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PROMOTING HORIZONTAL AND VERTICAL INTEGRATION IN MEDICAL EDUCATION: IMPACT OF A SEPTIC SHOCK CASE STUDY ON PRECLINICAL STUDENTS' LEARNING

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ABSTRACT
Medical students who aim to develop clinical reasoning skills must use information from various old subjects and new fields together. Experts have recognized two kinds of integration: horizontal which means combining several subjects to study one area and vertical, when the basic sciences are used with clinical practice. Rather than concentrating solely on major curriculum reforms, our approach targets modest scale joining of subjects and closely evaluates whether our approach works through the use of case studies. After completing the basic sciences module organized by organ systems, a group discussion on a critically ill patient took place. A cardiologist, pulmonologist and nephrologist were in charge of the conversation and led it toward a case of a patient who had suffered from septic shock and several complications. The session pointed out how the body responds physically and how shifts in various systems might affect decisions about treating the patient. Students were also shown the relationships among the cardiovascular, respiratory and renal systems which had been taught separately before. Once the session was over, the students responded to three open-ended questions on a brief and confidential survey to let us know how they felt about the learning experience.

The program helped participants explore both the physiological aspects and the uses of basic science for clinical purposes, in both horizontal and vertical integration. Feedback from students was very good, with many finding that the exercise helped them relate the material from multiple organ systems and respected the importance of physiology in treating diseases. Integration across business units can be examined effectively with just one case study. Such cases where multiple organ systems are involved give students a good opportunity to understand different topics together and learn the big role physiology plays in medicine. Moreover, when many doctors with different specialties work together, students learn that organ systems and disciplines are connected.

Key words: Clinical reasoning, Horizontal integration, Verticalintegration, Interdisciplinary case study, Physiology

INTRODUCTION

For the past decade, a few commissions have recommended combining basic and clinical sciences into medical school courses more strongly to ready future doctors for consulting patients [1,2]. There are two main parts to this integration: horizontal integration covers linking different sciences to understand a given medical problem (e.g. combined use of physiology and pharmacology in heart failure) and vertical integration means applying fundamental science to diagnosis and treatment methods (such as physiology in the care of a septic patient) [3]. Many studies have looked into how school curriculums can be improved for integration and how much importance both horizontal and vertical integration hold [4-8]. We noted in our teaching that this way is successful for students as it helps them immediately tie together physiology and pharmacology of the heart. Yet, organizing materials by organ systems alone made it hard to easily relate problems from different systems—an important ability for treating critically ill patients with many problems. The main goal was to introduce the interdependence of different organ systems, so a case study was designed to achieve this. At first, case method teaching was used in business settings and it has now been used successfully to address complicated, real-world issues by blending multiple areas in education during the preclinical years. As a difference from problem-based learning, the instructor supports the discussion, limiting it from being sidetracked by irrelevant subjects [10]. In some cases, using patient cases has allowed educators to teach students how to solve medical problems before they enter clinical work [11]. This manuscript describes how to bridge learning between the basic sciences and clinical practice during the preclinical phase. To encourage students to think about different subjects, we suggested they start to realize how working together can shape decisions for seriously ill patients. The group agreed that knowing the basics of physiology is necessary for good medical decision-making and effective treatment. Combining disciplines was encouraged and activities were designed to show that medical science knowledge applies across several body systems. By using three physician facilitators—a cardiologist, pulmonologist and nephrologist—the team was able to review the patient's case from each area of medicine. Using clinical scenarios in the first years of their studies sets students up for similar situations in their clinical years.

METHODS

This educational exercise was conducted with an interactive, multidisciplinary group discussion about a septic shock case which is frequently encountered by those working in ICUs. The information on the case was shared with preclinical medical students at a private medical school, after they completed most of their basic science training. To familiarize students with the case, they were given the case and related questions before the group discussion. An interdisciplinary group of three physicians guided the session, each educating students about how their organ functions. Instead, the class met in a wide lecture hall, so all students could attend together. The session included a casual interview among the three clinicians, who provided clinical details on the patient and asked the students questions before allowing the students to participate fully. They were meant to support students in linking their knowledge to understand the patient's whole disease. The facilitators were able to guide the session's flow as they thought was best. They could draw associations between concepts and find out the clinical meaning of each through discussions. They were furthermore invited to participate in the discussion by asking questions. The exercise was developed and first carried out in 2009 and has been used with students in subsequent years who have finished their physiology units. Up to 28 students participated in a recent exercise in 2013 and this group gave qualitative feedback. To evaluate and comment on the exercise, these students responded to three written questions anonymously. The faculty grouped and described the survey responses represented in Table 1. Different kinds of answers were organized differently: Specific physiological answers were joined into physiology groups and more general ones were paired together in themes. Because the study involved using tests and gathering anonymous data, it was determined by regulation to not require formal ethics approval. The goal of the case study was to highlight why learning about human physiology supports clinicians in taking a complete history, examining the patient and forming a correct treatment plan. We were required to understand the workings of cardiovascular, respiratory and renal physiology and apply them to patient situations (see Figure 1). Both the case details and the discussion questions are placed in the Appendix. We discuss a few teaching points from the physicians that worked to integrate physiology concepts into different organ systems.

