, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Sabita Jiwnani, MD Department of Thoracic Surgery, Tata Memorial Centre, Parel, Mumbai, India

Erkan Kaba, MD Department of Thoracic Surgery, Istanbul Bilim University, Istanbul, Turkey

Xiaozheng Kang, MD First Department of Thoracic Surgery, Beijing Cancer Hospital, Beijing, China

George Karimundackal, MD Department of Thoracic Surgery, Tata Memorial Centre, Parel, Mumbai, China

Michael S. Kent, MD Department of Thoracic Surgery, Beth Israel Deaconess Medical Center, Boston, MA, USA

Kemp H. Kernstine, Sr. MD, PhD Division of Thoracic Surgery, University of Texas Southwestern Medical Center, Dallas, TX, USA

Rodney J. Landreneau, MD General Thoracic Surgery, Allegheny Health Network, Pittsburgh, PA, USA

Fengwei Li, MD Department of Thoracic Surgery, Beijing Aerospace General Hospital, Beijing, China

Hui Li, MD General Thoracic Surgery, Beijing Chaoyang Hospital, Beijing, China

Jianfeng Li, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Xiao Li, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Yun Li, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Xu Li, MD Department of Thoracic Surgery, Jiangsu Cancer Hospital, Nanjing, China

John C. Lipham, MD, FACS Department of Surgery, Keck School of Medicine, University of Southern California, Los Angeles, CA, USA

Michael J. Liptay, MD Department of Cardiovascular and Thoracic Surgery, Rush University Medical Center, Chicago, IL, USA

Hui-Ping Liu, MD, PhD Department of Thoracic Surgery, Chang Gung Memorial Hospital, Taiwan

Jun Liu, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Yanguo Liu, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Brian E. Louie, MD Division of Thoracic Surgery, Swedish Medical Center and Cancer Institute, Seattle, WA, USA

James D. Luketich, MD Department of Cardiothoracic Surgery, University of Pittsburgh, Pittsburgh, PA, USA

Robert J. McKenna Jr., MD Department of Thoracic Surgery, Providence St Johns Health Center, Santa Monica, CA, USA

Xianjun Min, MD Department of Thoracic Surgery, Beijing Haidian Hospital, Beijing, China

Teng Mu, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Juan A. Munoz, MD Division of Thoracic Surgery, Boston University School of Medicine, Boston, MA, USA

Hirokazu Noshiro, MD, PhD, FACS Department of Surgery, Faculty of Medicine, Saga University, Saga, Japan

Mark Onaitis, MD Department of Thoracic Surgery, Duke University Medical Center, Durham, NC, USA

Bernard J. Park, MD, FACS Memorial Sloan Kettering Cancer Center, New York, NY, USA

Diego Avella Patino, MD Department of Surgery, The University of Chicago, Chicago, IL, USA

D. Ian Paul, PhD, FRCS Department of Surgery, Thoracic Service, Memorial Sloan Kettering Cancer Center, New York, NY, USA

Vivek Prachand, MD Department of Surgery, The University of Chicago Medical Center, Chicago, IL, USA

C.S. Pramesh, MD Division of Thoracic Surgery, Department of Surgical Oncology, Tata Memorial Centre, Parel, Mumbai, India

Nabil P. Rizk, MD Department of Surgery, Hackensack University Medical Center, Hackensack, NJ, USA

Pamela Samson, MD Department of Surgery, Washington University in St Louis, St. Louis, MO, USA

Inderpal S. Sarkaria, MD Department of Cardiothoracic Surgery, University of Pittsburgh, Pittsburgh, PA, USA

Christopher Scott, MD Department of Thoracic Surgery, Duke University Medical Center, Durham, NC, USA

Christopher W. Seder, MD Department of Cardiovascular and Thoracic Surgery, Rush University Medical Center, Chicago, IL, USA

K. Robert Shen, MD Division of General Thoracic Surgery, Department of Surgery, Mayo Clinic, Rochester, MN, USA

Xizhao Sui, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Lijie Tan, MD Department of Thoracic Surgery, Zhongshan Hospital, Fudan University, Shanghai, China

