Active learning in a large medical classroom setting for teaching renal physiology

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In recent years, the Liaison Committee on Medical Education has emphasized reductions in the number of passive basic science lectures with a move to a more active learning environment. In the past, we have met this challenge by introducing small-group sessions for each of the major areas of medical physiology where a faculty member meets with a group of 8–12 first-year medical students to discuss clinical cases. The cases were specifically designed to emphasize important physiological principles. Over time, this approach proved difficult as class size increased and the number of expert physiology faculty members decreased. Also, the logistical problems of attempting to schedule ~15–18 conference rooms for ~6 sessions/semester became increasingly troublesome. As an alternative, some faculty members experimented with dividing the class in half and presenting clinical cases in two lecture halls, each with an expert in that subject area. That approach worked fairly well but allowed many students to remain passive with little active participation.

The active learning exercise described here has been used to replace some lecture hours in the renal portion of an integrated, organ system-based curriculum for first-year medical students. The exercise takes place in a large auditorium with ~150 students. Two faculty members, J. R. Dietz (a physiologist) and F. T. Stevenson (a nephrologist) lead the discussions, which are based on two clinical cases developed from actual patient data. The cases have already been published in the American Physiology Society Teaching Archive (objects 195 and 3814) (1, 2). The students are preassigned to groups of 5 or 6 students/group and designated to sit in clusters to facilitate their individual group discussions. Each of the faculty members wears a lapel microphone, and each carries a handheld microphone to pass between the student groups.

The PowerPoint slides used in conjunction with the exercise (selected slides included) were produced with Turning Point software so as to take advantage of clicker questions, which have been shown to facilitate active learning. Our students are required to purchase Turning Point clickers (transmitters) as part of their "school supplies."

Timeline for the Active Learning Exercise

(Note: only selected PowerPoint slides are included here. The full set of slides can be obtained by e-mailing the author).

Slide 1. Introduction.

Slide 2. Objectives for case 1.

Slide 3 (Fig. 1). GROUP TASK. One of the faculty members reads the case, and the available data are displayed for the students to contemplate. The groups are instructed to take 5 min to discuss the two questions at the bottom of the slide:

1. In general, what are the possible causes of polyuria and/or polydipsia?
2. In this patient, can you rule out some of these?

Fig. 1. Turning Point slide 3. As a group task, one of the faculty members reads the case (case 1), and the available data are displayed for the students to contemplate. The groups are instructed to take 5 min to discuss the two questions at the bottom of the slide. BP, blood pressure; RBC, red blood cells; WBC, white blood cells.

A 48 year old male was seen in a clinic with a complaint of polyuria and polydipsia. History: frequent urinary tract infections secondary to a neurogenic bladder (traumatic spinal cord injury). BP = 130/90 mmHg & pulse rate = 100. He stated that the only medication he was taking was Tylenol. Blood samples were drawn and a 24 hr. urine collection was made on an outpatient basis.

<table>
<thead>
<tr>
<th>PLASMA</th>
<th>(lab normal range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺ 148 mEq/L</td>
<td>(135-145)</td>
</tr>
<tr>
<td>K⁺ 4.2 mEq/L</td>
<td>(3.5-5.3)</td>
</tr>
<tr>
<td>Creatinine 1.3 mg/dl</td>
<td>(0.6-1.4)</td>
</tr>
<tr>
<td>Hemoglobin 18.6 g/dl</td>
<td>(13-16)</td>
</tr>
<tr>
<td>Osmolarity 300 mOsm/Kg</td>
<td>(280-295)</td>
</tr>
<tr>
<td>Glucose 127 mg/dl</td>
<td>(non-fasting)</td>
</tr>
<tr>
<td>Ca²⁺ 9.7 mg/dl</td>
<td>(8.5-10.5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>24Hr. Urine</th>
<th>(lab normal range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vol. 4.2L</td>
<td>(1.5-3)</td>
</tr>
<tr>
<td>Na⁺ 40 mEq/L</td>
<td>(10-100)</td>
</tr>
<tr>
<td>Creatinine 60 mg/dl</td>
<td>(20-100)</td>
</tr>
<tr>
<td>Osmolarity 304 mOsm/Kg</td>
<td>(500-750)</td>
</tr>
</tbody>
</table>

Urinalysis:

- Glucose (-);
- Protein (-);
- RBCs (-);
- WBCs (very numerous);
- Casts (-).

In general, what are the possible causes of polyuria and/or polydipsia? In this patient, can you rule out some of these?

(some details have been modified or omitted to prevent patient recognition)
Which of the following is of the least importance in the renal concentrating mechanism?

1. Reabsorption of Na+ and Cl- in the thick ascending limb (diluting segment).
2. Reabsorption of Na+ in the Proximal Tubule.
3. Low flow through vasa recta.
4. Counter current multiplication.
5. Aquaporin channels
6. ADH

The purpose of the group task is to allow each small group to discuss the case information and present to each other the various hypotheses on the questions presented. This is a core feature of the active learning exercise. After the 5-min individual discussions, the faculty member holds a whole class discussion by passing around the hand microphones and soliciting opinions from the various groups. When a consensus is reached, we move on to the next question. Again, this is a core feature of the active learning exercise.