RESULTS

Table 1. Summary of Student Evaluations of the Multidisciplinary Physiology Case Study Exercise

Evaluation Aspect	Summary of Student Responses
Take-away Points	- All 28 students identified at least one general theme rather than just specific physiology concepts. - Themes included: role of physiology in clinical medicine, integrating physiology across organ systems, guiding treatment, clinical medicine principles (e.g., differential diagnosis, physical exam interpretation), and topics to review for wards. - 29% (8 students) did not list specific physiology concepts but focused on broader themes. - Indicates students appreciated the broader integration of physiology rather than isolated facts.
Change in Perspective on Physiology in Clinical Medicine	- 86% of students reported a positive shift in how they viewed applying physiology clinically. - The 4 students who reported no change already recognized physiology's importance but felt the exercise reinforced it.
Usefulness for Preparation for Clinical Wards	- 100% of participants found the exercise useful for ward preparation. - Positive feedback consistent over 5 years, even before formal feedback was collected. - Students requested more integrated cases like this. - A student commented: "During preclinical coursework, everything was taught and tested one system at a time...This exercise was a great integration. The wards will be a complete integration, which we have little experience doing."

Instead of only talking about physiology concepts, all 28 students highlighted some main themes. Some of these themes covered learning how physiology helps in clinical medicine, using knowledge from different organ systems, using physiology to help make treatment decisions, learning key clinical rules, reading about physical examination results and deciding on physiology concepts to build upon before starting clinical wards. Many students (8 out of 28) highlighted the themes mentioned above without explaining specific physiology points. These results demonstrate that reviewing basic physiology was helpful for many, but students as a group appreciated learning how physiology relates to medicine and can be applied to various body parts, not just separately studied.

The vast majority of students or 86% of them, reported their views on physiology in clinical medicine had improved after completing the exercise. Students who reported no changes said they already understood why physiology matters, but they were reminded of its importance through the exercises. All those involved felt that the case study was helpful in getting ready for ward work. In the past five years, many people have liked the response to food well before we started officially asking for feedback. Many students shared their opinions that equal cases in different systems should be included in the preclinical training because learning them together was new to them. One student said, "Prior to clinical sessions, we studied and tested the functions of different body systems individually… This came together really nice. The hospital will become a full integration and we haven't done anything like this before.

DISCUSSION

First Symptoms and Different Possible Diseases

To formulate a differential diagnosis, it is necessary to consider different causes of the patient's symptoms using knowledge from many professionals. The combination of shortness of breath, a cough with sputum and chest pain during breathing were signs of a problem in the lungs. On the other hand, fever, chills, a rise in the white blood cell number and immature white blood cells suggested possibly an infectious cause. Yet, the key findings of labored breathing and fever did not lead to specific causes, so the team discussed several possible reasons for having those symptoms. While the patient mainly has problems with breathing, the cause was not always related to the lungs. Students were asked to come up with other questions about the history to better diagnose the patient. The physician facilitators led students in using the history to draw up a list of possible conditions in the heart, including congestive heart failure, infective endocarditis and heart issues due to infection. More tests were needed to find out which disease might be causing the symptoms.

Keep an eye on Blood Pressure, Cardiac Output and how much fluid is outside the cells.

