Excellence in Basic Sciences: A Novel Model for Instruction of Medical Students

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ABSTRACT

An innovative and educationally sound method was introduced at the University of Louisville, School of Medicine for the education of the second year medical students. Instruction is by physicians, who present a clinical case in the Socratic manner. A group of students, through questioning, derive important facts about the case and ultimately agree on a differential diagnosis for the patient described in the case. The students then spend individual time arriving at the diagnosis of the disease and submit a report on their research. This information is shared with the entire class. This novel approach is amenable for use in other medical school years, as well.

INTRODUCTION

Extensive research on student learning has been conducted and has revealed that students learn most effectively (in ways that have sustained and substantial influence on the way they think, act, and feel) when at least five conditions prevail: 1) when they are trying to solve problems or answer questions that they regard as important, intriguing, or beautiful; 2) when they are able to do so in a challenging yet supportive environment in which they can feel a strong sense of control over their own education; 3) when they can work collaboratively with other learners to grapple with the problems; 4) when they believe that their work will be considered fairly and honestly; and 5) when they can try, fail, and receive feedback from expert learners in advance of and separate from any summative judgment of their efforts. This summation is distilled from the work described in references. [1-18]

Excellence in Basic Sciences (EBS) was formulated on the basis of the research described above and matches all the criteria listed for optimal learning conditions. It is a method designed for putting medical students into a situation of nonthreatening discovery, relevant and cooperative learning, and group and individual problem solving.

MATERIALS AND METHODS

The cases

A clinical case illustrating a particular organ system is developed for the series. This includes a write-up of the case, attachment of appropriate history of present illness, relevant symptoms, physical findings, laboratory tests, imaging studies, and anything else that leads to a definition of the medical cause of the case. Then, after the solution is developed, all of the relevant basic science facts, which relate to the case are added (Figure 1).

The complete case is made available to the physician presenters. However, only the stem of the case describing the patient and complaint which brings the patient to the physician is distributed to the students (in this instance the second year medical class) by email.

The presenters

Physicians at various stages of their career are recruited to present the case to medical students (described in results).

The session

Students come to the session with the case. The physician opens with the question: “What do you want to know?” The physician only provides answers for questions asked by the students. As the questioning proceeds, the history, physical examination, tests ordered and available results are revealed, if requested. In the beginning sessions, the physician may prompt the students to make sure all relevant data are covered in the discussion. Later sessions reveal that the students have acquired a very efficient data seeking methodology. The physician then helps the students develop a differential diagnosis based on what has been revealed. Often this involves discussion among the students who are present at the session. The students are left with several differential possibilities, including the true solution to the case. Ideally, the students then do their own research to come up with the diagnosis and support their findings. They email the solution to the course

Figure 1. (References 19, 20)

Beatrice, "Bee" to her friends, is a 39-y/o single woman who presents to the University of Louisville Hospital ER with increased shortness of breath, accompanied by left pleuritic chest pain. These symptoms started about 2 weeks ago. Prior to that she had no relevant health complaints. She is concerned.

What do you want to know?

History: She has a history over the past year of "dysfunctional uterine bleeding". Her chest pain has worsened upon respiration, is stabbing, and does not radiate. She also reports that she has increased coughing and brings up "yellow-green sputum" sometimes tinged with blood. She also states that she has had recent fevers, accompanied by chills. She is also easily fatigued and reports that she is disinterested in many of the things she likes to do. She reports she was tested for tuberculosis earlier this year, but the test was negative.

Family history- Significant for heart disease, her father, an aunt, and two uncles had early cardiac infarctions.

Social history- She is involved with church outreach activities and does not tolerate the use of alcohol, drugs or tobacco.

Meds- She is allergic to beta lactam antibiotics. She is currently on iron sulfate.

PE: Decreased chest movement during inhalation on the left side. Dullness of percussion on left lung base. Reduced breath sounds over left lung base and bronchial sounds auscultated on left side with friction rub. Tests on the right side are normal. Location of dullness moves with respiration and there is a decreased tactile fremitus over the left lung. Temperature is 102.9^{o} F; BP 87/55; pulse of 130, and respiration rate of 23. Head, neck, cardiac, abdomen, visual, extremity tests normal

LABS:

- CBC- elevated WBC with predominance of neutrophils
- Serum LDH- 248 U/L (100-190 U/L)
- Serum protein- 3.9 mg/dL
- Thoracentesis under CT guidance yields about 100ml of purulent fluid.
- Assay of purulent fluid: WBC 250,000 with 99% segs, 1 % lymphocytes, and no monocytes visualized. Pleural fluid glucose is 5.8mg/dL, protein 5.0mg/dL, and LDH at 20,000 U/L. Gram stain- visualize WBC and some Gram-positive cocci.
- Pleural fluid culture- Group A *Streptococcus.*
- Sputum culture- Gram stain- WBC, some epithelial cells and many Gram-positive cocci. Cultures grow *Staphylococcus aureus.*

CT: Chest shows "large left pleural effusion that has areas of loculation along the medial left heart border".

