Touro College and University System
Touro Scholar

College of Osteopathic Medicine (TUN)
Publications and Research

College of Osteopathic Medicine

2014

Teaching Critical Thinking to First-Year Medical Students through Concept Mapping

Amina Sadik
Touro University Nevada, amina.sadik@touro.edu

Follow this and additional works at: https://touroscholar.touro.edu/tuncom_pubs

 Part of the Curriculum and Instruction Commons, and the Medical Education Commons

Recommended Citation

Sadik, A. (2014). Teaching critical thinking to first-year medical students using concept mapping. In L. J. Shedletsky & J. S. Beaudry (Eds.), Cases on teaching critical thinking using visual representation strategies (pp. 197-222). Hershey, PA: IGI Global.

This Book Chapter is brought to you for free and open access by the College of Osteopathic Medicine at Touro Scholar. It has been accepted for inclusion in College of Osteopathic Medicine (TUN) Publications and Research by an authorized administrator of Touro Scholar. For more information, please contact carrie.levinson2@touro.edu.

Cases on Teaching Critical Thinking through Visual Representation Strategies

Leonard J. Shedletsky
University of Southern Maine, USA

Jeffrey S. Beaudry
University of Southern Maine, USA

A volume in the Advances
in Educational Technologies
and Instructional Design
(AETID) Book Series

Information Science
REFERENCE
An Imprint of IGI Global

Managing Director: Lindsay Johnston
Production Editor: Jennifer Yoder
Development Editor: Allison McGinniss
Acquisitions Editor: Kayla Wolfe
Typesetter: Christina Henning
Cover Design: Jason Mull

Published in the United States of America by
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com

Copyright © 2014 by IGI Global. All rights reserved. No part of this publication may be reproduced, stored or distributed in any form or by any means, electronic or mechanical, including photocopying, without written permission from the publisher.
Product or company names used in this set are for identification purposes only. Inclusion of the names of the products or companies does not indicate a claim of ownership by IGI Global of the trademark or registered trademark.

Library of Congress Cataloging-in-Publication Data

Cases on teaching critical thinking through visual representation strategies / Leonard J. Shedletsky and Jeffrey S. Beaudry, editors.
pages cm
Includes bibliographical references and index.
ISBN 978-1-4666-5816-5 (hardcover) -- ISBN 978-1-4666-5817-2 (ebook) -- ISBN 978-1-4666-5819-6 (print & perpetual access) 1. Critical thinking--Study and teaching. 2. Visual aids. I. Shedletsky, Leonard, 1944-, editor of compilation.
LB1590.3.C374 2014
370.15'2--dc23

2014005464

This book is published in the IGI Global book series Advances in Educational Technologies and Instructional Design (AETID) (ISSN: 2326-8905; eISSN: 2326-8913)

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

All work contributed to this book is new, previously-unpublished material. The views expressed in this book are those of the authors, but not necessarily of the publisher.

Chapter 9
Teaching Critical Thinking to First-Year Medical Students through Concept Mapping

Amina Sadik
Touro University Nevada, USA

EXECUTIVE SUMMARY

Helping students learn the basic sciences and demonstrating their importance in the practice of medicine presents a challenge for the majority of medical science educators. A curriculum change of medical biochemistry was implemented to include concept mapping as a visual strategy to enhance the analytical and critical thinking skills during clinical case-based workshops. A rubric was used to give detailed feedback and provide guidance to students. A number of clinical cases were judiciously selected to illustrate specific topics. Students meet with a faculty member to discuss the concept map prior to the workshop. During such meetings, all members are asked to participate in explaining their reasoning and decision-making and to thereby justify the flow of the concept map. This activity gives students the opportunity to demonstrate their capacity to visualize their knowledge using the concept map construction.

DOI: 10.4018/978-1-4666-5816-5.ch009

Copyright ©2014, IGI Global. Copying or distributing in print or electronic forms without written permission of IGI Global is prohibited.

INTRODUCTION

Teaching basic sciences in medical school can be challenging because some concepts are not easily connected to the practice of medicine and because formative assessments are not made central to learning. One of the major difficulties for a basic science educator is to make the connection between the sciences taught and their relevance to the functioning of the human body in health and disease. Students frequently perceive basic science as useful only for passing exams and allowing them to move into their clinical years. A recent study by the National Board of Medical Examiners demonstrated that by the STEP 2 clinical exam, students shed a significant portion of their basic science knowledge, including medical biochemistry (Haist, Swanson, Holtzman, & Grande, 2010). This trend is alarming, especially because basic sciences provide the foundation for one of the core competencies of a physician: practicing evidence-based medicine (Bierer, Dannefer, Taylor, Hall, & Hull, 2008). Research in cognitive psychology has shown that retention of basic science knowledge is dramatically improved when the connections between biomedical science and its clinical relevance are made (Woods, 2007; Woods, Brooks, & Norman, 2007a, 2007b). Consequently, it is the medical educator's responsibility to make these connections for learners early on in order to engage them in doing more than just memorizing and practicing pattern recognition.

The formative and summative evaluations of our students over the first five years have left us with a sense of urgency for changing our existing teaching methods. A needs assessment was conducted to discover the students' perception of the current learning environment. It assisted us in shaping the new curriculum by engaging students who otherwise would not have expressed their needs, either because (a) they lacked motivation to learn, (b) they might not have wanted to be identified as lacking knowledge, or (c) they were simply not given the opportunity to express their needs in the past.

This chapter describes the steps that have been taken to shift from an exclusively lecture-based biochemistry curriculum to a more scenario-based curriculum that incorporates team-based workshops of clinical cases where concept mapping was used as a means to visualize knowledge and make logical connections between biochemical concepts and the expression of a disease.

CONCEPT MAPPING A POWERFUL TOOL FOR TEACHING CRITICAL THINKING

The goal of using concept mapping as a teaching tool is to demonstrate to students that there is a way to visualize knowledge and to think critically through a medical

problem using principles acquired in the classroom. It trains students from the start to be responsible for their learning and enables them to become self-motivated, good team players and lifelong learners as medical knowledge and practice continue to evolve.

We chose concept mapping as a method to teach critical thinking in biochemistry because we believe in learning by doing. Concept maps foster understanding of the biochemical background of disease because their construction requires logical reasoning and critical thinking. In clinical case-based workshops, students are expected to construct a logical map, with "linking words" between concepts and "notes" that explain how altered biochemical pathways were responsible for a patient's physical symptoms and abnormal lab results. Building a successful concept map requires (a) knowledge of the relevant biochemical concepts and (b) identification of correct hierarchical relationships among these concepts as well as between the concepts and the pathophysiological changes of the patient. Now that one of the core competencies in medicine education is reinforcing the teaching of evidence-based medicine, this concept mapping exercise introduces students to the physician thought process early in the curriculum.

Before the implementation of the change in the curriculum that included concept mapping as one of its major components, the instruction of basic sciences curriculum (including the medical biochemistry course) was primarily based on Microsoft PowerPoint lectures. This approach tended to lead to a dry delivery of the material without soliciting the participation of students, due to the fact that there is an enormous wealth of material to be covered in a short time. The problem with this "exhaustive" lecturing is further compounded by the fact that there were no workshops or small group activities that would assist students to clearly understand and master the concepts through a clinical scenario. In this transmission type curriculum, students tend to memorize pages of pathways and disease names without trying to understand the mechanism by which the dysfunction of one organ or another occurs as a result of a specific metabolic disorder. When faced with a vignette type question on a summative assessment such as a board exam, the majority of students confessed to not being able to solve a medical problem. Therefore, it became evident that there was a need to implement changes in the medical biochemistry curriculum and to expose our students to the clinical relevance of basic science concepts early in the curriculum. Studies have previously shown that early exposure to any clinical teaching reaps positive results and is beneficial in the long run (Bowen, 2006).

