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全国高等学校教材

供临床医学专业及来华留学生 (MBBS) 双语教学用

# Medical Imaging

## 医学影像学

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Fred A. Mettler

改编教学版  
Annotated Edition

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Fred A. Mettler

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1995年,我国首次招收全英文授课医学留学生,到2015年,接收临床医学专业 MBBS (Bachelor of Medicine & Bachelor of Surgery)留学生的院校达到了40余家,MBBS院校数量、规模不断扩张;同时,医学院校在临床医学专业五年制、长学制教学中陆续开展不同规模和范围的双语或全英文授课,使得对一套符合我国教学实际、成体系、高质量英文教材的需求日益增长。

为了满足教学需求,进一步落实教育部《关于加强高等学校本科教学工作提高教学质量的若干意见(教高[2001]4号)》和《来华留学生医学本科教育(英文授课)质量控制标准暂行规定(教外来[2007]39号)》等相关文件的要求,规范和提高我国高等医学院校临床医学专业五年制、长学制和来华留学生(MBBS)双语教学及全英文教学的质量,推进医学双语教学和留学生教育的健康有序发展,完善和规范临床医学专业英文版教材的体系,人民卫生出版社在充分调研的基础上,于2015年召开了全国高等学校临床医学专业英文版规划教材的编写论证会,经过会上及会后的反复论证,最终确定组织编写一套全国规划的、适合我国高等医学院校教学实际的临床医学专业英文版教材,并计划作为2017年春季和秋季教材在全国出版发行。

本套英文版教材的编写结合国家卫生和计划生育委员会、教育部的总体要求,坚持“三基、五性、三特定”的原则,组织全国各大医学院校、教学医院的专家编写,主要特点如下:

1. 教材编写应教学之需启动,在全国范围进行了广泛、深入调研和论证,借鉴国内外医学人才培养模式和教材建设经验,对主要读者对象、编写模式、编写科目、编者遴选条件等进行了科学设计。

2. 坚持“三基、五性、三特定”和“多级论证”的教材编写原则,组织全国各大医学院校及教学医院有丰富英语教学经验的专家一起编写,以保证高质量出版。

3. 为保证英语表达的准确性和规范性,大部分教材以国外英文原版教科书为蓝本,根据我国教学大纲和人民卫生出版社临床医学专业第八轮规划教材主要内容进行改编,充分体现科学性、权威性、适用性和实用性。

4. 教材内部各环节合理设置,根据读者对象的特点,在英文原版教材的基础上结合需要,增加本章小结、关键术语(英中对照)、思考题、推荐阅读等模块,促进学生自主学习。

本套临床医学专业英文版规划教材共38种,均为国家卫生和计划生育委员会“十三五”规划教材,计划于2017年全部出版发行。

In 1995, China recruited overseas medical students of full English teaching for the first time. Up to 2015, more than 40 institutions enrolled overseas MBBS (Bachelor of Medicine & Bachelor of Surgery) students. The number of MBBS institutions and overseas students are continuously increasing. At the meantime, medical colleges' application for bilingual or full English teaching in different size and range in five-year and long-term professional clinical medicine teaching results to increasingly demand for a set of practical, systematic and high-qualified English teaching material.

In order to meet the teaching needs and to implement the regulations of relevant documents issued by Ministry of Education including "Some Suggestions to Strengthen the Undergraduate Teaching and to Improve the Teaching Quality" and "Interim Provisions on Quality Control Standards of International Medical Undergraduate Education (English teaching)", as well as to standardize and improve the quality of the bilingual teaching and English teaching of the five-year, long-term and international students (MBBS) of clinical medicine in China's higher medical colleges so as to promote the healthy and orderly development of medical bilingual teaching and international students education and to improve and standardize the system of English clinical medicine textbooks, after full investigation, People's Medical Publishing House (PMPH) held the writing discussion meeting of English textbook for clinical medicine department of national colleges and universities in 2015. After the repeated demonstration in and after the meeting, PMPH ultimately determined to organize the compilation of a set of national planning English textbooks which are suitable for China's actual clinical medicine teaching of medical colleges and universities. This set will be published as spring and autumn textbooks of 2017.

