Reform in teaching preclinical pathophysiology

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During medical education, pathophysiology is the scientific discipline that studies the onset and progression of pathological conditions and diseases, and pathophysiology is one of the core courses in most preclinical medical curricula. In China, most medical schools house a Department of Pathophysiology, in contrast to medical schools in many developed countries. The staff in Chinese Departments of Pathophysiology generally consists of full-time instructors or lecturers who teach medical students. These lecturers are sometimes lacking in clinic knowledge and experiences. To overcome this, in recent years, we have been trying to bring new trends in teaching pathophysiology into our curriculum. Our purpose in writing this article was to share our experiences with our colleagues and peers worldwide in the hope that the insights we have gained in pathophysiology teaching will be of some value to educators who advocate teaching reform in medical schools.

**History of Medical Education in China**

Medical education in China has experienced several distinctive periods of development (Table 1). Before 1949, Western-style medical education was introduced into China by Western or Western country-educated Chinese doctors. For instance, in the Shanghai area, Fudan University Shanghai Medical College was established in 1927 by a group of doctors, headed by Dr. Yan Fu-Qing, who received their medical education in the United States, and Tongji University School of Medicine was inaugurated by a group of German doctors in 1907.

After 1949, China’s medical education was greatly impacted by the former Union of Soviet Socialist Republics (USSR), with the curricula, staffing, departmental organization, and teaching methods following USSR’s model to a certain extent. Pathophysiology as an independent discipline and independent departments of teaching and research sections first appeared in Kazan University in Russia in 1879. In 1954, a group of Soviet pathology experts offered training courses of pathophysiology in Beijing, as a governmental aid program, to medical lecturers of Chinese medical schools, and they introduced a Russian pathophysiology textbook translated into Chinese. By 1956, Departments of Pathophysiology had begun to be established in Chinese medical schools. In the 1960s, textbooks of pathophysiology in Chinese languages became available. The content included basic pathological processes of disease and organ system pathogenesis, with instruction hours ranging from 32 to 78 h depending on the school and teaching program.

Since 1979, reform and an open-door policy have prevailed in China, and there is now a common understanding that the traditional medical education approach in China needs modernization to face ever-growing international challenges. Many Chinese medical educators are trying their best to bring new trends of reform to their respective fields to help students to develop skills for lifelong learning, critical thinking, and innovation (5, 12). In 2009, the Ministry of Education issued a set of general guidelines for reform of medical education. These Ministry guidelines mandate principal elements of medical education as well as guidelines for reform. Schools have discretions in aspects such as selecting instructors, when, how, and what to reform, choosing the best teaching modes, optimizing teaching contents, and eliminating the repetitive and overlapping contents.

The reform pace and content in different medical schools have varied tremendously, from minimal to substantial. There are >600 medical-pharmaceutical schools and universities in China (9), and it is difficult to list how every medical school performs its own reform since these schools belong to different systems. Despite the fact that everyone recognizes the importance and urgency of the reform of medical education, there is

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**DURING MEDICAL EDUCATION, pathophysiology is the scientific discipline that studies the onset, progression, and underlying mechanisms of clinical pathological processes and diseases, emphasizing theoretical concepts: etiology, pathogenesis, outcome, and the pathophysiological basis of prevention and treatment (7). All medical educators around the world recognize the necessity and importance of understanding the etiology and pathogenesis of diseases for medical practice. At Harvard University Medical School in the United States, for instance, the pathophysiology course is up to 200 teaching hours for medical students, whereas in Humboldt University Medical School in Germany, pathophysiology classes are given in the third and fourth semesters (6). These courses are offered by clinical professors who use a case-based approach through which the etiology, pathogenesis, and prevention of diseases are explained in a lively and vivid manner.

In China, pathophysiology has also been a core course in medical curricula in most medical schools and universities. In contrast to other parts of the world, most medical schools in China house a full Department of Pathophysiology. This department, like Departments of Anatomy, Physiology, Biochemistry, etc. is under the general administration of the medical school or institute of basic medicine. Departments of Pathophysiology are staffed by full-time instructors or lecturers who are strong in the theoretical basis of medicine but who sometimes lack clinic knowledge and experiences. In addition, a major difference of pathology teaching in China is that the course is divided into two subcourses: pathoanatomy and pathophysiology, each with its own department. To understand this model of pathophysiology teaching developed, it is helpful...**
The Current Status of Pathophysiology Teaching

In most medical schools of China, there is a Department of Pathological Anatomy and a Department of Pathophysiology that are responsible for teaching two separate courses, the backbone of preclinical medicine. These two courses share the same study object: individuals in pathological states. Pathological anatomy mainly focuses on bodily anatomic and structural changes, and pathophysiology focuses on functional and metabolic alterations (2, 7). The two divisions usually work independently, resulting in a disconnected knowledge system and unnecessary repetition of content and taking more teaching hours than necessary.