According to Novak and Caňas (2006), concept maps represent knowledge geographically by enclosing important concepts in shapes and connecting them to show relationships and the logical flow of a given process. Ambrose et al. (2010) cite concept mapping as one strategy to reveal and enhance knowledge organiza-

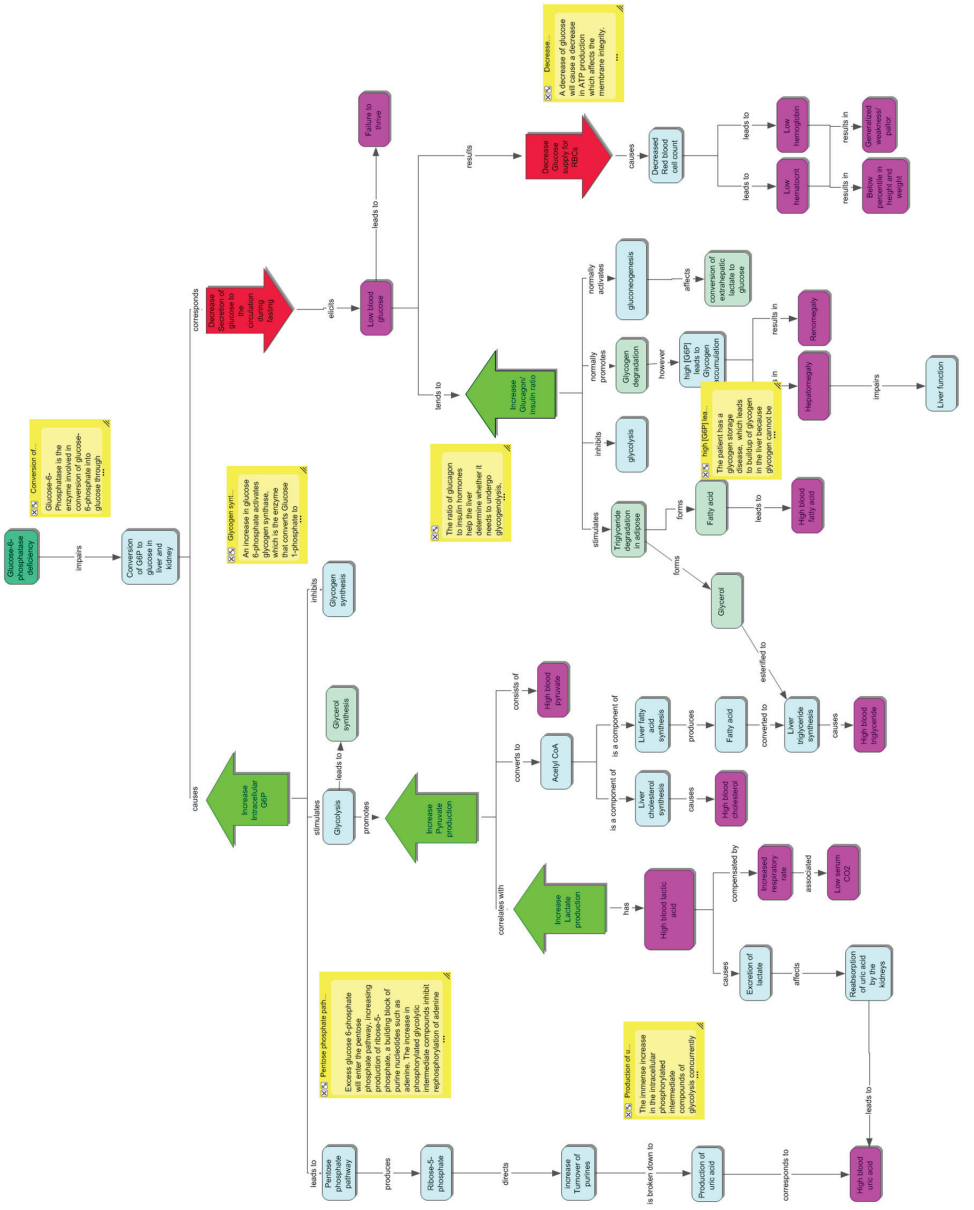
tion. They define concept mapping as "a technique that helps people represent their knowledge organization visually" (p. 59).

A typical concept map showing an example of knowledge and understanding of a first- year student in medical biochemistry is depicted in Figure 1. Students utilize the Inspiration 9.0 ™ software to build concept maps. As an initiation to this visualization tool, they are given a one- hour presentation on successful concept map creation using the software. Additional reading on the theory behind concept mapping is also provided (Beaudry & Wilson, 2009; Novak & Caňas, 2006).

The majority of small group-based activities tend to present students with clinical scenarios that may require some degree of critical thinking but fail to teach critical thinking as a skill. Increasing the number of opportunities for students to apply a skill they have not mastered does not necessarily help them master the skill. In the clinical years of medical education, clinical cases are used to teach pattern recognition void of any clinical reasoning. Being able to master pattern recognition through practice does not teach critical thinking and may lead to false conclusions when decisions are based on memorization rather than logical deduction. Although every educator strives to foster an environment that is inclusive of all students during small group activity to teach critical thinking, activities that are limited to presenting scenarios that may require critical thinking allow students who lack critical thinking to gain credit based on the effort of students who possessed the skill before the activity began. Including concept mapping as an activity that requires individual participation forces each student to develop the mechanics of critical thinking, and because students will be assessed individually on their mastery of the skill, their dependence on peers is greatly diminished through the activity.

One could approach teaching critical thinking by trying to define to students how critical thinking should happen and why it is important if one is to acquire a deep understanding of concepts behind any basic science discipline. However, designing a group activity to teach students how to visualize their knowledge using concepts learned during lecture and through assigned reading and finding the logical flow of disease processes proved to be a more effective method to engage students and teach critical thinking without being philosophical. Using concept mapping in medical biochemistry is not only a tool for visual learners to retain difficult content, but also a powerful self-assessment tool that leads any given student to deeply understand and irrevocably retain the basic concepts using logical and deductive reasoning. This process is facilitated by the fact that it is grounded by the use of clinical case scenarios discussed in a small group setting. Learning to think critically seems to be a social learning process (Brookfield, 2012).

