The Synthesis Unit: A Complementary Approach to Integration in a Problem-Based Learning Curriculum

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Summary

Integration across disciplines is an important component of a problem-based curriculum. However, clinical problems are often complex and require a high level of integration, not only across basic sciences and clinical disciplines, but also across different organ systems. The Geneva PBL curriculum is divided into four modules, each module being further divided in 3 to 4 units, corresponding to fundamental individual organ systems or body functions. A Synthesis Unit is designed at the end of each module to allow an integration across organ systems. For illustration purposes, the second module, situated in the first preclinical PBL-year, is described. It consists of 3 units: Circulation, Excretion & Homeostasis and Respiration. The Integration Unit at the end of this module contains 4 problems, which combine key concepts from the individual units. For example, development of right heart failure with peripheral edema in a patient with respiratory failure due to chronic obstructive pulmonary disease entices the student to study the interplay of the cardiovascular and renal systems in the pathogenesis of sodium retention, and the interaction between the renal and respiratory system in acid-base balance. Despite the high cognitive level of this task, and the requirement that the basic concepts in each organ system be mastered beforehand, preliminary experience is encouraging, with positive feedback from both tutors and students. Whether such a precocious transsystemic integration process is effective in favouring elaboration of knowledge in a preclinical curriculum remains to be demonstrated.

Introduction

A new problem-based curriculum was started in Geneva in October 1995, ranging from the second to the fifth year of the six-year medical studies. One aspect of the preclinical years (years 2 and 3) consists of prevalent or prototypical clinical problems, aiming at learning basic sciences (including pathophysiology), and semiology. They are divided into "Units", each unit representing an important body function and/or organ system. Units with related themes are in turn regrouped into four "Modules" (Table 1). A detailed description of the curriculum is provided in other articles.[1,2]

Inside each unit, basic sciences, clinical and psychosocial issues are integrated in the problems, a common type of integration of most PBL curricula.[3] However, comprehension of complex, albeit frequent clinical problems, require a supplemental level of integration, i.e. across the units of the PBL program. For example, understanding the pathophysiological mechanisms responsible for edema in heart failure necessitates the combination of concepts from both renal and circulatory systems. Acid-base balance, a notoriously difficult concept, requires integration of renal and respiratory physiology.[4] To meet these requirements, a "Synthesis Unit" was designed at the end of each Module, consisting of complex and integrative problems, with the following complementary objectives:

- to allow students to revise essential concepts originating from individual units;
- to combine these concepts in a meaningful way and to elaborate complex networks of pathophysiological concepts across systems;
- to reach a more in-depth understanding of the individual concepts by going through the above processes.

In addition, this also helped the students to review and prepare for the evaluation which concludes each Module.

This paper describes the contents and development processes of a "Synthesis Unit", an added concept in PBL, taking the second Module of the Geneva curriculum (Table 1) as an example.

Module 2 - Synthesis Unit

The 3 units of Module 2 are described in Table 1. Each unit lasts 4 weeks and comprises 7 to 8 problems, a typical problem requiring 12 to 14 hours of self-directed learning. The Synthesis Unit lasts 2 weeks and consists of 4 problems, each problem integrating objectives not only from different disciplines, but also from different organ systems. The summaries of the problems of the Module 2 Synthesis Unit and of their objectives are described below.

Problem 1

A 10-month old female baby with a 2-day history of vomiting and diarrhea presents at the emergency room. Physical examination discloses tachycardia and borderline hypotension. Laboratory tests reveal hyponatremia and renal insufficiency.

The objectives of this problem are the understanding of the interactions between circulatory and renal systems in counteracting the effects of volume depletion. The existence of hyponatremia allows a revision of the separate effects of the renin-angiotension-aldosterone (RAA) system and the antidiuretic hormone (ADH) system.

Advances in Medical Education
A.J.J.A. Scherpbier, C.P.M. van der Vleuten, J.J. Rethans, A.F.W. van der Steeg (Eds)
 pp 519-522

Table 1: Contents of the 4 modules of the 2nd and 3rd year of the Geneva curriculum.

Module	Unit			
1	Cell growth & aging	Nutrition & Digestion	Reproduction	Synthesis
2	Circulation	Excretion & Homeostasis	Respiration	Synthesis
3	Perception & Motor control	Behaviour & Communication	Locomotion	Synthesis
4	Infections	Defenses & Immunity	-	Synthesis
Length	4 weeks	4 weeks	4 weeks	2 weeks

Problem 2

A symptomatic arterial hypertension is diagnosed in a 33-year old asymptomatic blood donor. The serum potassium is borderline low. A diagnostic work up which is done to rule out renovascular hypertension turns out negative.

