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Journal of NeuroImmune Pharmacology
Sulie Chang, Ph.D.
Guest Editor for the issue related to
NeuroImmune Pharmacology Education

Dear Prof. Sulie Chang:

It is really my greatest honor and also my pleasure to submit the manuscript entitled "Inclusion of neuroimmune pharmacology as a component of pharmacology curriculum for the medical school students" as a response to the invitation to write a manuscript related to neuroimmune pharmacology education.

I would like to express my appreciation to the Journal of Neuroimmune Pharmacology on the opportunity to submit a manuscript on the topic of neuroimmune pharmacology in medical student education. This work that is presented is original and is not under consideration to submit elsewhere.

Best Regards,

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Abstract

This article introduces the inclusion of neuroimmune pharmacology as a component of pharmacology curriculum for medical school students. Pharmacology is part of the scientific foundations of medicine curriculum. The foundation curriculum to basic medicine would followed by an organ system-base module. The introductory lectures of neuroimmune pharmacology would be focused in the immunity and nervous system diseases including (1) the neuroimmune system in psychiatric disorders, molecular pathogenesis for schizophrenia and major depression, and the uses of antipsychotic and antidepressant agents, (2) neurodegenerative disorders such as parkinsonism, and the treatment, and (3) drugs of abuse and the immune system. With particular emphasis on the competency of critical thinking, problem solving ability and enhance the learning interest and effectiveness of medical students, problem based learning and case study discussions would be applied to the neuroimmune pharmacology curriculum.

Keywords: neuroimmune pharmacology; pharmacology curriculum; medical school students

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Running Title: Neuroimmune pharmacology for medical students

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Abstract

This article introduces the inclusion of neuroimmune pharmacology as a component of pharmacology curriculum for medical school students. Pharmacology is part of the scientific foundations of medicine curriculum. The foundation curriculum to basic medicine would followed by an organ system-base module. The introductory lectures of neuroimmune pharmacology would be focused in the immunity and nervous system diseases including (1) the neuroimmune system in psychiatric disorders, molecular pathogenesis for schizophrenia and major depression, and the uses of antipsychotic and antidepressant agents, (2) neurodegenerative disorders such as parkinsonism, and the treatment, and (3) drugs of abuse and the immune system. With particular emphasis on the competency of critical thinking, problem solving ability and enhance the learning interest and effectiveness of medical students, problem based learning and case study discussions would be applied to the neuroimmune pharmacology curriculum.

Keywords: neuroimmune pharmacology; pharmacology curriculum; medical school students

Introduction

Neuroscience, immunology, and pharmacology are broad disciplines and foundation to basic medicine curriculum for medical school students to enter the medical field. Foundation curriculum first guides students to know the structure, development and functions of normal human organs (curriculum integrates anatomy, histology, embryology and physiology) therefore medical students are familiar with the human body in health condition. Then, human diseases caused by a variety of biological pathogens, transmission routes (combined microbiology, virology and parasitology), and the body's immune system to produce defense against external pathogens (immunology) would be introduced to students. Following is the pathology caused by pathogens and pathogenic mechanism (pathology) and how the basic concepts of drug therapy (pharmacology), and so on. Hence, enable students to understand health and pathological comparison of the circumstances with their professional knowledge and abilities of clinical manifestations of these diseases together to apply to the future diagnosis, treatment and prevention of diseases. In addition to traditional lecturing methods, clinical case study and problem-based learning would be included in the curriculum in order to accelerate students' acquire their ability of active learning and competencies of professional knowledge. These foundations are required for the medical students to deep understand

the molecular and cellular biology of basic medicine. Take for example, neuroscience introduces neurobiology, neurophysiology, neurogenesis, neuropathology, neurodevelopment, and neuroimaging, which is a foundation discipline to medical students regarding to the nervous system. Immunology mainly introduces the immunity and the self-defense system, such as innate immunity, adaptive immunity, humoral immunity, immunodeficiency, autoimmune disease, allergy, immunomodulation, oncology, rheumatology, and HIV/AIDS etc. This discipline is an essential foundation for immunopharmacology. Pharmacology mainly introduces the pharmacodynamic and pharmacokinetics of clinical used agents, regarding to their action mechanism and untoward effects. All these three disciplines must first be understood as a single entity, when they converged and integrated together formed the multidiscipline of neuroimmune pharmacology. It is required another level of insight and seeking to better define the epidermiology, prevention, and treatment of immune disorders of the nervous systems (Ikezu and Gendelman, 2008).

Typically, foundations to basic medicine curriculum of medical school students takes place during the second year of medical school in Taiwan, and would occur over a period of 8 months (Table 1). The foundation curriculum to basic medicine would followed by an organ system-based module curriculum that would last at least for 8 months of study (Table 2). The organ system-based module is setting to a given organ system while

concurrently studying core subjects such as, anatomy, embryology, histology, physiology, pharmacology, pathology, clinical medicine and medical imaging. Clinical case studies and problem-based learning would be integrated into both the foundation curriculum to basic medicine and organ system-based curriculum, including the neuroimmune pharmacology sub-module. In this instructional model, both teaching faculties of basic medicine and clinical medicine would interface with each other to present the appropriate topical module materials in order to accomplish unit horizontal integration and to provide students the learning effectiveness.