Figure 1. A concept map explaining a genetically based disease, glucose-6-phosphatase or Von Gierke, process based on medical biochemistry concepts. A few "Notes" were opened to show their use

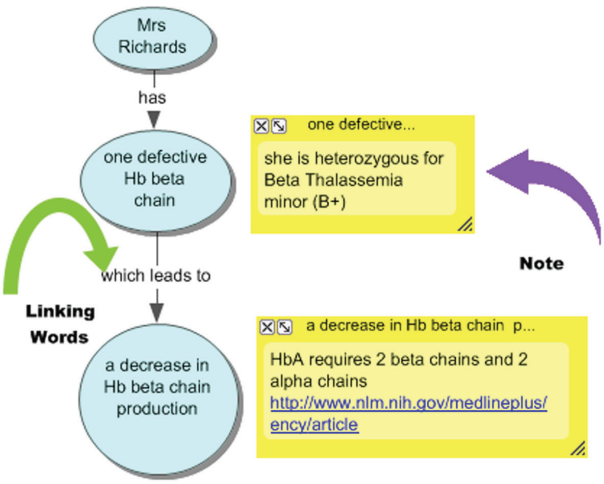


CLINICAL-CASE- BASED WORKSHOPS

The first step toward teaching critical thinking through concept mapping is finding clinical cases that will illustrate the material at hand. Clinical case- based workshops were introduced into the curriculum of the entering class of fall 2009. The nine workshops that currently span the fall semester are organized into quasi-Team Based Learning™ sessions that also incorporate concept mapping as a tool to teach how to visualize knowledge and to apply biochemical concepts to physiological/ pathological processes (Beaudry & Wilson, 2009; Novak & Canas, 2006). This approach enforces reasoning and critical thinking skills, both of which are required in the construction of a concept map with complete "Notes" and in a careful selection of "Linking Words." Figure 2 is an example showing open "Notes" and "Linking Words." One can choose to close all the "Notes" in order to have a better idea of the flow of the concept map as it can be seen on Figure 1. By the end of the course and after completing nine concept maps, students become almost expert in this process as we will discuss later in the chapter.

The workshops are based on clinical cases that are posted at least 4 days before the workshop date. Students are grouped into teams of five to seven students. On the day of the workshop, after taking a readiness assurance quiz individually and as a team, students are given time to finalize their concept maps within their groups. Feedback provided by faculty members during meetings prior to the workshop, during the workshop, and after the concept map is submitted assists students in

Figure 2. A section of a concept map illustrating Thalassemia where "Linking Words" and "Note" are shown



identifying the gaps in their knowledge. Students are encouraged to use adequate "Linking Words" that tell the story. Although they may not provide complete sentences or full assays, students are required to explain the flow of their concept maps in a "Note."

It is very interesting to observe the evolution of the construction of the concept maps as the course progresses. At first, students are taken aback by the idea of visualizing their knowledge using concept mapping. Eventually they start using concept mapping to make connections in other disciplines such gross anatomy and physiology. One second- year student said "I [hand-write] concept maps of the information I am studying to keep things logical and use the visual presentation of the flow of the information to review the material in a concise manner."

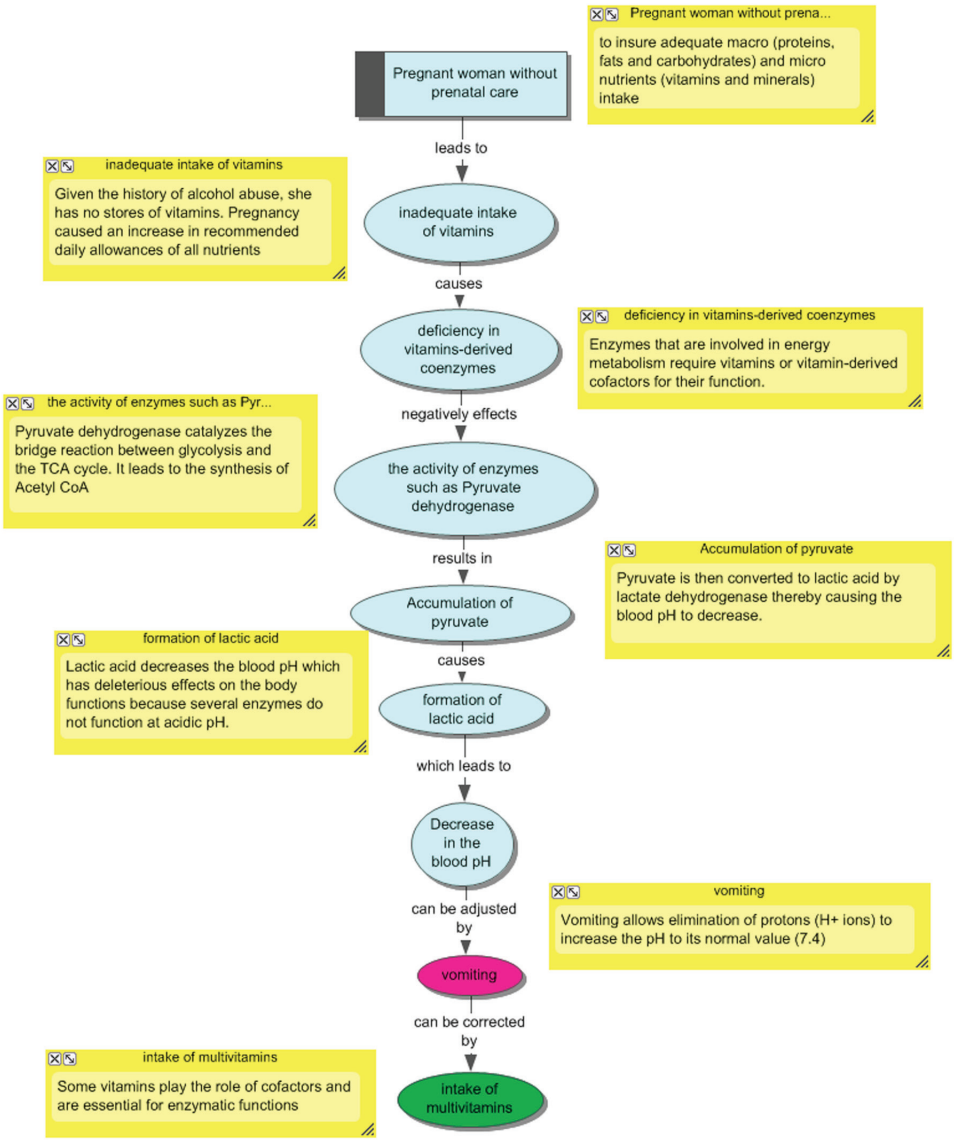
Figure 1 shows the end product of a concept map explaining a metabolic disease caused by genetic inheritance, Von Gierke disease. As one can see from the flow of the bubbles and the notes, students were able to explain the different symptoms and laboratory findings based on medical biochemistry principles and not based on physical diagnosis and/or pattern recognition. This method contributes the most in teaching basic sciences in the practice of medicine as required in a competency-based curriculum (Bierer et al., 2008; Litzelman & Cottingham, 2007; Smith, Dollase, & Boss, 2003).

Acquiring Clinical Cases

The workshops of our medical biochemistry curriculum are designed to make needed connections between basic science concepts and their clinical relevance. Consequently, each case study illustrates a topic in medical biochemistry. For example, the first case is about a pregnant woman without prenatal care with a history of alcoholism. She presents with vomiting, which cannot be stopped by antiemetic drugs, hyperventilation and acidosis. This case illustrates the need for vitamins as cofactors to enzymes. We want students to realize that excessive alcohol consumption interferes with the absorption and therefore storage of certain vitamins (such as thiamine), that the absence of vitamin-derived coenzymes prevents enzymatic activities such as that of pyruvate dehydrogenase, thereby leading to other metabolic pathways modifications inside the cell. Consequently, the absence of cofactors leads to the medical condition called "lactic acidosis" which results in a blood pH decrease that can be rectified by buffering mechanisms such as vomiting through which protons (H+) are eliminated from the body resulting in a pH increase (Figure 3).

The study cases we use are published clinical scenarios (Anderson, 2007, 2008, 2009; Anderson & Kirkish, 2007; Toy, Seifert, Strobel, & Harms, 2005). We modify some cases such that they more accurately illustrate the concepts at hand.

