Evaluation of the teaching strategy of cardiovascular system in a problem-based curriculum: student perception

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Received 30 April 2003; accepted in final form 22 December 2003

The study is to identify where improvements can be made. Monitoring and evaluation of any curriculum, as a whole or by its components, is considered integral to fine tuning and improvement of the educational system in which students and teachers are systematically and periodically involved in the program evaluation (4, 12). The cardiovascular system (CVS) was chosen in this study because it is an important system to integrate in a PBL curriculum; also, it is one of the first systems that our students encounter in their study of organ/system units of the preclerkship phase. The purpose of this paper is first to describe how the CVS is taught in a PBL curriculum and second to report the results of our recent evaluation of the course from students’ perspectives. The ultimate aim of the study is to identify where improvements can be made.

The CVS is studied, together with the respiratory system, during the second phase of our medical curriculum; both subunits comprise Unit II of the organ/system units. The themes and intermediate objectives related to the CVS are formulated by the unit committee and included in a unit booklet. Disturbances of this system are conveniently studied through seven major health problems and extend over a period of seven weeks. These health problems cover the following general themes (objectives): function of the heart as a pump, including valves, development of the heart and great vessels, coronary circulation, cardiac electrical impulse generation and conduction, and hemodynamics (Table 1). The unit committee chooses the appropriate problems that address these objectives according to certain criteria: frequency, gravity, treatability, appropriateness for level, multisystem coverage, and potential for learning basic medical sciences, professional skills, and community health issues. Therefore, common and important cardiovascular events, diseases, and clinical presentations provide the basis for the study of the structure of the heart and blood vessels and their embryological development, regulatory and control mechanisms, important pathological processes, and pharmacological principles of treatment. The students learn not only laboratory and professional skills but also important concepts in community medicine, such as burden of illness, risk factors, screening, and health education, during the entire unit.

For example, one of the health problems that students encounter in their study of the CVS is a retired worker who had been suffering from hypertension for the past five years and...
developed shortness of breath and edema because of congestive heart failure (CHF). Students interact in their first tutorial (day 1; Fig. 1) so as to develop learning needs to understand the cardiac muscle and its properties, intrinsic and extrinsic control of cardiac muscle, measurement of cardiac output, control of heart rate, pathophysiology of fluid retention, investigations including chest X-ray, principles of drug treatment in heart failure, and community-oriented problems. The students within a group then distribute these learning needs among themselves and obtain the required information through textbooks, the Internet, assigned disciplinary resource staff, laboratories, anatomy museum, and audio-visual aids. At the end of that week, the second tutorial (day 5) commences with discussion of those learning needs on which self-study was undertaken (Fig. 1). On days 3 and 5, multidisciplinary resource sessions are also arranged to orient the students and to explain complex or difficult topics such as pressure-volume loop and pathophysiology of CHF as well as stressing the linkage between basic medical sciences and clinical practice. To strengthen the contention that the etiology of CHF varies, the students are given three miniproblems on day 5 (second tutorial), namely right heart failure, left heart failure, and digitalis toxicity. These miniproblems not only broaden the clinical presentation of CHF but also assist the students to gain some insight into the pathophysiology and complications of the disease process and improve self-assessment skills. For example, in the miniproblem of acute left-ventricular failure, students go through the case history of a 55-year-old man brought to the Accident and Emergency Department complaining of sudden onset of dyspnea and a history of retrosternal pain radiating to his left arm of four hours duration before the dyspnea. After being provided some additional general and chest examination findings, students are asked about the likely diagnosis, the significance of chest pain, the immediate non-invasive investigation required, and the drug therapy that is considered in this patient. On day 1 of the next new problem, an interactive review resource session on earlier issues of CHF takes place in the presence of all concerned faculty to ensure that students have acquired basic knowledge of the disease process and have been exposed to the cutting-edge research data.

Students are also exposed simultaneously to the professional skill program to appreciate the need for clinical examination. For example, during the week of CHF, the students are expected to know waves of jugular venous pressure and their significance. Also, surface markings of cardiac borders and heart valves are emphasized, and ability to interpret radiological changes of the heart is stressed. The question obviously arises as to whether or not the students find difficulty in mastering all the required knowledge and skills within one week’s time in relation to a particular problem. This is partly avoided because the triggers of the problems are constructed in such a way that many of the learning needs fall on the subsequent problems (such as electrocardiogram interpretation in the problem of myocardial infarction) so that the students get ample time to catch up. The students are also informally assessed in the tutorial by being provided multiple-choice questions at the end of the second tutorial session.