The pharmacology course of medical students during the foundation to basic medicine curriculum would be divided into two parts (Table 3). In the first part, the fundamental concepts of pharmacodynamics, pharmacokinetics, and agents that act to affect autonomic and central nervous systems would be discussed. In the second part, agents act to circulatory system, endocrine system and chemotherapeutic agents would be addressed. Subsequent lectures would address immunopharmacology which is focused on immuno-suppressive and immuno-regulatory agents. The foundation of these lectures is based on the concepts from the immune system. These conceptual lectures in immunopharmacology would serve as a foundation for neuroimmune pharmacology sub-module to be presented.

Description of the inclusion of neuroimmune pharmacology in the pharmacology course

In order to introduce the field of neuroimmune pharmacology to medical students, a course sub-module formulated in a lecture format is designed to provide medical students with a basic knowledge of neuroimmune pharmacology as a sub-discipline of pharmacology course. Base on the concepts introduced in the immune system and immunopharmacology, this sub-discipline would be focused in the immunity and nervous system diseases. The contents would include (1) the neuroimmune system in psychiatric disorders, molecular pathogenesis for schizophrenia and major depression, and the uses of antipsychotic and antidepressant agents, (2) neurodegenerative disorders such as parkinsonism, and the treatment, (3) Drugs of abuses. With particular emphasis on the competency to use critical thinking, problem solving ability and enhance the learning interest and effectiveness of medical students, PBL and case study discussions would be applied to this module.

Teaching, learning objectives and goals for the neuroimmune pharmacology included in the pharmacology course

Upon completion of the pharmacology course sub-module, the medical students would be able to (1) describe the immune system in the central nervous system and neuro-immune interaction, (2) apply the knowledge of pathologic process, pharmacokinetics, and pharmacodynamics to guide safe and effective treatments in psychiatric disorders, neurodegenerative disorders and abuse of drugs, (3) develop competency to apply basic principles to clinical care and lifelong learning in medical practice.

Principles of the course performance assessment

The course performance assessment is described in Table 4. It summarizes the outcome and performance assigned to instructional course of neuroimmune pharmacology:

1. Instructional methods

   Classroom lectures supplemented with multimedia such as animations, and molecular models. Teaching materials would be on the web a week ahead of each lecture.

2. Lecture would be presented as a sub-module of the pharmacology course during the organ system-based curriculum.

3. Clinical case study and problem-based learning would be focused on the clinical correlation with immunity and nervous system diseases.

Recommended textbook

1. Ikezu T ,Gendelamn HE: Neuroimmune Pharmacology, Springer Science + Business Media, LLC, 2008.

2. Katzung BG, Masters SB, Trevor AJ: Basic and Clinical Pharmacology, McGraw Hill Lange, 2009

Lecture syllabus for neuroimmune pharmacology included in the pharmacology curriculum (Ikezu T ,Gendelamn HE; 2008)

Lecture 32 – The neuroimmune system in psychiatric disorders, molecular pathogenesis for schizophrenia and major depression, and the uses of antipsychotic and antidepressant agents

Introduce the students how the hypothalamic-pituitary-adrenal axis, the CNS and the immune system are integrated and regulated each other's activity. There are many neurotransmitters and nureohormones that act through the CNS on the immune system to regulate the immune response. Give a brief overview of how the neuroimmune system plays a role in psychotic illnesses such as depression and schizophrenia and the action mechanisms of antipsychotic agents, antidepressants would be introduced in this lecture.

Lecture 33 – Neurodegenerative disorders such as parkinsonism, and the treatment

Parkinson's disease is the second most frequent neurodegenerative disorder of the aging brain. Most ascending dopaminergic pathways are affected as revealed from autopsy investigation. Studies performed in autopsy tissues from patients afflicted with parkinsonism have led to the conclusion that inflammation is a generic phenomenon that arises from neuronal death. In this lecture, the role of inflammation in parkinsonism, and agents used in Parkinson disease would be discussed

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Lecture 34 – Drugs of abuse and the immune system

There is indisputable evidence of natural physiological connections between the neural and immune systems. Many evidences supporting the link of opioids and cannabinoids and their effects on immune responses. In this lecture, effects of drugs of abuse on the production of cytokines and chemokines and effects of drugs of abuse on infection would be addressed.

References

Ikezu T, Gendelman HE: (2008) Neuroimmune Pharmacology. Springer Science + Business Media, LLC., New York

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Lowery RC (2005) Teaching and learning with interactive student response systems: c comparison of commercial products in the higher-education market. The annual meeting of the Southwestern Social Science Association and its affiliates, March 23 - 26, 2005 at New Orleans, LA.

Slain D, Abate M, Hodges BM, Stamatakis MK, Wolak S (2004) An interactive response system to promote active learning in the doctor of pharmacy curriculum. Am J Pharm Educ 68(5):117.