This problem focuses on the interactions between circulatory and renal systems in the regulation of blood pressure.

Problem 3

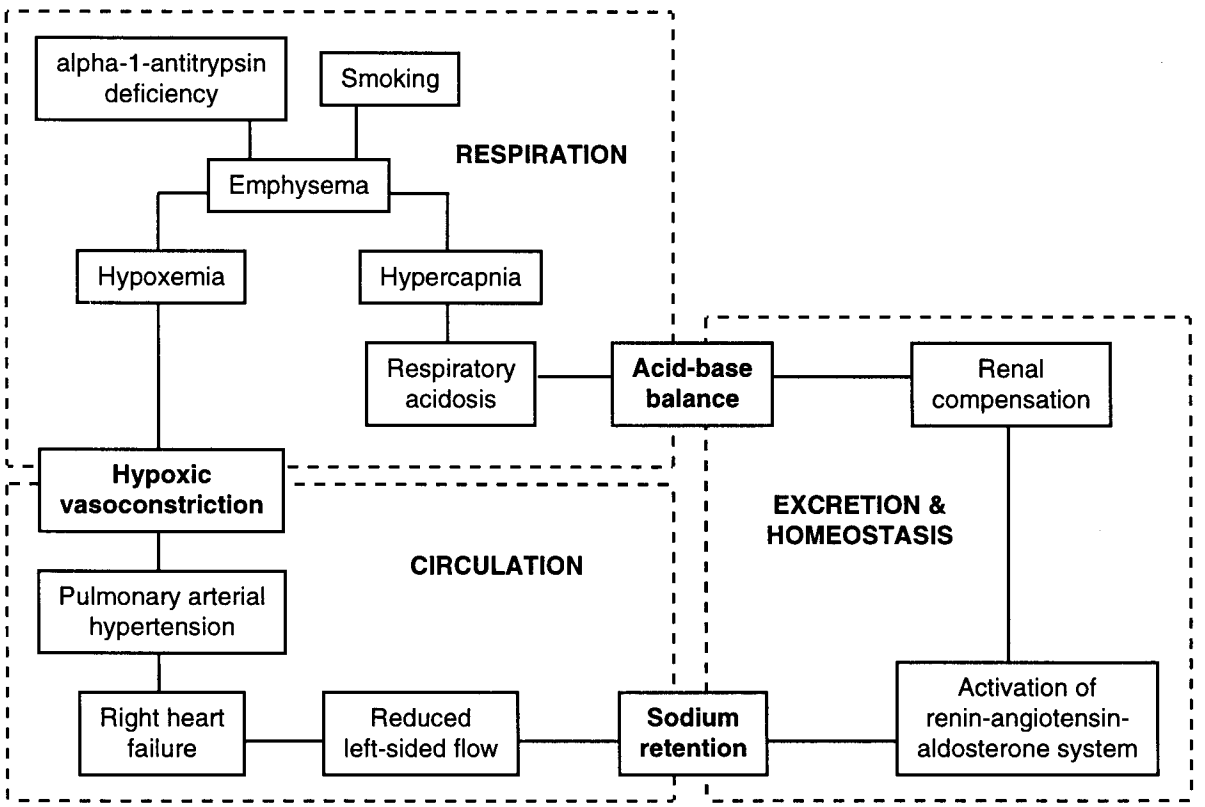
A 72-year old female with a history of long-standing arterial hypertension presents with symptoms and signs of congestive heart failure, and incipient pulmonary edema.

The problem aims at explaining the interplay of circulatory and renal systems in the pathogenesis of sodium retention and edema in congestive heart failure. The students must also reflect on the consequences of pulmonary edema on gas exchange, and of hypoxemia on the failing myocardium.

Problem 4

This problem is a sequel to a problem seen in the Respiration Unit. In the former unit, severe chronic obstructive pulmonary disease (COPD) was diagnosed in a 45 year-old male smoker, due to alpha-1-antitrypsin deficiency. The pathophysiological consequences of COPD on lung mechanics and gas exchange

Figure 1: Concept tree of problem 4. The contents of individual units (indicated in bold capital letters) are delineated by dashed lines, and the integrative concepts are indicated in the boxes with bold lettering.



and the effects of cigarette smoke on the lung were studied. In the Synthesis Unit, 2 years have elapsed, and the patients condition has worsened. He has developed increasing shortness of breath and signs of right heart failure. Blood gas analysis confirms severe hypoxemia and hypercapnia. The blood pH is normal due to renal compensation of acid-base balance.

The objectives are the understanding of the concept tree figured below (Figure 1).