Diagnosis: Pleural disease as a sequelum to bacterial infection

Treatment: A left chest tube is inserted and a liter of fluid is drained. Bee's temperature decreases but she continues to have some fever and her white cell count does not moderate. When the fluid has drained, an X-ray demonstrates some areas of loculated fluid. She is treated with streptokinase through her chest tube to facilitate drainage. She subsequently responds to the treatment and is ultimately released and prescribed antibiotics to resolve any residual bacterial infection.

Basic science discussion: Effusions may be due to infection (viral, mycobacterial, bacterial, fungal) or malignancy, congestive heart failure, cirrhosis, nephrotic syndrome, trauma, pancreatitis, collagen disease and drug reactions. Effusions are transudative or exudative

	Transudative	Exudative
Pleural TP/serum TP	<0.5	>0.5
LDH	<2/3 upper normal	>2/3
Pleural LDH/serum LDH	<0.6	>0.6
WBC	<1000	>100,000
Glucose	= blood	< blood
Protein	<3g/dL	>3g/dL
Causes:	CHF, cirrhosis, nephrotic syndrome, peritoneal dialysis, hypoalbuminemia, urinothorax, atelectasis	TB, infections, malignancy, pancreatitis, pulmonary embolus, Chylothorax (milky pleural fl.), drugs, collagen vascular disease

Incidence of Pleural Disease (USA per year)			
CHF	500K	Pulmonary embolism	150K
Pneumonia (bacterial)	300K	Viral diseases	100K
Malignancy	200K	Cirrhosis (ascites)	50K
Lung	60K		
Breast	50K		
Lymphoma	40K		
Other	50K		

Figure 2. Sample solutions from students

1) A little review: "The pleura is a serous membrane made of a single layer of mesothelial cells. The *visceral pleura* covers the lung parenchyma, and the *parietal pleura* covers the remaining structures of the thoracic cavity. The airless space between the parietal and visceral pleurae is the *pleural space*. The fluid in the space is normally clear and colorless with a low protein concentration (less than 1.5 gm/dL) estimated at 10 ml in humans."-Noble:Textbook of Primary Care Medicine, 3rd Ed.

   Parapneumonic Effusion is defined as a pleural effusion associated with bacterial pneumonia. It occurs in 40% of bacterial pneumonia cases on the ipsilateral side of pneumonia. Pneumococcal pneumonia...although most common...does not usually cause parapneumonic effusion. This is usually caused by anaerobes, Gram-negative bacteria, *Staphylococcus aureus* and *Streptococcus pyogenes*. (Our patient had a Staph/Strep pneumonia).

   Criteria are as follows: Pleural effusion has 3 cardinal signs-dyspnea, chest pain, and a nonproductive cough. Parapneumonic effusion if exudative with leukocytes>10K and mostly PMNs. Uncomplicated if effusion resolves with antibiotic therapy only. Complicated if fluid needs a chest tube drainage, is empyemic, has a pH <7.0, glucose<40mg.dL or LDH > 1000 IU/L (our patient fits this profile)

   Source: Noble: Textbook of Primary Care Medicine, 3rd Ed.

2) I came in a little late, so I may not have all the correct information, but here is what I think: The patient's presentation is most consistent with a diagnosis of bacterial pneumonia with the complication of pleural effusion. Her fever, chills, pleuritic (stabbing, non-radiating) chest pain, cough production of yellow blood tinged sputum, dullness at left lung base, friction rub, decreased chest movement on the left, increased neutrophils, and Gram-positive cocci are all diagnostic features. I would even venture to say she may have empyema due to leukocytosis and infection.

director within three days (Figure 2). As an added benefit, a cost analysis of what the students "ordered" can be presented to the class to expose them to the reality of medical costs (Figure 3).

The solution to the case

The complete solution is posted a few days later for the class to review and copy if needed. Also, the solutions offered by students are posted along with the case for everyone to review.

RESULTS AND DISCUSSION

During the last two academic years, 57 voluntary Excellence in Basic Sciences (EBS) sessions have been done at the University of Louisville School of Medicine. The sessions occurred each Wednesday at noon, except during examination weeks and vacation time. The attendance varied with the sessions and the other events occurring at the medical school (ranging between 10 and 40 students per session/class of 140). There was a core of students that did not miss a session. There were several who came to most of them. Other students attended some sessions but not others, as time permitted. However, as shown in Figure 4a, the worth of these sessions was high for everyone who completed the survey and who attended the sessions. The overall effectiveness was rated as very high (Figure 4b). Since only a fraction of the class participated in this voluntary activity, the results may be skewed by the fact that motivated students, who would benefit most from these sessions, participated most and rated it well. This cannot be disproved, though experience has shown that students who are not at the top of the class have also come to the sessions regularly and even if not visibly participating, still took careful notes and presumably benefited from the exercise. A minority of the students turned in reports, though some did it regularly. Many more copy the posted case, solution and basic science correlation. Some request that the solution be emailed to them. Many keep a portfolio of these cases and use it as a