Table

Table 1 Foundation to basic medicine curriculum of medical school*

Module	Topical areas
1	Introduction to biochemistry, amino acids, structure of proteins and carbohydrate, metabolism of carbohydrate, lipids, DNA, RNA, gene expression, signal transduction and second messenger pathways
2	Introduction to embryology, gametogenesis, embryonic development, introduction to histology, epithelium tissue, connective tissue
3	Introduction to physiology, homeostasis and transmembrane transport, excitable tissues and membrane potential
4	Introduction to immunology, innate immunity, adaptive immune responses, immune system in health and disease
5	Basic concepts of bacteriology, basic concepts of virology
6	Introduction to parasitology, the amoeba protozoa, lumen protozoa, the blood and tissue protozoa, trematodes, cestodes, nematodes, arthropods
7	Introduction to pharmacology, pharmacodynamics, pharmacokinetics, drug receptors, pharmacogenetics
8	Introduction to pathology
9	Introduction to clinical medicine and medical imaging

* Foundation curriculum includes anatomy, embryology, histology, physiology, microbiology, parasitology, pharmacology, pathology, clinical medicine and medical imaging.

Table 2 Organ system-based curriculum of medical students

Module	Organ system	Topics[#]
1	Musculoskeletal system	Anatomy and Embryology, Histology, Physiology, Pharmacology, Pathology, Clinical medicine, Medical Imaging
2	Circulatory system	Anatomy and Embryology, Histology, Physiology, Pharmacology, Pathology, Clinical medicine
3	Lung respiratory	Anatomy and Embryology, Histology, Physiology, Pharmacology, Pathology, Clinical medicine, Medical Imaging
4	Nervous system	Anatomy and Embryology, Neuroanatomy, Histology, Physiology, Pharmacology, Pathology, Clinical medicine, Medical Imaging
5	Digestion and Nutrition System	Anatomy and Embryology, Histology, Physiology, Pharmacology, Pathology, Clinical medicine
6	Renal urinary system	Anatomy and Embryology, Histology, Physiology, Pharmacology, Pathology, Clinical medicine
7	Growth and development and male and female reproductive systems	Anatomy and Embryology, Neuroanatomy, Histology, Physiology, Pharmacology, Pathology, Medical Imaging, Clinical medicine
8	Endocrinology and Metabolism System	Histology, Physiology, Pharmacology, Pathology, Clinical medicine
9	Blood oncology system	Pharmacology, Pathology, Clinical medicine
10	Gross Anatomy Lab	Anatomy and Embryology, Neuroanatomy

suggested order of topic discussion

Table 3 Pharmacology course lecture schedule

Part I	Part II
Lecture 1 — Introduction to pharmacology	Lecture 17— Regulation of blood pressure by the autonomic nervous system
Lecture 2 — Drug Receptors & pharmacodynamics	Lecture 18 — Antihypertensive drugs
Lecture 3 — Pharmacokinetics: rational dosing & the time course of drug action	Lecture 19 — Diuretics: Drugs that increase the excretion of water and electrolytes
Lecture 4 — Drug biotransformation	Lecture 20 — Antiarrhythmic drugs
Lecture 5 — Development and regulation of drugs	Lecture 21 — Drugs to treat heart failure
Lecture 6 — Introduction to autonomic pharmacology	Lecture 22 — Vasodilators and nitric oxide synthase
Lecture 7 — Drugs affecting the parasympathetic nervous system and autonomic ganglia	Lecture 23 — Lipid-lowering drugs and atherosclerosis, drugs to treat blood disorders
Lecture 8 — Drugs affecting the sympathetic nervous system	Lecture 24 — Mechanisms of action of antineoplastic drugs, clinical effects of antineoplastic drugs
Lecture 9 — Introduction to the pharmacology of drugs that act on the central nervous system	Lecture 25~27 — Drugs that kill invading organisms
Lecture 10 — Sedative-Hypnotic drugs, The alcohols	Lecture 28~29 — Drugs affecting endocrine systems
Lecture 11 — General anesthetics, Local anesthetics	Lecture 30 — Gene therapy and emerging molecular therapies
Lecture 12 — Skeletal muscle relaxants	Lecture 31 — Immunopharmacology
Lecture 13 — Treatment of seizure disorders	Lecture 32~34 — NeuroImmune Pharmacology Sub-Module
Lecture 14 — Opioid analgesics & antagonists	Review II
Lecture 15 — Nonsteroidal anti-inflammatory drugs	
Lecture 16 — Disease-modifying antirheumatic drugs, Drugs used in gout	
Review I	

Table 4 Principles of the module performance assessment

Evaluation description	Evaluation type
Lecture topics	Written examination
Interactive Response System (IRS)	ISR systems appear to provide several benefits that can facilitate active learning in the classroom setting, such as improve student learning, improve teaching effectiveness and reduce the paperwork and faculty labor. All students have the capability of answering every question anonymously. In addition, instructors can immediately assess student comprehension of concepts and address any misconceptions or areas of confusion. (Slain et al. 2004; R. Lowery 2005)
Problem-based learning/ small group discussion	Evaluated by group peers based one individual's performance of problem-discussion and presentation
Case study	Oral presentation
Laboratory	Experimental competency skills and written examination