Figure 3. A concept map showing the flow of events in lactic acidosis to illustrate the importance of vitamins as cofactors necessary for enzymatic activity



A typical case contains a two page description of the history, symptoms and lab data of the patient. This information is supplemented with "guiding questions" in order to assist students in their readiness for the workshop and for the construction of the concept map.

Although the presence of the questions could seem "too guiding" to some, they are designed to direct students' focus in the right direction and to better use their time. Because the body has a limited number of symptoms to show its malfunction, several diseases have more than one symptom in common and very few specific characteristics. The guiding questions allow students to find these characteristics as they are usually covered in that week's lecture material and assigned reading. In this way, students are free to think critically in order to find the correct flow of events in the body function that led to the final symptoms without the risk of wasting time by pursuing irrelevant lines of thought. Additional information (such as further lab tests or biochemically and/or nutritionally relevant treatments) is provided two days before the workshop via Blackboard Learning Management System™.

Modifying the Case Material

Although we downloaded the case material from MedPortal, modifications were made to better illustrate the concepts as to the importance of a combination of medicinal drugs, nutritional changes, and exercise for a successful recovery. We then decide what will be included in the first post in order to introduce the case and give enough information without giving away the final diagnosis. For example students analyze the case of *Familial hypercholesterolemia* (shown in Appendix 1) during the fourteenth week of the course. This case of myocardial infarction was chosen because it beautifully illustrates lipid metabolism and focuses students' attention on a major health problem linked to the diet. It makes the function of lipoproteins seem more concrete and introduces the importance of knowing a key enzyme in the synthesis of cholesterol and how drugs target this enzyme specifically.

Components of the First Post

Objectives

Outcome-based curriculum designs are rapidly gaining popularity in medical education (Harden, Crosby, Davis, & Friedman, 1999; Smith & Dollase, 1999). One of the reasons for this popularity is the tremendous expansion of medical knowledge in the last few decades, which has made traditional transmission-type curriculum impractical. Teaching in the medical field is becoming more and more assessment-driven to emphasize clinically relevant basic science information that a medical student must possess to become a competent physician. In order to adhere to this trend in medical biochemistry curricula, every faculty member is required to provide a clear "learning outcomes and performance indicators" section at the start of every lecture. This section generally summarizes the most important biochemical concepts and

their relevance to medical applications while providing guidance to students as to their preparedness for success in any type of assessment (Azila, Tan, & Tan, 2006; Boudreau, Jagosh, Slee, Macdonald, & Steinert, 2008; Callahan, 1998; Carraccio, Benson, Nixon, & Derstine, 2008; Hamilton, 1999; Hawke, 2002). Knowing what a medical student should know is the first step to being a skilled educational planner and one of the essential competencies any teacher should possess (McTighe & O'Connor, 2005). In addition, we provide objectives for each clinical case's material in the first post (see Appendix 2). These objectives are usually very carefully formulated to orient students' focus to the most relevant material and assist them in being well prepared for their formative and summative assessments. Care is taken to use the cognitive words indicated in the article by Leslie Owen Wilson (2006), which allow us to adhere to one of the core competencies requiring that a learning objective must start with a word indicating assessable knowledge or a skill.

Guiding Questions

Guiding questions are designed to be specific to the clinical case at hand. Answers to the guiding questions will lead students to ideas that they will include in the concept map and the appropriate order of these concepts. The questions are randomized so that students are forced to think critically and to make decisions at the individual and team levels to determine the most logical flow of events in order to explain the disease process based on the biochemical concepts.

Introduction to Medical Vocabulary

We provide a list of vocabulary words that are necessary to tell the story on the concept map. These words are tools that are meant to trigger the thinking process that leads to choosing orderly logical reasoning. Students that succeed in using all the vocabulary words in the bubbles of their concept map and/or in the "notes" to explain the reasoning behind their depiction of the flow of events show the extent of their learning and the depth of their knowledge of that specific process.

Each group is encouraged to meet with a faculty member prior to the workshop in order to assess the progress of the concept map. During this meeting, one can orchestrate the discussion among team members and elicit the participation of each individual in demonstrating the logic of choices made to tell the story through the visualization of their understanding of the lecture material and therefore of the clinical case. Moreover, the discussion among team members, as facilitated by the faculty member, can allow him or her to observe the dynamic within the learning team.

Bubble Words

Providing bubble words instead of medical vocabulary can decrease the time students spend on creating the right combinations of words. Students then have to place the words in their concept map in a way that will visualize their understanding of the topic and the clinical case at hand. Again, they still have to provide their reasoning by adding a "Note" for most concepts included in the bubbles. The real learning occurs when students choose words to link concepts in the bubbles and select modifiers such as *increased*, *decreased*, *accumulation*, or *deficiency* to include in the bubble that will indicate that they understand the relationships between bubble words as they pertain to key concepts in the biochemical basis of medicine. As the course progresses, students learn that the flow of the story depends on correct choices of linking words and modifiers. These choices constitute progress toward acquiring critical thinking skills for those who lack such skills, and they hone the abilities of those who are already critical thinkers.

The Concept Map

The climax of the workshop is the construction of the concept map. This is the sole assignment in this course for which students come together to answer questions, help each other understand concepts or clarify material that may have skipped their attention during the lecture and/or the assigned reading, and receive feedback from a faculty member. Each team member has to assume leadership of the team at least once during the semester. The workshop leader usually assigns each team member the task of answering specific guiding questions and mapping a section of the case. An hour is assigned in the schedule for the first meeting among the team members. At the meeting, students are expected to discuss and verify their answers to the guiding questions using the course material and/or reference material provided with the case. We will discuss the importance of this formative assessment and its role in preparing students to do well on their summative assessments in the following sections.

The Beginners and Almost Experts

As in every aspect of learning, applying acquired knowledge to a new skill takes practice and requires feedback. Although students are given examples of successfully completed concept maps and guidance on how they should construct their concept maps, students rarely submit a perfect draft on their first try. However, as the semester progresses and even as early as the third concept map, students start to prepare complete, well connected, well justified concept maps. By the end of

course, they are almost experts in constructing maps, and their concept maps reflect not only the mastery of the software used to construct the concept map but also the sophistication they reach in communicating their knowledge and understanding visually. Some students take pleasure in using icons to show the increase or the decrease of a metabolite and which organ and/or tissue is affected by the changes thereby making their concept maps more visually appealing and/or easier to read (Figure 4).

THE ROLE OF CONCEPT MAPPING IN TEACHING CRITICAL THINKING AND THE RETENTION OF MATERIAL

As indicated by Westberg and Jason in their *Fostering Learning in Small Groups: A Practical Guide* (2004), any activity that allows students to interact and discuss what they are learning fosters learning. Using concept mapping as formative assessment provides learners an environment where they can build their knowledge, visualize it, make decisions, and receive feedback. Feedback is given using a very descriptive rubric (Appendix 3). The combination of two methods of teaching (lectures and clinical case-based workshops) as well as two methods of assessment (summative in the form of multiple-choice vignette questions and formative in the form of concept mapping) has contributed to increased scores on board exams. Indeed, the school's average biochemistry board exam scores (COMLEX step 1) went from below the national average before the change of the curriculum to above the national average after the change was implemented (Table 1). We firmly believe, as indicated in other studies, that having included a formative assessment using concept mapping has helped increase students' deep understanding of the major concepts of medical biochemistry and equipped all students with critical thinking skills (Bierer, et al., 2008; Rushton, 2005).