Alper Toker, MD Department of Thoracic Surgery, Istanbul Bilim University Ozel Sisli Florence Nightingale Hospital, Sisli, Istanbul, Turkey

Simon R. Turner, MD Division of Thoracic Surgery, University of British Columbia, Vancouver, BC, Canada

Jun Wang, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Qun Wang, MD Department of Thoracic Surgery, Fudan University Zhongshan Hospital, Shanghai, China

Xun Wang, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

John K. Waters, MD Division of Thoracic Surgery, University of Texas Southwestern Medical Center, Dallas, Texas, USA

Benjamin Wei, MD Division of Cardiothoracic Surgery, University of Alabama-Birmingham Medical Center, Birmingham, AL, USA

Sean C. Wightman, MD Department of Surgery, The University of Chicago, Chicago, IL, USA

Jennifer L. Wilson, MD Department of Thoracic Surgery, Beth Israel Deaconess Medical Center, Boston, MA, USA

Fan Yang, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Yang Yang, MD Department of Thoracic Surgery, Shanghai Pulmonary Hospital, Tongji University School of Medicine, Shanghai, China

Joerg Zehetner, MD, FACS, MMM Department of Surgery, Keck School of Medicine, University of Southern California, Los Angeles, CA, USA

Hui Zhao, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Tiejun Zhao, MD Department of Thoracic Surgery, Changhai Hospital Shanghai (CHHS), Shanghai, China

Bin Zheng, MD Department of Thoracic Surgery, Fujian Medical University Union Hospital, Fuzhou, Fujian, China

Jian Zhou, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Lixin Zhou, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Zuli Zhou, MD Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China

Juan Zhu, MD Department of Anesthesiology, Peking University People's Hospital, Beijing, China

Introduction

1

Mark K. Ferguson

Contents

1.1 Background

Minimally invasive surgery (MIS) of the thorax was introduced about 100 years before the publication of this atlas. It began primarily as a diagnostic modality, and was taught to me during my training in the late 1970s. The applications of thoracoscopy 40 years ago were limited to pleura biopsies and drainage of pleural effusions. There were no dedicated instruments other than a suction cannula and biopsy forceps, and viewing was limited to the operator looking directly through a small diameter low resolution telescope. Thus the technique was not used commonly. Technological advances in the late 1980s and beyond offered improved telescope optics, compact high resolution video cameras, and instrumentation including tissue and vascular staplers. These advances permitted performance of complex procedures such as lobectomy, esophagectomy, and mediastinal operations. A small number of adventurous surgeons were pioneers in establishing the safety and utility of these operations, from which many other surgeons and their patients have benefitted.

M.K. Ferguson, MD
Thoracic Surgery Service, University of Chicago Medicine,
5841 S. Maryland Avenue, MC 5040, Chicago, IL 60637, USA
e-mail: mferguso@surgery.bsd.uchicago.edu

The first MIS operations included lung biopsy and pleural procedures for pneumothorax and empyema. In the early 1990s the first major lung resections were reported, which initially in many centers were non-anatomic resections—SIS lobectomy, or stapled in-situ lobectomy—in which most hilar structures associated with a lobe were stapled collectively. Anatomic resections as they are now performed followed quickly, however, and reports from single institutions of large experiences with outstanding results were first published in 2006 [1]. Esophagectomies performed with hybrid procedures or exclusive minimally invasive approaches were first reported in the early 1990s, with the first large series of successful cases published in 2003 [2].