The Curriculum

Depending on the individual schools, different programs may be offered to medical students: a 5-yr program (for a Bachelor degree), a 7-yr program (for a Master’s degree), and an 8-yr program (for a Doctoral degree). The requirements for credits and theses are different in these programs, so this article will focus on teaching in the 5-yr program.

Table 2 shows the basic science courses for the medical students in the 5-yr program at Tongji University School of Medicine. The first study year (semesters 1–2) also includes common basic courses, such as Medical Chemistry, Medical Physics, Medical Mathematics, Multimedia Technology and Applications, and College English, except for the professional basic science courses shown in Table 2. The second and third study years (semesters 3–6) focus on professional basic science courses and preclinical courses. Clinical courses and practice are arranged in the fourth and fifth study years (semesters 7–10).

“Experiment of Pathophysiology” is an important component in the study of pathophysiology (1). Animal experiments in this laboratory course are in agreement with international guidelines for the care and use of laboratory animals and are approved by the Animal Ethics Committee of Tongji University (Shanghai, China). In laboratory experiments, students learn how to duplicate certain animal models of human diseases and pathological processes, such as hypoxia in mice, hyperkalemia in rabbits, hemorrhagic shock in rabbits, and acute hepatic dysfunction in rabbits. Through the usage of multidisciplinary methods and skills, students learn to observe and detect metabolic changes in the animal models, deliberate on and analyze the experimental results, and write experiment reports. This study helps students build the ability to link knowledge with practice and fosters precise working style and strict scientific thinking.

Curricular Reform

Pathophysiology serves as a bridge across the basic science/clinical chasm in medicine by linking knowledge from different medical disciplines. This means that students need to acquire a huge amount of knowledge in pathophysiology courses. Due to the breadth, depth, difficulty level, and scope of the discipline, students frequently feel intimidated and discouraged (8).

The primary teaching method for pathophysiology has been oral classroom teaching by instructors based on the State Ministry of Education-endorsed textbook. The typical curricular structure of most medical education programs in Chinese medical schools is predesigned and discipline centered (12). The didactic lecture is the most dominant teaching method of preclinical courses, accounting for three-quarters of the entire course hours. Lecturing from the textbook left students bored, and it is hard to relate classroom learning to clinical practice. For years, discontent with this classroom teaching method had surfaced, and the voices demanding medical education reform grew louder and louder among both students and instructors.

In the last 10 yr, along with the growth of demanding medical education reform in most Chinese schools, consensus
has developed around the best ways for promoting students’ learning and for cultivating their inquiry skills and clinical thinking. Meaningful teaching and learning of medicine and successful approaches for preparing qualified medical professionals with the ability to face international competition have shaped the thinking and topics of discussion among Chinese medical educators (11). At Tongji University in the last several years, we have switched from textbook-based, didactic lecturing to collaborative teaching with clinical instructors, and we have adopted methods of modular teaching and problem-based learning (PBL) and case-based learning (CBL) in pathophysiological study. Our purpose in writing this article was to share and discuss our experience with our colleagues and peers worldwide, and we hope that the insights we gained during these years in pathophysiology teaching will be of some value to other medical educators who engage in medical curricular reform.

Reforming Pathophysiology Teaching at Tongji University

In an effort to reduce students’ burden and to promote their willingness and initiative to learn through curiosity and problem solving, we have worked out and implemented rational reforms to make teaching and learning more efficient and fruitful. Our reform has been in three areas: course content and curricular integration, teaching approaches, and assessment.

Course content and curricular integration. To meet societal and student expectations, curricular design needs to be modernized. In our university, we have merged the separate courses in pathology and pathophysiology into one preclinical course named Basic Pathology and Pathophysiology (please see Table 2 postreform). The classes are given in semesters 4–5 for medical students. The teaching content included chapters on fundamental pathological processes in various diseases, such as inflammation, tumor, water and electrolyte imbalance, acid-base imbalances, hypoxia, fever, stress, shock, disseminated intravascular coagulation, ischemia-reperfusion injury, organ insufficiency, etc. Using typical clinical cases, the new lectures help medical students understand complete pathological processes and master the relevant knowledge of etiology, pathogenesis, and functional, morphological, and structural changes in disease or injury. Moreover, this integration directly guides students along the path of evidence-based medicine; they can acquire systematic and comprehensive knowledge, enhancing their ability to analyze and unravel applied clinical problems.