At AGU, students are assessed in a comprehensive manner. Multiple strategies are used, as it is known that no single

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Table 1. General objectives (themes) of CVS and corresponding health problems that address these objectives

<table>
<thead>
<tr>
<th>Themes</th>
<th>Health Problems</th>
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<tbody>
<tr>
<td>Function of the heart as a pump including valves</td>
<td>Congestive heart failure</td>
</tr>
<tr>
<td>Development of the heart and great vessels</td>
<td>Rheumatic heart disease</td>
</tr>
<tr>
<td>Coronary circulation</td>
<td>Congenital heart disease</td>
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<tr>
<td>Cardiac electrical impulse generation and</td>
<td>Myocardial infarction</td>
</tr>
<tr>
<td>conduction</td>
<td>Arhythmia</td>
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<tr>
<td>Hemodynamics</td>
<td>Hypertension</td>
</tr>
<tr>
<td></td>
<td>Pulmonary embolism</td>
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CVS, cardiovascular system.
Table 2. List of 11 items comprising part 1 of questionnaire used in study

For each of the following question items, students were asked to respond by ticking one of the opposite boxes of “Yes” or “No”:

A. Knowledge
1. Did the course help you to achieve the unit’s general objectives (themes)?
2. Did the resource sessions help you to understand difficult or complex topics?

B. Integration
3. Did the course succeed to integrate different disciplines within the CVS?
4. Did the course succeed to link between different health problems of the CVS?
5. Did the course help you apply knowledge of basic science in clinical reasoning and diagnosis?

C. Skills
6. Did the course succeed in promoting your problem-solving skills?
7. Were the basic science laboratory skills useful for understanding and clinical reasoning of the health problems?
8. Did the professional skill laboratories help you acquire skills that are useful for clinical diagnosis and application?
9. Did the arrangement of the resource materials in the anatomy museum help you in self-study?
10. Do you think that some gaps in knowledge are still present after completing study of CVS?
11. Overall, are you satisfied with the learning outcome from study of the CVS unit?

Results

Student responses. Of 60 questionnaires distributed, 90% were completed sufficiently for data analysis. Respondents consisted of 42 females and 18 males, and their mean age was of 20 years. Data from the closed-ended questions were analyzed by assigning 1 to the “yes” response and 0 to the “no” response about the items in the questionnaire. The Cronbach’s α-coefficient of the questionnaire was 0.72. The relative frequency distribution of each item was obtained. Qualitative content analysis of the open-ended questions in part 2 of the questionnaire was also done.

Responses to part 1 of the questionnaire. The average percentage scores of student positive responses to items related to the three main domains of learning (knowledge, integration, and skills) were 62.7, 87.3, and 77.1%, respectively. Percentage scoring of student positive responses to individual items in the questionnaire (Table 3) indicate that the lowest score was given to the role of resource sessions in understanding difficult concepts (32.7%), and the highest score was given to student overall satisfaction with the study of the unit in the integrated problem-based approach (92.7%). Interestingly, 90.7% of the students were aware of the presence of gaps in their knowledge at the end of the unit.

A series of χ² tests was used to test the associations among the items of the questionnaire. Those tests show significant associations among the items. Figure 2 shows the Spearman
rank correlation coefficients and their corresponding $P$ values among the three main sections/categories of the questionnaire (knowledge, skills, and integration). Achievement of unit objectives was significantly associated with 1) integration between different disciplines ($\chi^2 = 7.74$, $P = 0.005$), 2) linkage between different problems ($\chi^2 = 14.25$, $P < 0.000$), 3) role of the anatomy museum in promoting self-study ($\chi^2 = 13.44$, $P < 0.000$), and finally 4) overall satisfaction with the study of the unit ($\chi^2 = 10.67$, $P = 0.001$). Integration among different disciplines of the unit was significantly associated with 1) linkage between different problems ($\chi^2 = 8.58$, $P = 0.003$), 2) role of basic science laboratory skills ($\chi^2 = 5.58$, $P = 0.018$), 3) awareness of gaps in knowledge, and 4) achievement of unit objectives. In addition to the association with achievement of unit objectives and integration among the different disciplines of the unit, linkage between different problems in the unit was also significantly associated with items such as application of basic science knowledge in clinical diagnosis ($\chi^2 = 13.94$, $P < 0.000$), role of the anatomy museum in promoting self-study ($\chi^2 = 33.70$, $P < 0.000$), and overall satisfaction of the study of the unit ($\chi^2 = 14.26$, $P < 0.000$). Also, there was a significant association between problem-solving skills and role of the anatomy museum in promoting self-study ($\chi^2 = 4.52$, $P = 0.034$). Finally, the role of the anatomy museum in promoting self-study was significantly associated with overall satisfaction with the study of the unit ($\chi^2 = 5.95$, $P = 0.015$) besides its association with other items mentioned.