It is noteworthy that working within a team of classmates that have the same purpose plays an important role in students' appreciation of the importance of working with concept mapping. This setting provides the opportunity for students to build leadership and communication skills as well as professionalism. Before receiving feedback from faculty, students are encouraged to give feedback to each other on the answers to the "guiding questions" and to be prepared to receive feedback from others. They are also required to provide references for every question they answer and to be ready to explain the choices they make. Although students do not have to answer guiding questions in full sentences or paragraphs, the process of critical reasoning to complete the concept map using "Notes" and adequate "Linking Words" is crucial. Additionally, the feedback provided by faculty members helps students identify the gaps in their knowledge as the semester progresses. Moreover,

Figure 4. A student concept map with additional icons showing the organs affected by the disease as wells as the possible foods that initiated the disease process

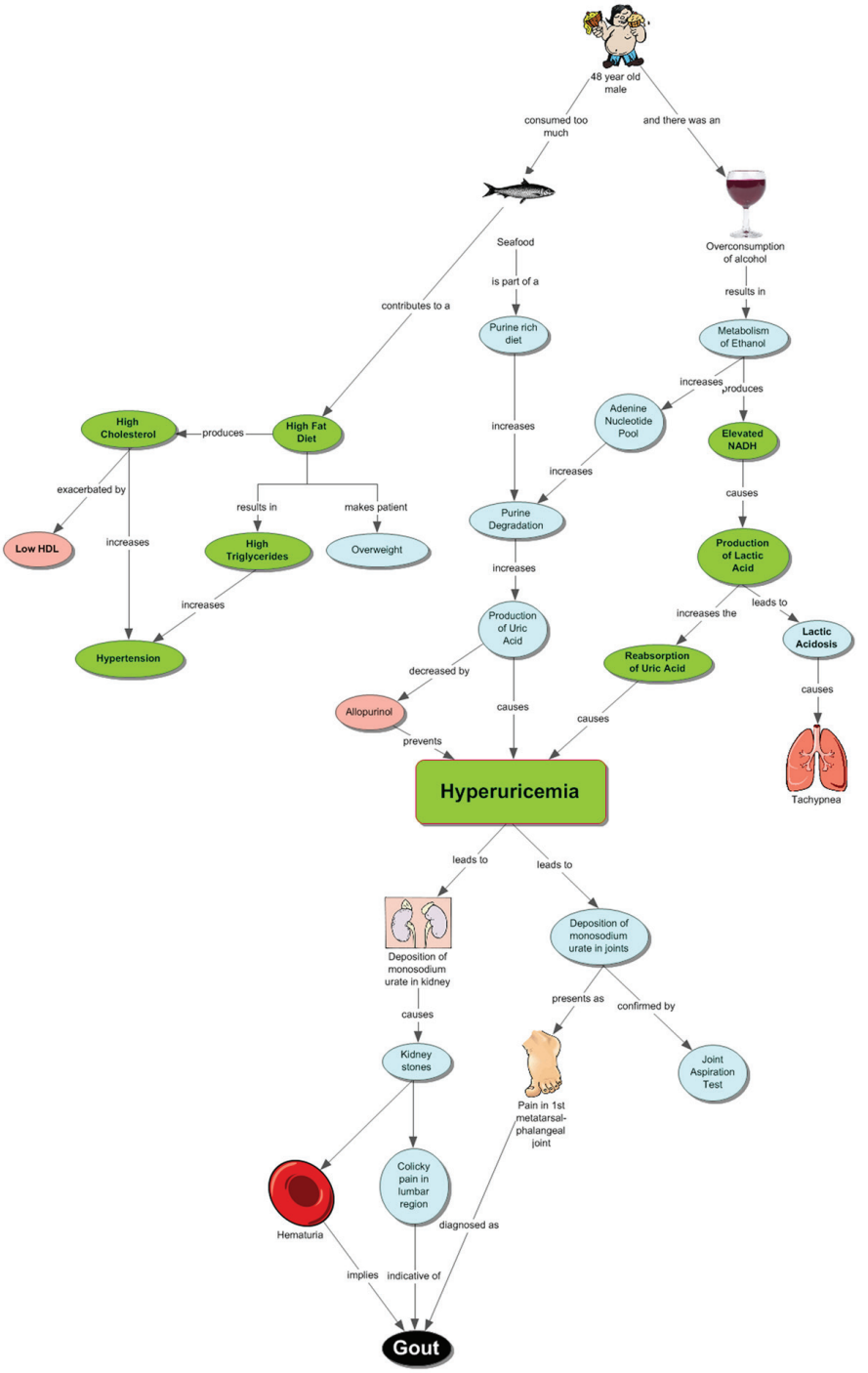


Table 1. Using concept mapping to teach critical thinking and the organization of knowledge and understanding visually allowed an increase in the board exam scores

COMLEX Date	Total COMLEX	Biochem TUN Mean	Biochem Natl Mean	TUN SD	Natl SD	n
5/08-4/09	470	481.27	518.68	110.06	120.86	131
5/09-4/10	503	520.69	523.96	106.14	121.79	117
5/10-4/11	509	516.87	515.92	131.03	143.71	134
5/11-4/12	524	546.73	541.77	154.81	153.51	121

the majority (90%) of student evaluations reflected their satisfaction with the new course design. We read student comments very closely and try to address their concerns. For example when group leaders indicated that they found themselves carrying most of the responsibility of organizing the meeting and finalizing the concept maps throughout the semester, we made the leadership rotational. Now, every student in the team is required to lead the team at least once during the semester. Here are some of the students' comments:

…concepts were clinically related (which enhanced my understanding/made subject more interesting and relevant), and professors did a great job teaching the complex topics…

I enjoyed the concept maps because I felt that they helped me to understand the material better.

…The concept map exercises, although at times seemed like extra work, were very effective for me to learn that material…

…The cases were definitely very interesting. I enjoyed having the clinical scenarios…

Workshops were a very effective use of our time...

Constructing a concept map in a group setting allows for peer learning and teaching and provides a means for checks and balances. It is humbling to observe the interactions among team members, which illustrate the capacity students have to explain difficult concepts to each other more simply than a specialist may. We all know that our knowledge can prove irrelevant if one does not have the skill to share it in a clear and concise manner.

REFERENCES

Anderson, M. (2007). What about Bob? *MedEdPORTAL*. Retrieved from http://services.aamc.org/30/mededportal/servlet/s/segment/mededportal/?subid=684

Anderson, M. (2008). Fred and Wilma's lucky day. *MedEdPORTAL*. Retrieved from http://services.aamc.org/30/mededportal/servlet/s/segment/mededportal/?subid=1675

Anderson, M. (2009). Rachel Jacobson's painful hip. *MedEdPORTAL*. Retrieved from http://services.aamc.org/30/mededportal/servlet/s/segment/mededportal/?subid=7702

Anderson, M., & Kirkish, M. (2007). Sophie Claiborne's upset stomach - An ornithine transcarbamolyase deficiency problem-based learning case. *MedEdPORTAL*. Retrieved from http://services.aamc.org/30/mededportal/servlet/s/segment/mededportal/?subid=642

Azila, N. M., Tan, N. H., & Tan, C. P. L. (2006). Inducing curricular change: Initial evaluation of outcomes. *Medical Education*, *40*, 123–1147. doi:10.1111/j.1365-2929.2006.02574.x PMID:17054624

Beaudry, J., & Wilson, P. (2009). *Concept mapping and formative assessment: Elements supporting literacy and learning*. Retrieved from https://blackboard.une.edu/Webct/RelativeResourceManager/Template/Session5/ConceptMappingandFormativeAssessment.pdf

Bierer, S. B., Dannefer, E. F., Taylor, C., Hall, P., & Hull, A. (2008). Methods to assess students' acquisition, application and integration of basic science knowledge in an innovative competency-based curriculum. *Medical Teacher*, *30*(7), e171–e177. doi:10.1080/01421590802139740 PMID:18777415

Boudreau, J. D., Jagosh, J., Slee, R., Macdonald, M. E., & Steinert, Y. (2008). Patients' perspectives on physicians' roles: Implications for curricular reform. *Academic Medicine*, *83*(8), 744–753. doi:10.1097/ACM.0b013e31817eb4c0 PMID:18667888

Bowen, J. L. (2006). Medical education: Educational strategies to promote clinical diagnostic reasoning. *The New England Journal of Medicine*, *355*, 2217–2225. doi:10.1056/NEJMra054782 PMID:17124019

Brookfield, S. D. (2012). *Teaching for critical thinking: Tools and techniques to help students question their assumptions*. San Francisco, CA: Jossey-Bass.