The inflammatory markers of the patient's vital signs were consistent with SIRS. Apart from fever and shortness of breath, the patient displayed both a fast heartbeat and low blood pressure. The topic explored the main causes of blood pressure—the output of the heart, its rate and the state of blood vessels—as well as methods for increasing the body's circulation. While the patient had tachycardia, the hypotension remained, so it is likely stroke volume and peripheral resistance play a role. Pinpointing stroke volume was possible when the patient's point on the Frank-Starling curve was understood (see Figure 2). A lack of fluid in the ventricle because of bloody loss results in less return of blood to the heart, lower pressure in the heart chambers and reduces the amount pumped by the heart. However, when ventricular filling increases too much, it stretches the heart muscle fibers (which follows Laplace's law), reducing how much blood the heart can pump. Since the cause of the problem varies greatly, telling if the ventricle has too little or too much blood can guide the treatment. If the patient has lost volume, medical cards usually give intravascular fluids to boost preload and outpouring. Even so, if the ventricle is already too full, giving fluids will only increase its stretch and will not fix the heart's output, so removing some blood is needed, no matter how low blood pressure becomes. For this reason, blood pressure alone is unable to indicate a person's volume status. Hearing rales which indicate fluid in the alveoli, typically makes pulmonary edema a likely cause, unless the increased vascular permeability from inflammation (for example, pneumonia) could also create these findings. Clinical signs in early septic patients can be warmness, increased blood flow and a rise in heart output when they receive fluids. Still, increasing the amount of fluids in the body can make pulmonary edema worse by increasing pressure in the small blood vessels, making it necessary to care for both blood circulation and lung health. Another way to raise cardiac output is to use positive inotropic drugs which shift the Frank-Starling curve upward (Figure 2). For example, among such drugs are beta-adrenergic agonists, phosphodiesterase inhibitors and digoxin. These medications, however, cause myocardial oxygen use to increase which is an important balancing act. lowering afterload which relies on the ventricle's size and the difficulty the aorta experiences in moving blood, could improve cardiac output. The use of peripheral vasodilators may drop afterload, but can cause poor results in people with low or borderline blood pressure. Primarily, heart output can be increased by tending to the heart's fill, as well as by encouraging stronger contractions and relieving stress on the heart—depending on the patient's situation.

Problems Involving Blood Oxygen Levels and the Acid–Base Balance

Likely, the patient's hypoxia resulted from poor perfusion due to low blood pressure and from trouble with oxygen absorption by the lungs. The low level of oxygen saturation (92%) did not improve after he was placed on 100% oxygen. Rapid breathing, noisy breathing sounds and abnormal levels of blood gases proved there was a problem with the lungs. Acidemia (pH 6.98) and hypercapnia, along with a partial pressure of carbon dioxide of 50 mm Hg, was found in the arterial blood gas test. The high alveolar-arterial oxygen gradient demonstrated that there was some intrinsic pulmonary impairment. Possible causes shown by imaging included pulmonary edema and pneumonia. When there is fluid in the alveoli, air cannot move well and the exchange of gases between blood and air in the lungs is slowed. Since the arterial oxygen saturation did not rise to normal, the gradient that appears hints at an anatomic shunt. There was clear evidence of a combined respiratory and metabolic acidosis in the blood gas profile. The patient's hypercapnia triggered respiratory acidosis and along with a low bicarbonate (10 mEq/L) and a raised anion gap, metabolic acidosis occurred as well. High lactate is what drove up the anion gap. In the first phase, lactic acidosis supports the body, as it increases how much oxygen from hemoglobin can be given off to muscular and other tissues. Yet, if pulmonary oxygen fails, the body's efforts are not enough to overcome tissue hypoxia.

CONCLUSION

The one-hour case discussion introduced students to how physiology is used to guide treatment decisions in the clinic, while deciding what to focus on later on in training. After just one session, students saw the benefit of using knowledge from several areas and put that approach into practice with critically ill patients. The discovery was especially important for the first author, who went through this activity as a student. Under these circumstances, early experiments indicate that adding horizontal and vertical integration to the curriculum, if done little by little, brings genuine benefits to education. Those leading the case or similar lessons should look at what their students already know and understand in the curriculum, then identify where there may be missing linkages because of the design of the curriculum. The content in cases can be designed to improve areas where needed such as linking topics from physiology and pharmacology at schools that offer them separately. While information processing and dedication for teaching are standard requirements, the informal style in this program relies on facilitators being adaptable and forming friendly, collegial relationships. Facilitators noticed that a loose style encouraged students to remain involved which removed the impression of it being a simple case discussion. Many students pointed out that the exercise was a fun way to study, because of the light, open and some times comical exchanges that developed between the clinicians. The positive results of horizontal and vertical integration in many curricula are documented by both educators and learners [5]. Also, repeated discussions among clinicians underlined how all basic science fields and organ systems are tied together, making sure the patient's overall clinical condition was always considered. This report has a problem because it lacks independent test results and counts only on students' perceptions. The authors believed that answering a simple post-exercise question was a better indicator of immediate utility than taking part in multiple-variable clinical cases. It's hard to determine if students used the experience they had during the short session to reason better in hospitals. Even though the response was positive, we do not know if this physiology knowledge is well integrated into real-world use. An important benefit of having clinicians who taught as well as practiced lead the discussion was their ability to link cardiovascular, pulmonary and renal physiology in a situation relevant to practicing medicine. Solving this case required students to use their knowledge of physiology more thoroughly than is usual at their level. Even though some students found the case quite difficult, it encouraged them to study the tough concepts before starting their clinical work. They were told that additional clinical training would allow them to improve their reasoning and put physiology into action when caring for patients. As a result, students developed a greater sense of how various bits of knowledge must be challenged when working with patients who have various medical conditions.

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