Figure 3. Estimated cost analysis of procedures in this case. (Average charges at our ER)

Level III ER Visit (Facility fee)	$348
Level III ER Visit (Physician fee)	$150
Chem 7	$115
CBC	$102
Chest X-ray	$190
Chest CT scan	$897
(Could you have treated with CXR only? Note huge cost difference)	
Chest tube insertion (Facility fee)	$396
Chest tube insertion (Surgeon fee)	$150
IV Clindamycin	$120/day x 7days
TCU hospital bed for 4-days/chest tube care	$1900/day
Physician hospital follow up visit for 6days	$55/day
Med/Surg hospital room for 3 days	$845/day
Total charges to Patient	$13,653

Remember these are average charges and it doesn't mean the insurance company will pay this. They usually steeply discount reimbursement. Medical care is expensive and should be considered as you order procedures and labs.

Figure 4a. Analysis of Student Responses to Questions about EBS (1 year)

Questions	Frequency
Were you able to correctly diagnose cases?	69% (22/32)
Did you find the case studies valuable even when you missed the diagnosis	88% (28/32)
These sessions will continue in the 2003-4 academic year. Would you recommend the EBS sessions to those coming behind you?	78% (25/32)

Figure 4b. On a scale of 1 to 5 with one being worst to 5 being best, please rate the effectiveness of EBS

Frequency						Mean	Median	SD
Scale	1	2	3	4	5			
# respondents	1	3	11	11	6	3.6	4.0	00

study aid. The students can interact with EBS at three levels-active research and solution of the case, passive note taking and copy of the solutions, or just listen to the presentation and derive knowledge of the clinical discovery mechanism. All are valid responses to the EBS series. More students would participate, if there were not competing events at lunchtime and the pressures of block exams at our school. Other schools may choose to operate a similar series at a different time of day.

In the last academic year we ran sessions on: kidney stones, MS, portal hypertension, idiopathic myelodysplasia, inflammatory bowel disease, PHH, Von Willebrand's Disease, acute pancreatitis, chronic granulomatous disease, myelodysplastic syndrome, pleural disease, tic doulourex, osteomalacia, juvenile rheumatoid arthritis, arsenic poisoning, Von Gierke's disease, hypothalamic amenorrhea, Munchausen's syndrome, depression after MI, sarcoidosis, Legionnaire's disease, pheochromocytoma, CMV colitis and *clostridium difficile* in AIDS, jaundice-neonatal and estrogen induced cholestasis, protein malnutrition-kwashiorkor, pancreatic-pleural fistula compounded by chronic pancreatitis and onset diabetes, and bioterrorism.

The faculty who ran these sessions ranged from residents and chief residents in Family Medicine, Pediatrics, Internal Medicine, and Medicine to faculty in Pediatrics, Medicine, Surgery, Family Medicine and Psychiatry. We also had the Dean of Student Affairs, the Associate Dean for Curriculum, and course directors for Pathology, CPS (Clinical preparation course) and PCC (Clinical Services). The sessions worked with no formal preparation of the faculty. They all received the full case several days before their presentation and had time to prepare themselves for the questions the students offered. Preparation time varied from person to person but usually consumed no more than a couple of hours. Some also brought ancillary materials and also prepared some basic science explanation of what results from physical exams, labs, and devices would indicate for the patient under discussion. We have videotaped some of our presentations and intend to use them as training material for future physicians.

The whole session is student question driven and relies on the innate knowledge of the physicians to relate the relevant facts to the students. Several of the physicians presided over multiple cases, and every one of them found this to be a stimulating and "fun" experience. Every one of the presenters has volunteered to run a case next year and we have several new volunteers as well. The Dean for Student Affairs ran two sessions, one early and one later in the year. She was impressed how far the students had progressed in their discovery questions and correlations.

CONCLUSIONS

In sum, EBS represents an exciting, novel education technique that both the students and the presenters appreciate. The learning in these sessions is multifaceted, not only exposing the second year students to the discovery process that they will learn in detail in the third year, but also causing them to recall and fix in memory basic science facts from previous courses and relating them to medical situations. Similar sessions, adapted for the needs of the other medical school years, would also provide an attractive variant to standard lectures. We have arranged for some EBS sessions in the first medical school year, initiated a session for the transition summer between first and second years, and have already run some for the third year medical students. This method should be applicable to a variety of curricula, impacting not only those which are standard lecture driven but also providing a refreshing alternative to purely PBL-based education. It must be mentioned that an EBS session covers a clinical case with many basic science applications, but requires considerably less time and faculty effort than standard PBL cases.

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