Callahan, D. (1998). Medical education and the goals of medicine. *Medical Teacher*, *20*, 85–86. doi:10.1080/01421599881147

Carraccio, C. L., Benson, B. J., Nixon, L. J., & Derstine, P. L. (2008). From the educational bench to the clinical bedside: Translating the Dreyfus developmental model to the learning of clinical skills. *Academic Medicine*, *83*(8), 761–767. doi:10.1097/ACM.0b013e31817eb632 PMID:18667892

Haist, S. A., Swanson, D. B., Holtzman, K. Z., & Grande, J. P. (2010). *The scientific foundations of medicine: Going beyond the first two years of medical school*. Paper presented at the Fourteenth Annual Meeting of the International Association of Medical Science Educators. New Orleans, LA. Retrieved from http://iamse.org/conf/conf14/3fs5.html

Hamilton, J. D. (1999). Outcomes in medical education must be wide, long and deep. *Medical Teacher*, *21*, 125–126. doi:10.1080/01421599979725 PMID:21275724

Harden, R. M., Crosby, J. R., Davis, M. H., & Friedman, M. (1999). AMEE guide no.14: Outcome-based education: Part 5--from competency to meta-competency: A model for the specification of learning outcomes. *Medical Teacher*, *21*(6), 546–553. doi:10.1080/01421599978951 PMID:21281173

Hawke, G. (2002). *Keeping curriculum relevant in a changing world*. Paper presented at the SENAI International Seminar. Belo Horizante, Brasil.

Litzelman, D. K., & Cottingham, A. H. (2007). The new formal competency-based curriculum and informal curriculum at Indiana University School of Medicine: Overview and five-year analysis. *Academic Medicine*, *82*(4), 410–421. doi:10.1097/ACM.0b013e31803327f3 PMID:17414200

McTighe, J., & O'Connor, K. (2005). Seven practices for effective learning. *Educational Leadership*, *63*, 10–17.

Novak, J. D., & Canas, A. (2006). *The theory underlying concept maps and how to construct and use them (Technical Report IHMC CmapTools Rev 2008-01)*. IHMC.

Rushton, A. (2005). Formative assessment: a key to deep learning? *Medical Teacher*, *27*(6), 509–513. doi:10.1080/01421590500129159 PMID:16199357

Smith, S. R., & Dollase, R. (1999). An introduction to outcome-based education. *Medical Teacher*, *21*(1), 15–22. doi:10.1080/01421599979978

Smith, S. R., Dollase, R. H., & Boss, J. A. (2003). Assessing students' performances in a competency-based curriculum. *Academic Medicine*, *78*(1), 97–107. doi:10.1097/00001888-200301000-00019 PMID:12525418

Toy, E. C., Seifert, W. E., Strobel, H. W., & Harms, K. P. (2005). *Case files biochemistry*. New York: McGraw-Hill, Medical Publishing Division.

Woods, N. N. (2007). Science is fundamental: The role of biomedical knowledge in clinical reasoning. *Medical Education*, *41*(12), 1173–1177. doi:10.1111/j.1365-2923.2007.02911.x PMID:18045369

Woods, N. N., Brooks, L. R., & Norman, G. R. (2007a). It all make sense: Biomedical knowledge, causal connections and memory in the novice diagnostician. *Advances in Health Sciences Education: Theory and Practice*, *12*, 405–415. doi:10.1007/s10459-006-9055-x PMID:17318360

Woods, N. N., Brooks, L. R., & Norman, G. R. (2007b). The role of biomedical knowledge in diagnosis of difficult clinical cases. *Advances in Health Sciences Education : Theory and Practice*, *12*(4), 417–426. doi:10.1007/s10459-006-9054-y PMID:17206465

KEY TERMS AND DEFINITIONS

Basic Sciences: Disciplines such physiology, biochemistry, immunology and microbiology that are at the root of understanding the functions of the human body.

Clinical Scenario: A sequence of signs and symptoms, real or imagined, used to illustrate a concept in medical biochemistry or any other basic science discipline that uses clinical cases.

COMLEX: National board of osteopathic medical examiners licensure exam, usually taken after the two first years or the preclinical years of medical education.

Concept Mapping: A visual representation of knowledge in a geographical manner showing a logical flow of events to justify or explain a phenomenon.

Familial Hypercholesterolemia: An inherited disease leading to the accumulation of cholesterol in the bloodstream.

Guiding Questions: Questions meant to force students to read the material for understanding. If answered correctly, they lead to solving the case and constructing the concept map with relative ease.

Hyperventilation: Rapid breathing leading to the elimination of carbon dioxide from the body.

Inspiration: Software allowing for the construction of a concept map using templates.

Linking Words: Selected words from a list provided by the software or created by the user to make a logical connection between two events on the concept map.

Metabolic Acidosis: A decrease in the blood pH caused by the accumulation of a chemical compound, such as lactate or a ketone body, as a consequence of an enzymatic malfunction or an ingestion of a xenobiotic such as alcohol.