Design of a Synthesis Unit

The working group responsible for designing the Synthesis Unit was composed of 10 to 15 basic scientists and clinicians (for Module 2: 2 pharmacologists, 3 physiologists, 1 cardiologist, 1 pathophysiologist, 3 nephrologists and 2 pneumologists). In order to ensure the coordination between the contents of the Synthesis Unit and the individual units of a learning module, the majority of those members were also members of the latter unit's working groups. The Synthesis Unit working group was responsible for setting the objectives, and creating the problems as well as the evaluation of the unit.

Experience with the Synthesis Units in year two

Since the Geneva curriculum is in its first year of implementation, the experience with this concept is obviously limited, and a few pitfalls could not be avoided in the design of this type of learning unit.

Module 1 Synthesis Unit

The units composing this first module are somewhat heterogeneous (Table 1), rendering the design of truly integrative problems more difficult. Moreover, faculty in this group was concerned by the little time allotted to the individual units of the module, which resulted in a "spillover effect": some problems that could not be addressed in a unit were moved into the Synthesis Unit (for example, a case of hyperthyroidism).

Consequently, the students were dissatisfied with the process, and considered that this unit was merely the fifth unit of the module and not a true integrative one.

Module 2 Synthesis Unit

Elaborating on the former experience with Module 1, the Synthesis Unit of Module 2 was more successful. The students described the problems as truly integrative and acknowledged the limited number of new learning objectives. Even so, 5 of the 28 students considered that the time for self-directed learning was insufficient, and a few remarked that the Unit was too centered on the cardiovascular system, at the expense of the renal and respiratory systems. Evaluation of the Unit by the tutors was unanimously favourable, even though not all the tutors had originally participated to the design of the Unit.

Potential limitations of the Synthesis Unit

Tutors

In the setting of the classical controversy on the degree of expertise necessary to tutor a PBL group, such an integrative unit added a degree of anxiety among tutors.[5] Indeed, the selected problems seemed to have a very clinical character, crossing the boundaries of several clinical specialties, whereas the objectives were really in the domains of basic science, particularly physiology, pathophysiology, and pharmacology. So, the basic scientists were reluctant to tutor in this Unit, since the breadth of the required knowledge base appeared to be overwhelming. Eventually however, 7 tutors participated in the Unit (4 basic scientists and 3 clinicians), and there was no difference in the student's evaluation of the clinician and basic scientist tutors. A "tutor effect" did not seem to exist in the evaluation, which was successfully completed by 26 of 28 students. Though this positive experience will probably put basic scientists more at ease, the future will show whether recruiting enough basic science tutors for a whole class of students (approximately 120) is feasible.

Learning process

Integration of concepts across both disciplines and organ systems is a complex cognitive task. Before implementing the unit, we anticipated that the integration process would require the students to master the individual concepts involved in order to be able to combine them in a meaningful fashion. This was not only correct, but we also observed that students who had not completely understood the basic physiological or pathophysiological concepts were able to use this Unit both as a revision and an opportunity for further knowledge elaboration. However, the time for self-directed learning may have been insufficient for these students who must carry out the tasks of both revision and elaboration simultaneously.

It can be hypothesized that such a unit prepare students to encapsulate knowledge of pathophysiology. In their cognitive model on the acquisition of medical expertise, Schmidt et al. describe 4 stages of the learning process.[6] The first stage is the elaboration of complex causal propositional networks, in which very detailed information is arranged in causal relationships. Stage 2 is the compilation of these elaborated networks into abridged ones. At this stage, repetitive encounters of similar problems allows the generation of short-cuts. The students do not have to activate all the possibly relevant knowledge to understand the problem. In a Synthesis Unit, pathophysiological networks from individual units must be recombined, requiring a compilation of the individual networks to obtain a more global one such as the one presented in Figure 1, representing a stage 2 activity. That this phenomenon may happen as early as the second year of the medical studies would be an interesting observation since the examples given by Schmidt et al. of stage 1 and 2 reasoning are those of a fourth- and sixth-year student, respectively. Whether the integration we are discussing truly represents a stage 2 cognitive level, and whether this level may be attained already in the preclinical years may be debated. However, we believe that such an integration favours the learning of pathophysiology in an

encapsulated form, a feature that might be important in the process of expertise acquisition. Indeed, although experts often refer to illness scripts containing little if any pathophysiology, expertise is correlated with the ability to recall pathophysiology when necessary.[5] This hypothesis remains to be demonstrated.

Conclusions

The Synthesis Unit is an added concept in the fertile realm of Problem-based learning, aiming at an integration not only across disciplines, but also across different organ systems. It may allow both a more in-depth understanding and an encapsulation of important pathophysiological concepts. Precocious high cognitive level, transdisciplinary and transsystemic integration has proved to be feasible in a preclinical curriculum; whether it is effective in favouring elaboration of knowledge remains to be demonstrated.

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