This set of English textbooks meets the overall requirements of the Ministry of Education and National Health and Family Planning Commission, the editorial committee includes the experts from major medical colleges and universities as well as teaching hospitals, the main features are as follows:

1. Textbooks compilation is started to meet the teaching needs, extensive and deep research and demonstration are conducted across the country, the main target readers, the model and subject of compilation and selection conditions of authors are scientifically designed in accordance with the reference of domestic and foreign medical personnel training model and experience in teaching materials.

2. Adhere to the teaching materials compiling principles of "three foundations, five characteristics, and three specialties" and "multi-level demonstration", the organization of English teaching experts with rich experience from major medical schools and teaching hospitals ensures the high quality of publication.

3. In order to ensure the accuracy and standardization of English expression, most of the textbooks are modeled on original English textbooks, and adapted based on national syllabus and main content of the eighth round of clinical medicine textbooks which were published by PMPH, fully reflecting the scientificity, authority, applicability and practicality.

4. All aspects of teaching materials are arranged reasonably, based on original textbooks, the chapter summary, key terms (English and Chinese), review questions, and recommended readings are added to promote students' independent learning in accordance with teaching needs and the characteristics of the target readers.

This set of English textbooks for clinical medicine includes 38 species which are among "13th Five-Year" planning textbooks of National Health and Family Planning Commission, and will be all published in 2017.

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# PREFACE

*Medical Imaging* is a specialty that uses medical imaging techniques to diagnose diseases seen within the body. This textbook discusses a variety of imaging techniques such as X-ray radiography, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, and nuclear medicine including positron emission tomography (PET), which are used for diseases diagnosis. *Medical Imaging* also includes aspects of treatment procedures using the guidance of imaging technologies, namely, interventional radiology.

*Medical Imaging* evolved as a basic textbook that residents and students of *medical imaging* students would first turn to for an introduction to our fascinating and expanding specialty. This is a truly outstanding book with information and images are of the highest quality.

This textbook is mostly oriented more toward students, foreign medical students studying in China, interns, residents, and other health care professional. I hope that this book will maintain its role as the leading general textbook for those pursuing radiological training in China and the rest of Asia, and

that it will become a valuable resource for *medical imaging* residents at any level. Students who used our text as we conceived it have motivated us to produce the best updated edition that we can offer.

Now in the third edition of the textbook, I have invited radiologists who have highly successful careers in China to contribute for the evolution and updating of many chapters. We tried our best to match the excellent work of our contributors with updates of the fundamentals of digital imaging, molecular imaging, nuclear medicine and interventional radiology. You won't be a radiologist after you have read this book, but you should be able to recognize abnormalities and interpret images better, and you will assist in the care of patients with more assurance and confidence.

We thank all our authors for their dedication to teaching and their superb contributions to our text. Their thoughtful suggestions and support have greatly improved the quality of this edition.

**Baozhong Shen Qiyong Gong**

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# Introduction

## HISTORY AND DEVELOPMENT OF MEDICAL IMAGING

Medical imaging is an application in clinical medicine comprising several minimally invasive techniques for visualizing internal organs and tissues in order to diagnose and treat medical conditions. Medical imaging includes Diagnostic imaging and Interventional radiology, and the latter can be divided into Interventional diagnosis and Interventional therapy. These techniques give important insights into normal internal anatomy and physiology, which can be used to identify abnormalities as well as to diagnose and treat disease.

In 1895, German physics professor Wilhem Roentgen discovered the X-rays, an achievement that earned him the first Nobel Prize in physics in 1901. Shortly after this discovery X-rays began being used for diagnosis of human disease, thus building the foundations of a new Medical Imaging field.

Ultrasonography (US) is a technology that has been applied in Medical Imaging since 1940 and which uses high frequency sound waves reflected by tissues into varying degrees to produce images. Several other imaging technologies were developed in the 20th century, including: X-ray Computed Tomography (X-ray CT) and Magnetic Resonance Imaging (MRI). Conventional X-ray imaging has also been adopted for X-ray Computed Radiography (CR), Digital Radiography (DR) and Digital Subtraction Angiography (DSA). The development of these new imaging technologies greatly broadened the

original diagnostic radiology field.