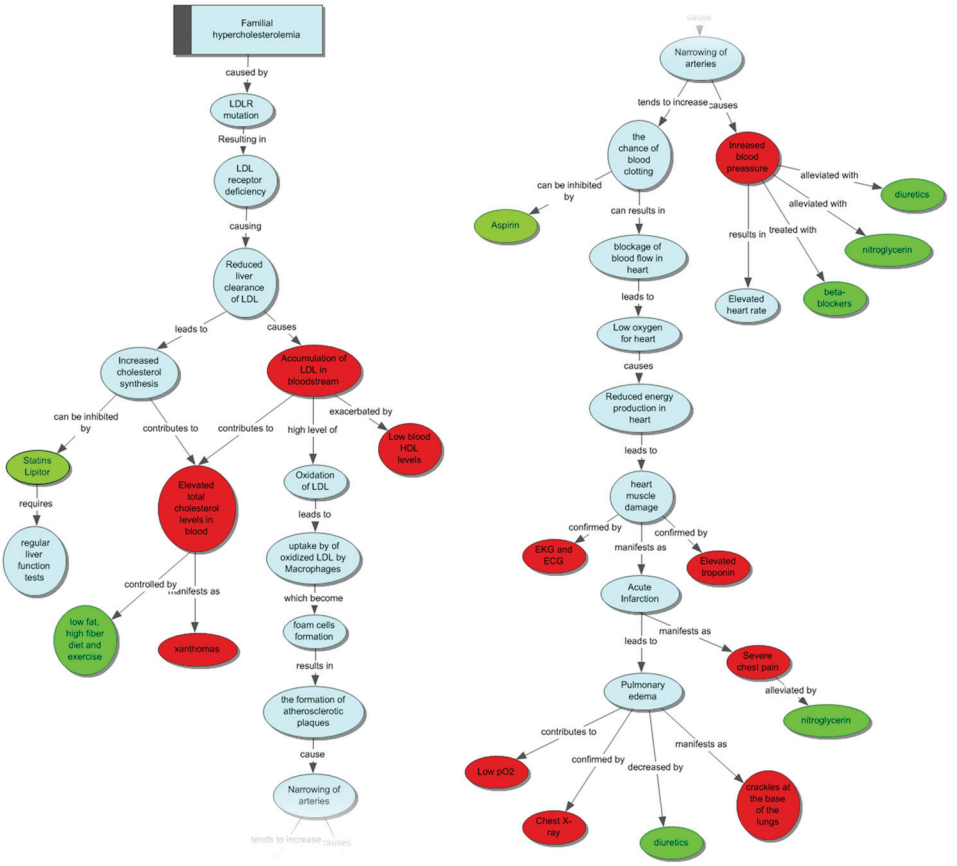
APPENDIX 1

Preparing to Teach Concept Mapping via Faculty Development

Designing a small group activity to teach critical thinking to medical students, especially surrounding a challenging task such as making the connection between a basic science discipline and the practice of medicine, requires a commitment to excellence in medical education. Medical students can detect very quickly the interest a faculty member has in what he or she is trying to teach as well as the degree of cohesiveness between faculty members. Students can become frustrated if faculty members fail to model the behavior they expect from students. If we are to teach students how to behave professionally while working in a group and to instill responsibility, we must show them how a group of seemingly different individuals can transform into a cohesive team. We have to model our expectations for the students. First, regardless of who is the major contributor to the lecture is, we work as a team on each clinical case that will be used to illustrate the major topic of the week. Then, each of us constructs the concept map that we think should be used as a template showing all the concepts of medical biochemistry that should be used to explain the disease processes covered in the clinical case (Figure 5). Though we are all experts in the discipline of medical biochemistry, not every faculty member uses the same method to communicate his or her knowledge on the concept map. In the beginning, it took the team a few hours to make each other understand how knowledge should be organized in the model concept map and communicated to students. With time and experience and even when new clinical case is used or new information comes to light about an existing case, the team reaches consensus relatively quickly. Each faculty member contributes actively to construction of the model concept map and to the modifications of the case to accurately illustrate the topic at hand. Again, these meetings take preparation before the material is posted on Blackboard Learning Management System™. Each faculty member attends faculty development sessions in order to reach a stage where all the participating faculty members are able to model preparedness and effective teamwork for students. It is not an easy task to teach concept mapping to students if one is not aware of how he or she would organize his or her own knowledge. To echo Ambrose et al. (2010), "It can be difficult for experts to recognize how they organize their own knowledge, and thus difficult for them to communicate this organization to students. One way to make your own knowledge organization apparent to yourself is to create your own concept map" (p. 59). In addition to creating a model concept maps based on our existing knowledge, we strive to acquire new knowledge and experience in teaching medical students — especially those who are not naturally interested in knowing the minutia of our respective research interests. The teaching experience of the

faculty members in our team of biochemistry experts ranges from five to 23 years. All three faculty members completed (a) the Essential Skills in Medical Education (ESME) course, (b) a Team Based Learning™ workshop, (c) Test question writing, and d) the "How to be an Efficient Course Director" workshop, all of which were offered at the International Association of Medical Science Educators conference (IAMSE). It is rare indeed to make a group of faculty teaching the same discipline evolve to form a team, administer a curriculum that is student oriented, be willing to leave their comfort zone, and use a new and challenging method to teach critical thinking. Critical thinking can be learned when (a) the goals are focused, (b) the assessments are limited and yet they are of quantity and frequency that allow for skill development and academic progress, and (c) the feedback is behavioral and specific so that the students know what they do well in order to continue do it and what they do not do well so they may improve.

Figure 5. A template of the familial hypercholesterolemia as constructed by the three faculty members before posting the case



APPENDIX 2

First Post of the Case Material

The Biochemical Basis of Medicine

John Dorsey's Severe Chest Pains
By: *Marshall Anderson, Ph.D. Modified by Amina Sadik, Ph.D.*

Objectives

1. Identify the roles of the various lipoproteins in lipid transport and metabolism.
2. Name the lipoproteins necessary for chylomicron maturation
   a. Indicate their source, and
   b. provide their function (s)
3. Name the enzymes that interact with lipoproteins.
4. Describe the synthesis of LDL and diagram its path of delivery of cholesterol to cells
5. Explain the role of the LDL receptor in the regulation of cholesterol concentration in the hepatocytes
6. Explain the role(s) of each apoprotein in lipoprotein function(s)
7. Discuss the mechanism by which atherosclerotic plaques form
8. List the manageable and none manageable risk factors in coronary artery disease
9. List the lipoproteins the level of which is directly proportional to CHD
10. List the proteins and enzymes used in the diagnosis of myocardial infarction, and explain how the diagnosis is made on the basis of these values
11. List the functions of cholesterol in the body
12. List the sources of cholesterol found in the body

John Dorsey's Severe Chest Pains

John Dorsey is a 39-year-old black male who is admitted to the hospital with a three-hour history of severe chest pain. He describes similar but less severe pain in the chest during heavy exertion over the last year, but he thought that it was due to pain in the chest muscles. Mr. Dorsey describes himself as an insomniac and associates the beginning of his sleep problems with his first experiences of chest pain. This present pain is the worst he has ever experienced, and it is felt in both arms, his neck, and back. He reports feeling sick to his stomach and having some trouble breathing.

Mr. Dorsey had no significant medical problems until three years ago when he began to have chest pains and noticed small growths on his hands. Mr. Dorsey is a real sports fan and eats a lot of fast foods, and enjoys potato chips and beer while watching the Sox, Bears, Hawks, and Bulls on TV.

Dr. Sigh, the emergency room physician, treats Mr. Dorsey with aspirin (325 mg orally) followed by nitroglycerin to relieve the acute pain, and she performs a quick physical exam.

Significant findings on the physical exam are the following:

- Blood pressure:160/100
- Heart rate: 110/min
- Respirations are 20/min
- No fever
- Crackles in the bases of the lungs
- Systolic bulge at the left of the sternum
- S4 gallop is heard over the ventricle and a systolic murmur is present
- Abdominal exam: normal
- Extremities: xanthomas over the tendons of the hands
- Electrocardiogram (EKG) shows evidence of acute infarction of the left anterior wall of the heart.
- The nitroglycerin is controlling the acute pain, so morphine was not administered.
- Blood was drawn for analysis, a beta blocker and a chest X-ray was ordered, and Mr. Dorsey was transferred to the coronary care unit or CCU.

Lab Result for John Dorsey

Mr. Dorsey is treated with oxygen by mask and is given a dose of diuretic to reduce fluid accumulation in the lungs. An echocardiogram shows that the anterior wall of the left ventricle contracts poorly. Mr. Dorsey receives the necessary care that allowed for normal contractions the following day.