Despite these advances, general adoption of minimally invasive thoracic surgery was slow. The majority of surgeons in the West who had routine access to minimally invasive resources had not been trained to do MIS surgery and were reluctant to take time from their busy practices to develop MIS skills. Training in MIS general surgery was in its infancy, and the variety of procedures thought to be appropriate for MIS techniques was limited to cholecystectomy in carefully selected patients and biopsies. Thus, even younger thoracic surgeons didn't have a very extensive background in MIS resulting from their general surgery training. No certified training courses existed early on, and surgeons interested in learning the techniques had to search out an

J. Wang, M.K. Ferguson (eds.), *Atlas of Minimally Invasive Surgery for Lung and Esophageal Cancer*,
DOI 10.1007/978-94-024-0835-5_1

experienced mentor and arrange to spend the necessary time observing; such mentors were soon overwhelmed with requests by potential observers and found it difficult to meet the demand. A system of sponsored training courses for thoracic surgeons in practice wasn't introduced until 1992, when the Society of Thoracic Surgeons created an infrastructure and curriculum for MIS training in thoracic surgery that served the needs of the physicians until training during fellowship became routinely available.

Training in MIS thoracic surgery remains less regulated than training in MIS general surgery. The latter effort includes a skills course (Fundamentals of Laparoscopic Surgery), the successful completion of which is required prior to graduation from residency and obtaining board certification in the United States [3]. No such curriculum for MIS thoracic surgery has been developed in the US. Efforts in other regions of the world are similarly underdeveloped. Skills needed for MIS thoracic surgery are demonstrably different than those learned during abdominal surgical training. However, we expect our graduating thoracic trainees to be skilled in MIS techniques without having developed skills definitions, the infrastructure for simulation training, or methods of determining competency. Clearly there is considerable room for improvement in how we train and certify young thoracic surgeons in MIS abilities.

1.2 Frequency of MIS Thoracic Surgery in Developed Countries

It is difficult to determine exactly how many lung and esophageal resections are performed annually using minimally invasive techniques. Outside of the United States there are no large databases that mandate recording of such practices. Even within the US the collection of such data are often inaccurate and analyses of such data can be misleading. A few resources in the US that help provide some insights include the Nationwide Inpatient Sample (NIS), the SEER (the Surveillance, Epidemiology, and End Results) Program, NSQIP (the National Surgical Quality Improvement Program of the American College of Surgeons), the State Inpatient Database (SID) and the Society of Thoracic Surgeons (STS). These data sets are not available for direct inspection, and so we must assess outcomes from reports published in scientific journals.

1.3 Video Assisted Thoracic Surgery (VATS) Lobectomy

The incidence of VATS is related in part to the percentage of patients with early stage lung cancer and reflects to some extent the expertise of the contributing surgeons, which is greater in the STS, NSQIP and SID datasets (Table 1.1) [4–9]. The NIS demonstrated an increase in VATS usage from 26 % early in the study to 39 % in the final year of the study [8]. Overall, the percentage of major lung resections performed by VATS in the US is moderate, is increasing over time, and likely will have exceeded 50 % at the time of this publication.

Assessment of the frequency of MIS resections performed in Europe is a little more difficult because of the fragmented nature of the data. A review of published results demonstrates surprising differences among countries in the use of VATS for lobectomy. The EPITHOR project in France demonstrated a fourfold increase in the use of VATS for lobectomy from 2005 to 2012, culminating in an incidence of nearly 11 % [10]. In Denmark from 2007 to 2011, clinical stage I lung cancer was treated by VATS lobectomy in 47 % of patients [11]. The European Society of Thoracic Surgeons (ESTS) Database, a large voluntary effort including nearly all European countries, demonstrates a very variable penetration of VATS techniques at present, with Denmark having the highest percentage and many countries lacking centers of excellence [12]. The overall rate is between 10 % and 15 % (Table 1.2) [10–14].

The rates of VATS use for lobectomy in other developed countries are difficult to determine. From an analysis of the literature, no nationwide databases reporting such results were available from Japan, Taiwan, South Korea, or Australia.