In addition, we have chosen to use modular teaching, with information from multiple organ systems integrated around a single pathological event. Several modules of organ insufficiency are now used in our course, and each one contains interrelated pathological information and integrated key points of professional knowledge (Table 3). Our module on organ insufficiency and failure, for example, contains information on pulmonary insufficiency, cardiac insufficiency, renal insufficiency, and so on. These topics are traditionally dispersed among several different textbooks of pathophysiology, internal medicine, and surgery and lectured by the relative different departments. However, these topics share similarity in pathogenic mechanisms and pathological changes, repetition and overlapping in lecturing contents occurred.

To develop these modules, instructors from different departments came together to discuss the lectures. We have learned that the critical point in modular teaching is to develop logical, independent, and self-contained modules that embrace systematically organized teaching content with defined objectives. Medical students are mature, disciplined, and conscientious, so modular teaching works surprisingly well for them. They learn more in less time, harvesting real rewards in their study. It is true that adoption of an integrative approach to thinking and acquiring knowledge makes it possible to synthesize coherent structures from heterogeneous data (9). Hence, modular teaching plays a positive role in cultivating innovative, outstanding future medical professionals with international competitiveness, as well as actively contributing to improving the overall teaching quality of the faculty members in this school.

Reform in teaching and learning approaches. LINKING THE TEACHING OF BASIC MEDICINE CLOSELY TO CLINICAL MEDICINE. The status quo in Chinese medical schools is that instructors in the Department of Pathophysiology, despite the majority having a Medical Doctor degree, teach and do basic science research full time. As a result, they have little recent clinical practice experience and therefore lack up-to-date clinical experiences (10). To overcome the lack of clinical practice in our staff, we have recruited experienced clinicians to assist in curricular development and teaching. For key chapters in textbooks, such as chapters on shock and disseminated intravascular coagulation, we provide students with real clinical cases and invite experienced clinicians to lecture together with our instructors on the same podium and at the same time. While pathophysiology instructors focus the lecture on the etiology, pathogenesis, and pathophysiological changes of disorders, the clinical doctor highlights the manifestations during the pathological processes as well as prevention and therapy based on pathophysiological principles (3). During the classes, students are encouraged to ask questions, thus promoting teacher-student interactions and heuristic teaching.

This approach of closely cooperating with clinicians directly benefits students with denser and more meaningful knowledge. Focusing on real-life clinical cases purportedly helps students build their awareness of clinically relevant knowledge and accelerates their clinical way of thinking. The feedback from

Table 3. Modular teaching

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<tr>
<th>Module of the cardiac system</th>
<th>Teaching Content</th>
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<tr>
<td>Cardiac physiology</td>
<td>Cardiac physiology (focuses on the pathogenic mechanisms of cardiac insufficiency and failure)</td>
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<td>Renal physiology</td>
<td>Common diseases of cardiac system</td>
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<tr>
<td>Respiratory physiology</td>
<td>Respiratory pathophysiology (focuses on the pathogenic mechanisms of respiratory insufficiency and failure)</td>
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<td>Common diseases of respiratory system</td>
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<td>Physiology of digestive system</td>
<td>Pathophysiology of digestive system (focuses on the pathogenic mechanisms of hepatic insufficiency and failure)</td>
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<tbody>
<tr>
<td>Renal physiology</td>
<td>Renal pathophysiology (focuses on the pathogenic mechanisms of renal insufficiency and failure)</td>
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<td>Common diseases of renal system</td>
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students indicates that this new practice provokes independent thinking and demands more practical abilities, laying down a solid foundation and better preparing them for entering the clinical phase of study.

ADOPTING CBL AND PBL METHODS. In the later stage of pathophysiology teaching, classes change from traditional textbook-based didactic lecturing to student-centered, instructor-guided discussions, using modified CBL or PBL with comprehensive clinical cases. In our modified CBL classes, students meet in a large group (50–70 students). The instructor introduced a real-life case that involves multiple complex pathological phenomena. Students then have to reason and ponder about the cases, robustly voice their opinions, argue for or against different assertions, and enthusiastically apply their pathophysiological knowledge to analyze and discuss the case.

For example, a crush syndrome patient is shown as a real-life case who suffered multiple pathological processes, such as hyperkalemia, shock, acid-base imbalance, acute renal failure, and acute respiratory distress syndrome. These conditions impacted each other during the development of the syndrome, and some of them formed vicious cycles, threatening the patient’s life. By means of sufficient discussion, our students correlate their knowledge learned from class and textbook and come to understand that these multiple pathological processes can often happen in one case simultaneously or sequentially at different stages in disease or injury. The case presentation is integrated, in contrast to the way the content is described in different chapters in their textbook. More importantly, students come to understand that pathological processes correlate, exacerbate, and/or reinforce each other; and they have learned that blocking these transformations, i.e., vicious cycles, is the key to the therapy of disease or injury. By the analysis and discussion of typical cases, students recognize the complexity of diseases and injuries and further understand and grasp the key points of knowledge in the lectures and textbook, enhancing their interest in the medical profession and clinical study during the next phase.