Although these various imaging systems differ in the imaging principle, method of examination, diagnostic value and limitations, they are all used to reveal morphological, physiological and pathological changes in the human internal organs, with the aim of providing an accurate and minimally invasive diagnosis. Thus, medical imaging is an important and unique diagnostic technology with marked differences from traditional diagnostic methods such as clinical physical exams and laboratory analyses. Moreover, while traditional diagnostic approaches rely on morphological changes, medical imaging technology can provide a more detailed diagnosis based on morphology function and metabolic changes of integrated systems.

Over the past 30 years, there has been a rapid development in diagnostic imaging technology. More advanced imaging equipment has been put into clinical application, such as multi-detector row CT (MDCT), high field MR machines, Color Doppler ultrasonic diagnostic apparatus, digital gastrointestinal machine, digital mammography, and hybrid operating room. Inspection technology is also constantly innovative, with recent examples including imaging with energy spectrum CT, weighted magnetic susceptibility and ultrasound. Finally, new image post-processing software have been introduced, as well as a variety of contrast agents such as cell- and protein-specific contrast agents for MRI image post-processing. The development of these new imaging equipments and technologies has significantly contributed

for the improvement of imaging performance and quality. Indeed, while detecting the original organ morphology and structural organization remains challenging, it is now possible to clearly assess the function and metabolism of internal anomalies. CR, DR, DSA, CT, MRI and US are all digital imaging technologies. Digital imaging has transformed the way in which traditional X-ray imaging is utilized and also how the data is handled. Notably, the application of digital information to picture archiving and communication systems vastly facilitated image data storage, retrieval and transmission, thereby promoting the development of real-time remote consultation via teleradiology. Moreover, digital imaging introduced computer-assisted detection and diagnosis, thus improving efficacy, consistency and accuracy in clinical diagnosis.

### Applications of medical imaging

Medical imaging is sometimes referred to as diagnostic imaging because it is often used to assist doctors in diagnosis. Although there are a large number of different types of technologies used in medical imaging, they all aim at providing an internal picture of the body in a way that is as non-invasive as possible. Imaging technology can be used to identify a variety of anomalies including broken bones, tumors and leaking blood vessels. This clinical imaging data is utilized for diagnosis, monitoring and treatment of human disease, but also as teaching tools.

### Learning and applying diagnostic imaging

The training of physicians for diagnostic imaging is inherently different from the clinician culture. During this learning process the physician should: (i) Become familiar with the basic principles of various imaging techniques and inspection methods, including identifying their strengths and weaknesses, to be capable of making correct choices in their clinical work; (ii) Grasp the image features of various imaging techniques and inspection methods, and identify from which technology an image is derived; (iii) Become aware of normal and abnormal performance of imaging technology and inspection meth-

ods, as well as of the resulting acquired images, as this the main basis for imaging diagnosis; key reports should therefore be compared; (iv) Master the multiple imaging diagnosis of some common diseases and pathogenesis, and the execution of diagnostic imaging reports on the performance assessment of disease severity and prognosis.

Imaging technology and inspection methods are the clinician's primary link to diagnosis, and they effectively are the best economic versus diagnostic efficacy choice for providing important diagnostic information. It is therefore essential to fully grasp the scope and limits of these technologies when dealing with imaging diagnostic reports. Moreover, another relevant aspect of reporting diagnostic imaging data is to consider the diagnostic clinical reports. The clinicians should combine the specific circumstances of the patient and if necessary communicate with the Diagnostic Imaging physician, in order to maximize the benefits of diagnostic imaging and optimize the follow-up treatment.

### Learning and applying interventional radiology

For the clinician, intervention radiology learning should mainly focus on its basic concepts. Interventional radiology contains a variety of treatment technologies and basic principles including adaptations, contraindications, complications, and clinical efficacy, which are comparable to the advantages and characteristics of traditional clinical treatment methods. Interventional radiology diagnosis and treatment methods can achieve the best treatment effectiveness depending on the disease or phase of disease progression.

### X-ray

Regular X-rays (plain X-rays, also called *radiographs*) account for about 75% of imaging examinations and consist of X-rays beams that pass through the patient. A portion of the X-rays are absorbed or scattered by the patient's internal structures, and the remaining X-ray pattern is transmitted to a detector that records an image. Although the absorption and scattering of X-rays causes the deposition of energy