Responses to part 2 of the questionnaire. Table 4 shows the percentages of the main comments made by 32 students only. In general, comments described the points of strength in the unit, in descending order, as 1) interesting and enjoyable learning experience, 2) good deal of horizontal integration within the unit, 3) laboratory skills (both basic sciences and clinical) were useful, and 4) well-organized unit. Suggested points for improvement in the unit included 1) more time to be assigned for the unit, 2) more facilities to be made available in laboratories and anatomy museum, and 3) request for review sessions made available before end-of-unit exams.

**DISCUSSION**

The evidence and experience to date support the assertion that students in general achieved satisfactory learning outcomes from the study of the CVS as part of the PBL curriculum at AGU. The distinctive features of the course include good structuring and organization, acquisition of sufficient basic knowledge, a good deal of horizontal integration, the central role of self-directed learning, the usefulness of learned skills in clinical reasoning and diagnosis, and special emphasis on appropriate personal needs and limitations.

As expected, learning CVS with the problem-based approach is considered an interesting method to study medicine as a majority of the students were satisfied and enjoyed studying the unit. The system of PBL practiced at AGU, while allowing some degree of early exposure to clinical situations in the form of professional skills, enables students to deal with hypothetical cases. Students perceive such exercise to be more interesting and enjoyable than lectures on the basic medical sciences, as is commonly practiced in conventional curricula. Furthermore, the feeling of satisfaction derived from the act of discovery certainly adds to the enjoyment of learning (6). However, despite this perceived advantage of PBL, more than 90% of our students felt that there might be gaps in their knowledge after completing study of the CVS, as the health problems do not necessarily address all the knowledge and skills they are required to master at this early stage of the curriculum and in a relatively short period of time. Gaps in knowledge are probably the same in both traditional and PBL curricula for the same obvious reason: time factor limitations vs. how much “core” knowledge needs to be covered. However, what perhaps is unique in PBL is the conscious realization and awareness by students of the presence of such gaps. This feature of self-appraisal or -awareness by itself can be considered a skill, which highlights two important aspects applicable to PBL. First the ability of students to make real assessments of their knowledge needs and second the awareness of the presence itself of knowledge gaps will motivate students for further self-directed learning. Furthermore, our current medical curriculum allows valuable means of filling some of these gaps later in the clerkship phase in the form of integrated multidisciplinary seminars and specially tailored courses in applied basic medical sciences given during clinical hospital rotations. As the learning process advances and more health problems are studied in units to come and beyond in the curriculum, knowledge and problem-solving skills will certainly increase in both depth and breadth in a spiral fashion, amplifying vertical integration (1).

One of the greatest advantages claimed for PBL is that it encourages integration of learning. Although this is logically so, it was interesting to determine whether students in fact
undertake an integrated learning approach when they review material in preparation for the CVS examination. In fact, the new face of the anatomy museum at AGU, which comprises 42 modules or learning carrels that focus on specific organ systems incorporating labeled gross, microscopic, and radiological anatomy specimens (3), has helped the students in promoting self-study by focusing on unit themes and has encouraged them to study across cardiovascular health problems as well. PBL is an important educational strategy for integrating components of the curriculum, which has been shown to bring real benefit to student learning (13). In the present study, the student evaluation percentage score for integration between basic and clinical sciences was 87% and between different problems within the CVS was 94%.

The observation that the percentage scoring of the role of the scheduled resource sessions in understanding difficult learning issues of the CVS was only 32.7% emphasizes a characteristic feature of the PBL process. It certainly strengthens the contention that students prefer the self-learning approach to didactic lectures/seminars. Whether or not the degree and level of integration in these resource sessions has any impact on student learning, however, needs to be carefully examined and addressed in the future. Nevertheless, our study clearly indicates that, by developing the skill of self-directed learning, PBL aids students to develop the ability to identify what they need to learn, the ability of recognizing limitations and/or deficiencies, and the ability of criticism. All these qualities are important in promoting the habit of critical self-appraisal and commitment for lifelong education.

In conclusion, although the present report emphasizes student perception of learning of CVS in a PBL curriculum, it remains to be seen whether this perception changes as students progress to study other system units. Nevertheless, results of the present study of the CVS have identified some characteristic features, as indicated by student responses. These include good structuring and organization, acquisition of sufficient knowledge, a good deal of integration, the usefulness of learned skills in clinical reasoning and diagnosis, the important role of self-directed learning, and recognition of appropriate personal needs and limitations, all blended in an enjoyable atmosphere of learning experience. These results support the assertion that students overall achieved satisfactory learning outcomes from the study of the CVS as part of the PBL curriculum at AGU.

ACKNOWLEDGMENTS

We are grateful to Profs. Raja Bandaranayake and Hossam Hamdy for their encouragement and continued support.

REFERENCES