For PBL classes, students are divided into small groups with one tutor for every seven or eight students. They usually meet twice, for 2 h each time. By the end of the first meeting, the students should have determined those terms, tests, procedures, symptoms, etc. that are relevant for the assigned case. In the second meeting, students share or exchange their opinions, thoughts, and data, trying to reach a conclusion on the diagnosis and a virtual treatment plan. Once in a while, a third meeting is required to uncover and discuss new information.

Reform of the system for assessing students’ learning. In the past, students usually attended classes and took notes for home study and then participated in graded examinations, generally at the end of each semester. The same pattern repeated year after year in this school. Students rushed day and night to memorize the textbook materials before the examination, but this type of “knowledge” was disconnected from clinical reality and faded away quickly after the examination.

We have now adopted a new assessment system for grading, which consists of four quizzes, four experiment evaluations during the course, and one term-end exam, accounting for 20%, 20%, and 60%, respectively, of the final grade. The content of quizzes includes multiple-choice questions, glossary/term explanations, true-or-false choices, and fill-in-the-blank questions. The experiment evaluation is based on the success of students in the animal experiments, including the duplication of disease models, data recording and analyzing, and report writing. The final term-end exam includes multiple-choice questions, short-answer questions, and a case analysis, all from a test database we have established in recent years. Compared with the previous assessment system, the new system mirrors student learning attitudes and learning efficiency and, hence, is more objective and impartial.

The Process of Reform

We realize that a reliable, responsive, and responsible teaching faculty is the key to successful curricular integration, an opinion expressed by other experts (4). In regular monthly seminars, we have full discussions, with different opinions expressed, about reform in teaching content, methods, and examination as well as choosing the cases to be presented in the course. After reaching consensus, our faculty members engage in long-term collaboration, helping and supporting each other, not only in teaching but also in research. We expend much effort for this integration and solve the problems effectively and in a timely manner and strive cooperatively for success.

Using typical clinical cases, the new lectures help medical students understand complete pathological processes and master the relevant knowledge of etiology, pathogenesis, and functional, morphological, and structural changes in disease or injury. Moreover, this integration directly guides students along the path of evidence-based medicine; they can acquire systematic and comprehensive knowledge, enhancing their ability to analyze and unravel applied clinical problems. The students’ interest in pathophysiology study has increased significantly since the inception of teaching reforms. As reported by a large number of students, knowledge and understanding of real-life cases and problems acquired through the student-centered cases intensely strengthen and improve their abilities for clinical thinking, comprehensive analysis, and problem-solving skills. Students now take the initiative to learn actively and seriously.

Our view of the success of the reform is supported by student evaluations. According to Tongji University’s website for teaching evaluation (an online anonymous reviewing and scoring system), both students and peer groups repeatedly awarded the highest score of “excellent” to the effectiveness of the teaching of pathophysiology, fully recognizing the staff’s efforts in educational reform (data not shown). In addition, graduates from this university have consistently achieved a high passing rate at the National Medical Qualification Examination (equivalent to the United States Medical Licensing Examination) in recent years, providing evidence of the teaching achievements in our medical school (personal communication of confidential statistics gathered by Tongji University School of Medicine).

Conclusions

Before the reform, textbook-based didactic classroom lecturing was the prevalent form of pathophysiological teaching, and students acquired knowledge passively. As reform progresses, teaching methods have gradually diversified, and use of multimedia, modules, and modified CBL/PBL have become common entities in our classrooms. Moreover, clinical and
basic medicine instructors have begun to teach on the same podium. The course content has been reorganized to form logical modules, which significantly improves the teaching efficiency and students’ understanding and retaining of information. Teaching pathophysiology by full-time instructors ensures knowledge integrity of the subject, especially the systematic and clinical characteristics of the common fundamental pathological processes, and guarantees the advance and completion of teaching/learning activities of the course. Through these reforms, we can continue to mobilize students’ interest in active learning and early clinical thinking and cultivate their ability of identifying, analyzing, and solving problems.

Since most of Chinese medical education reform policies have been issued only after 2009, the campaign of improving medical education in China can be described as being in its early infancy (12). Despite some achievements that have already been accomplished in our education reform, there is an even longer way ahead. We shall continue to consolidate our efforts, adhere to the concepts of teaching reform, and bring our success to a new height for the general objective of raising and developing a new generation of better-qualified medical professionals.

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