**Slide 4. Group Task.** This patient was transferred to the hospital, where additional tests were performed. Students are presented with the results and given 10 min to ponder several additional questions for group discussion. Again, as in slide 3, the faculty member holds a whole class discussion until a consensus is reached.

**Slide 5 (Fig. 2).** Slide 5 shows clicker questions that address factors that are important in the renal concentrating mechanism. Students are asked to submit their clicker responses individually. If there is notable disagreement, the groups may be asked to discuss the answer, and the students can then reenter their responses. ADH, antidiuretic hormone.

**Slide 12.** Clicker questions testing the student’s understanding of the hormones that affect Na$^+$ reabsorption and how each could contribute to edema.

**Slide 13 (Fig. 4).** Group Task. Additional data. Group questions were similar to those shown in slide 4.

**Slides 14–17.** Clicker questions to address K$^+$ handling and how diuretics produce hypokalemia.

**Slide 18 (Fig. 5).** Slide 18 shows a figure used to clarify any additional questions on the mechanism of diuretic-induced hypokalemia.

**Slide 19.** Slide 19 shows a figure used to answer student questions or to clean up misconceptions before moving on.

**Slide 20.** End of the active learning conference. The total time is ~1.5–2.0 h, but cases can be divided and used individually.

Note: since not all schools require their students to purchase Turning Point clickers, an alternative is to have students hold up numbered cards to survey group answers, as is done in team-based learning sessions at many institutions.

**Slide 7 (Fig. 3).** A 65 year old man is treated with the Maze Procedure (http://www.sts.org/doc/4511) for recurrent atrial fibrillation because it was refractory to pharmacological treatments with propranolol and verapamil.

**Slide 11.** Group Task. This was conducted similar to slide 3.
conference, the PowerPoint slides and answers to the questions are posted on the course website.

The active learning exercise performed in a large-group setting has several important advantages:

1. Since all of the groups are at the same location, each group benefits from every hypothesis and opinion shared by the instructors.
2. Passing the microphone between groups brings a large number of students into the discussions.
3. One or two expert faculty members can address a larger group to answer questions or summarize important points of the clinical case.
4. There is less strain on limited faculty and facilities than encountered when trying to schedule 20–30 small groups in separate rooms with separate facilitators.

Question slides are of two types. More open-ended, contemplative questions (e.g., “What are the three most likely causes of the patient’s complaints?”) are discussed by groups and shared in plenary discussion. More detailed questions can be asked by clicker responses, and the responses can either be confirmed, elaborated, or returned to group discussion by faculty members, depending on the responses submitted. This approach allows faculty members to monitor both the preparation and synthetic abilities of the students as the case progresses.

The active learning approach described here can be conducted with one faculty member in a large group but works best with two experts, especially with a clinician and a physiologist who interact well with each other and enjoy this type of interaction. It is important to have the two faculty members discuss the case, the teaching format, and potential difficult learning issues in advance. In addition, it is helpful to display collegiality and for each faculty member to rely on the other for information that the other lacks. This demonstrates faculty lifelong learning to students.

Ideally, the exercise should be run in a single large auditorium with enough extra seating to allow groups to spread out a bit. However, in our most recent year, our largest auditorium was under renovation, and we conducted the exercise simultaneously in two separate lecture halls with the class split in half (150 students divided between 2 halls with a capacity of 140 people each). This approach requires one expert faculty member in each room and requires excellent information technology support so that both auditory and visual interactions are maintained between the two rooms. As long as each faculty member could see and hear each other in the other room, this procedure works well. The discussion among groups can continue in each room more independently, and key conclusions can then be summarized from each classroom to the other. The faculty members continue to engage one another verbally back and forth during this process, symbolically uniting the two rooms.

One of the authors has presented the renal and acid-base sections of medical physiology for first-year medical students for many years, which has historically consisted of 16 lecture hours. This past year we have replaced 4 lecture hours of this section with the described active learning exercise of 2 h and an additional active learning exercise on acid-base cases, which also constituted 2 h. Student test scores for this section remained at the same high level as in previous years. Student satisfaction and engagement based on written comments have always been at very high levels for this section of physiology.
but were still improved from past years. Therefore, we were able to reduce lecture hours by 25% with no decrease in achievement and a noticeable increase in student satisfaction.

DISCLOSURES
No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS
J.R.D. and F.T.S., conception and design of research; J.R.D., interpreted results of the experiments; J.R.D., prepared the figures; J.R.D., drafted the manuscript; J.R.D. and F.T.S., edited and revised the manuscript; J.R.D. and F.T.S., approved the final version of the manuscript.

REFERENCES