Table 1.1 Frequency of use of VATS for lung resection among large US databases

Author	Database	Time period	Total patients	VATS patients
Paul [4]	STS	2002–2007	6,323	20 %
Paul [5]	SEER	2007–2009	6,008	22 %
Farivar [6]	STS	2010–2011	10,525	44 %
Mungo [7]	NSQIP	2005–2012	6,567	37 %
Harrison [8]	NIS	2008–2011	19,353	32 %
Kent [9]	SID	2008–2010	33,095	38 %

STS Society of Thoracic Surgeons, *SEER* Surveillance Epidemiology and End Results Program, *NSQIP* National Surgical Quality Improvement Program, *NIS* Nationwide Inpatient Sample, *SID* State Inpatient Database

Table 1.2 Frequency of use of VATS for lobectomy in European databases

Author	Database	Time period	Total patients	VATS patients
Thorsteinsson [13]	Iceland	1994–2008	404	0 %
Licht [11]	DLCR	2007–2011	2,230	47 %
Morgant [10]	Epithor	2005–2012	34,006	3.2 %
Begum [12]	ESTS	2010–2012	Not stated	11.3 %
Falcoz [14]	ESTS	2007–2013	28,771	9.5 %

DLCR Danish Lung Cancer Registry, *ESTS* European Society of Thoracic Surgeons

1.4 Minimally Invasive Esophagectomy (MIE)

The very low relative frequency of esophageal cancer compared to lung cancer, especially in Western countries, makes identification of rates of MIE quite difficult. In a survey of esophageal surgeons reported in 2010, the frequency of minimally invasive approaches worldwide was about 30 %. This figure varied considerably according to surgeon specialty, being highest for general surgeons (57 %) and lowest for surgical oncologists and cardiothoracic surgeons (20 %) [15]. Data from the STS Database for 2001–2011 indicate that 14 % of patients underwent MIE [16]. In Japan in 2011, the frequency of hybrid or totally minimally invasive esophagectomy was 33 % [17]. From these limited data it appears that the acceptance of minimally invasive approaches in developed countries remains limited.

1.5 Growth of MIS Thoracic Surgery in Developing Countries

Penetration of minimally invasive techniques into developing countries is very uneven. Obstacles to growth include lack of resources (equipment for thoracoscopy or laparoscopy; trained support staff; non-specialist anesthesiologists) and lack of training for surgeons. Whereas in most developed countries trainee instruction in thoracic MIS is routine and usually required, such is not the case in many developing countries. In centers of excellence that have high volumes of practice, particularly in India and China, VATS lobectomy and MIE are routine. In such centers more than 80 % of lobectomies are performed using VATS, and more than 90 % of esophagectomies are done via MIE.

1.6 Status of MIS Thoracic Surgery

There can be little doubt that VATS lobectomy and MIE are accepted as standard approaches to surgery for lung and esophageal cancer. The chapters in this atlas clearly identify outcomes after MIS and demonstrate numerous advantages over open surgery. Short-term benefits have been conclusively demonstrated, oncologic equivalence in terms of nodal harvest is similar to open operations, and oncologic equivalence in terms of long-term survival is apparent. What remains to be fully elucidated is relative costs, or cost-effectiveness, particularly for robotic thoracic MIS.

1.7 Future Areas of Study

Complex minimally invasive thoracic surgery was introduced in the early 1990s, less than 25 years before the publication of this atlas. In that short span of time its growth and acceptance have been remarkable. We can anticipate continued growth of this application in the developing world, and will also see rapid advancement in a variety of elements of MIS, including education, technology, and outcomes (Table 1.3).

Table 1.3 Target areas for future study of thoracic minimally invasive surgery

Education and training
Learning curves for competency and proficiency
With mentoring
Without mentoring
Current approaches to education
Training program
Centers of excellence
Specialized fellowships
Simulation training
How much can this shorten the learning curve?
Models
Animal models
Tissue models (perfused, unperfused)
3-D printed models, other artificial materials
Virtual models
Improved performance
Ergonomics
Double or single port techniques
More advanced complex operations including double sleeve resections
Advanced technology
Powered staplers
Tissue site marking
Measurement of perfusion for tumor, lymph node, or vessel identification
Ultrasound applications
Hybrid procedures
Robotics
Standard resections
Advanced resections
Single port or hybrid approaches
Technological enhancements (tissue perfusion, ultrasound, automated processes)
Improved clinical care
Fast tracking to discharge
Cost-effectiveness