Mr. Dorsey comes from a large family with three brothers and four sisters. His father died of a massive heart attack at the age of 42 and two brothers and one sister have had heart attacks in their mid-thirties. Mr. Dorsey had a normal childhood, with the normal array of childhood illnesses, including chicken pox and measles. He smoked one pack a day for six years in his twenties, but hasn't smoked since then. He was hospitalized once, at the age of 31 for injuries from a traffic accident, but otherwise has had no significant medical problems, until the chest pains began three years ago. He has never been overweight. Mr. Dorsey is a mailman, so he gets some

Table 2. Lab Result for John Dorsey

	John	Normal Reference Range
Electrolytes	normal	
Blood count	normal	
Troponin T	positive	(negative)
Troponin I	positive	(negative)
Arterial Blood Gas		
pH	7.46	7.36-7.45
pO2	65	90
pCO2	35	35-45
Chest X-Ray		
pulmonary edema, normal heart size		
Lipid Profile		
Cholesterol	510 mg/dl	(< 200 mg/dl)
HDL cholesterol	27 mg/dl	(35-55 mg/dl)
LDL cholesterol	483 mg/dl	(65-190 mg/dl)
Triglycerides	100 mg/dl	(30-200 mg/dl)

exercise every day walking from house to house, except Sunday. His wife has urged him to have his cholesterol checked, but he hasn't found time to get around to it.

Given Mr. Dorsey's family history of cardiovascular diseases, Dr. Sigh ordered a genetic test.

Guiding Questions

1. What would cause such severe chest pains in this patient?
2. What is the nature of the growths on the patient's hands?
3. What is the significance of the patient liking "junk food"?
4. What is the significance of the elevated blood pressure?
5. What do aspirin and nitroglycerin do?
6. Why was the patient given a diuretic?
7. What are xanthomas?
8. What does a positive Troponin T and I signify when found in the blood sample of this patient?
9. Why is the pO_2 decreased?

10. Why is it necessary to reduce fluid accumulations in the lungs in this patient?
11. Would the patient's previous history of smoking contribute to his condition?
12. What are the risk factors for coronary artery disease?

Bubble Words

1. HDL levels
2. Xanthomas
3. LDL levels
4. EKG and ECG
5. Total cholesterol in the blood
6. Cholesterol synthesis
7. LDL receptor
8. Chest X-ray
9. LDL oxidation
10. Macrophages
11. Foam cells
12. Atherosclerotic plaques
13. Levels of Troponin T and I
14. Severe chest pains
15. Liver clearance of LDL
16. Aspirin
17. Narrowing of arteries
18. Blood pressure
19. Heart rate
20. Heart muscle damage
21. Crackles in the bases of the lungs
22. Low O_2 in arterial blood
23. Blood clotting
24. Diuretics
25. Energy production in heart
26. Pulmonary edema
27. Acute infarction
28. Nitroglycerine
29. Beta blocker
30. Blockage of blood flow in heart
31. Oxygen for heart muscle

References

Thompson and Thompson Genetics In Medicine, 7th ed, Authors: R.L. Nussbaum, R. R. McInnes, and H.F. Willard ISBN-978-1-4160-3080-5 pp 260-261

Marks' Basic Medical Biochemistry, A Clinical Approach by M. Lieberman and A. Marks, 2013, 4th ed. ISBN: 13: 978-1-60831-572-7

Biochemistry, Molecular Biology and Genetics, BRS Board Review Series, by T.A. Swanson, S. I. Kim, and M.J. Glucksman, 5th ed. ISBN-13:9780781798754

Schaefer, E. J. (2002) Lipoproteins, nutrition, and heart disease Am. J. Clin. Nutr., 75 (2):191-212.

World Wide Web Resources

Hypercholesterolemia: http://ghr.nlm.nih.gov/condition/hypercholesterolemia

Primary Disorders of LDL-Cholesterol Metabolism: http://www.uptodate.com/contents/primary-disorders-of-ldl-cholesterol-metabolism(accessedSeptember16,2011)

Hyperlipidemia: http://www.heart.org/HEARTORG/Conditions/Cholesterol/AboutCholesterol/Hyperlipidemia_UCM_434965_Article.jsp (sccessed October 25, 2012)

Statin Drugs: http://www.nlm.nih.gov/medlineplus/statins.html (accessed October 25, 2012)

Lipitor: http://www.lipitor.com/aboutLipitor/benefitsOfLipitor.aspx?source=google&HBX_PK=s_+lipitor+benefits&HBX_OU=50&o=23127370|166376222|0&skwid=43700003061901690 (accessed October 25, 2012)

Second Post of the Case Material

Additional Information

Mr. Dorsey is diagnosed as a heterozygous familial hypercholesterolemia with a mutation of the LDLR common in Afrikaners. This defective gene is located on chromosome 19 p. He has a few risk factors for coronary artery disease, yet, has abnormally high total cholesterol and high LDL values and the presence of xanthomas on the tendons of his hands. Following his hospital stay of ten days, he is put on a low fat, high fiber diet, with no eggs or organ meats, and given 20 mg Lipitor® orally once a day to control his blood cholesterol and to continue on the beta blocker

until a re-evaluation at his next check-up in one month. He is enrolled in the cardiac patient exercise program at the hospital to increase his exercise level, and is told to cut out potato chips and beer while watching sports on TV. His liver function will be monitored at regular intervals.

Guiding Questions

1. What is hypercholesterolemia and what are its causes?
2. What is the role of LDL receptor in cholesterol regulation?
3. What are the differences in disease management between a homozygous and a heterozygous case?
4. Why is the patient advised to eat a low fat, high fiber diet?
5. Why is the patient advised to have liver function tests done at regular intervals?

Additional Bubble Words

1. Genetic mutation in LDLR
2. Familial hypercholesterolemia
3. Lipitor®
4. Low fat, high fiber diet and exercise
5. Regular liver function tests

References

Rader DJ, Cohen J, Hobbs HH. 2003. Monogenic hypercholesterolemia: new insights in pathogenesis and treatment. *J. Clin. Invest.* 111: 1795–1803

APPENDIX 3

Table 3. Rubric for the concept map assignment

Total point possible = 10 Points					
BMS 680/BSCI 609					
Names:					
The Instructor's Comments:					
Criteria	**Excellent 2.5**	**Very Good 2.0**	**Good 1.5**	**Fair 1**	**Poor 0.5**
Completeness (Bubbles)	90+ % of the concepts are mapped	80-90% of the concepts are mapped	70-80% of the concepts are mapped	60-70% of the concepts are mapped	less than 60% of the concepts are mapped
Relationship (Arrows and their connecting words)	90+% of the relationships are mapped correctly	80-90% of the relationships are mapped correctly	70-80% of the relationships are mapped correctly	60-70% of the relationships are mapped correctly	less than 60% of the relationships are mapped correctly
Communication (Structure and clarity of explanations included in the "Note")	90+ % of the information is presented clearly and allows for a high level of understanding	80-90% of the information is presented clearly and allows for a good level of understanding	70-80% or f the information is presented clearly and allows for a basic level of understanding	60 -70% of the information is presented clearly and some understanding can be gained	less than 60% of the information is clear, very difficult to understand
Timeliness	CM completed and submitted on time				

- **NB:** Completeness of concepts means that important pathways, metabolites, enzymes, symptoms, tissues involved, genetic background (if applicable), etc are placed in the bubbles on the map.
- **Relationship:** Means the placement of arrows connecting bubbles (pointing to the correct direction) with appropriate short text (connecting words) placed by the arrows.
- **Communication:** Covers, the structure of the non-linear map (tree) that is easily understandable with no crossovers, as well as the clarity of explanations placed at the right side of the bubble using the "Note" icon.
- **Assessment of Medical Biochemistry Concept Mapping:** There is a total of four criteria yielding a possible *10 points*. Each of the criteria is defined in the rubric. The criteria are weighted differently.