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Integrating Problem-Based Learning Into an Internal Medicine Residency Curriculum

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Background: Problem-based learning (PBL) is a form of constructivist learning that allows learners to use higher order thinking by promoting learners to construct their own knowledge and understanding. PBL is prevalent in medical school education, but literature on PBL in graduate medical education (GME) is lacking. Because of the limited amount of data on PBL curricula in GME and the need for young physicians to develop critical thinking, lifelong self-directed learning, and problem-solving skills, we sought to incorporate PBL into the curriculum for our internal medicine residency program in a university-based community hospital setting.
Methods: The PBL committee created 4 cases derived from actual patient encounters that address common chief complaints encountered in the hospital and served as a crash course curriculum for interns in internal medicine. The success of the PBL curriculum was measured using a 39-question survey created by PBL leadership to assess the learners' satisfaction with case content, likeability/design, feasibility, effectiveness, and motivation/self-learning. Additional questions asked for ways to improve PBL sessions in the future.
Results: Overall, interns felt the content was clinically relevant, challenged them to think critically, and aided in the medical management of their patients. They also found PBL to be more effective and more enjoyable than the traditional lecture-style curriculum.
Conclusion: Implementing a PBL curriculum in a residency program is possible. Although PBL has associated challenges such as scheduling, it is well received when supported by the program.

Keywords: *Education–medical, education–medical–graduate, problem-based learning*

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INTRODUCTION

Problem-based learning (PBL), or case-based learning, has been a part of education in various health professions since the early 1990s.[1,2] In addition to its use in allied health professional schools (ie, nursing, physical therapy, and occupational therapy), PBL has become increasingly more common in medical school education. PBL has been described as an effective educational style that promotes teamwork, self-directed learning, conceptual thinking, and interpersonal skills.[3,4] Additionally, PBL has been shown to be effective in long-term knowledge retention, application of knowledge, and group learning.[5] While PBL has been implemented in several medical schools throughout the United States and Europe to varying degrees, PBL is not common in graduate medical education (GME). Given the need for physicians-in-training to develop critical thinking, lifelong self-directed learning, and problem-solving skills, we sought to incorporate PBL into the curriculum for our internal medicine residency program in a university-based community hospital setting.

The structure of PBL varies from institution to institution.[6] Most curricula reflect the design we used which involves separating learners into small groups led by a facilitator or tutor and sessions based on a clinical case or topic.[1] Groups are given information related to a patient-based clinical case (ie, problem) in parcels to prompt discussion at significant points in the clinical scenario. The learners initiate and direct these discussions with the facilitator present to clarify information, referee discussion points, and move the discussion along if it stalls. The facilitators are not meant to be content experts or to lead the discussion. While each case has objectives, individual groups will have unique discussions. At the end of each session, each group develops individual topics for independent post-session learning in addition to the predetermined case objectives.

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This case-based learning environment is the diametric opposite of traditional didactic teaching in which a content expert objectively discusses and transmits a topic with little to no input from learners. PBL is a form of constructivist learning that allows learners to use higher order thinking by promoting learners to construct their own knowledge and understanding. While both didactic teaching and PBL have their advantages, we felt that incorporating PBL in addition to the traditional lecture series would enhance the overall learning experience of the interns in an enjoyable way. Moreover, PBL uses many other adult learning theories through the focus on self-directed learning (humanistic learning theory); critical reflection on prior knowledge, leading to further acquisition and improvement of knowledge (transformative learning theory); and discussion among peers encouraging collaboration similar to future community practice (social theory of learning).[7] Last, we anticipated that a PBL curriculum focused on common chief complaints would help interns enhance their knowledge and improve critical thinking early in their training. Although the PBL curriculum may positively impact interns' self-directed learning and clinical skills, this report focuses on the feasibility and reception of the curriculum within the residency program.

METHODS

Case Development

The PBL leadership team developed 4 pilot cases representing common chief complaints encountered on medicine wards: chest pain, shortness of breath, abdominal pain, and encephalopathy. Portions of 2 cases are provided in Appendices 1 and 2. The cases, based on actual clinical cases from the previous year, were written by senior residents with details altered to remove patient identifiable information. While each case ended in a diagnosis related to the chief complaint, other objectives were included specific to each case. For example, the shortness of breath case included an arterial blood gas and challenged learners to develop an approach to acid-base derangements.

A content expert (general medicine faculty and subspecialists) reviewed each case to ensure that all content was correct and objectives were met. Cases consisted of chief complaint, history of present illness, past histories, physical examination, laboratory values, imaging, and other relevant diagnostic studies. At the end of each section of the case, learners were required to make a problem list and differential diagnosis, interpret laboratory and imaging studies, formulate a list of poorly understood topics for further reading, and identify the best next steps in diagnostics and management. Our intern groups often created concept maps to further illustrate their approach to the complaint and used Bayesian reasoning to deduce the final diagnosis from their list of differential diagnoses.

Each PBL case included a question regarding admission orders at a point relevant to each case. At this point, interns were encouraged to create admission orders for the patient in the case using an admission orders sheet created for the curriculum (Appendix 3). The intent of this unique addition to traditional PBL cases was to incorporate practical clinical skills that interns would use in addition to the educational approach to common diseases. Each step of the case also included questions derived specifically to help learners meet all learning objectives as they worked through the case.

Materials consisted of PBL case pages containing clinical details, a facilitator guide (consisting of the case information and suggested answers to clinical questions posed to help guide discussion), objectives, and teaching points for each case. The PBL case pages (without the facilitator guide answers) were provided to learners during the exercise. Facilitators had access to the entirety of the materials prior to and during the exercise. Case objectives and teaching points were provided to interns via email immediately following the exercise to encourage independent learning. The case objectives ensured that learners knew what material was intended to be covered. The teaching points included answers to clinical questions and concept maps illustrating the approach to the clinical topics, such as the approach to acute kidney injury or categories of diarrhea. During each session, supplemental materials, including electrocardiograms and relevant imaging such as chest x-rays, were available for learners to interpret.

Session Design and Participants

The learners consisted of the 2018-2019, 2019-2020, and 2020-2021 intern classes (48 total interns) who were divided at random into 3 to 4 small groups of 3 to 5 people. A total of 4 sessions took place during the first 2 months of their intern year, occurring once every 1 to 2 weeks on Friday afternoons for 2 to 3 hours. Friday afternoons were chosen as this time had the least number of conflicts. During the first year, the sessions occurred weekly, but they were conducted every other week during the following years based on feedback from the learners. Small group member composition rotated based on call cycles and schedule conflicts, and facilitators rotated among groups to provide a diverse learning environment. Approximately 10 to 12 learners participated in each session based on call schedule. Interns were excused from the PBL session if it interfered with duty hours or clinical responsibilities. The PBL sessions occurred in small classrooms meant to accommodate no more than 12 learners at a time to ensure a comfortable, nonthreatening environment.

Facilitators consisted of selected senior residents with training in PBL, chief residents, and general medicine faculty on a volunteer basis. All facilitators received a brief training session from the PBL curriculum leader regarding the structure and nature of PBL, instructions on leading a PBL case, and specific case information. The training sessions included an opportunity to ask questions. Facilitators had access to the case information and objectives prior to each session.

At the beginning of the PBL session, each facilitator read a statement outlining the goals, process, and structure of the session (Appendix 4). During the first year, groups self-assigned 2 roles: quarterback and scribe. The role of the quarterback was to lead the group, read the session content, and guide the conversation. The scribe took notes on a whiteboard or windows with dry erase markers to keep track of the differential diagnoses, problem list, and further learning objectives. These roles were abandoned in later years based on feedback from the learners stating that they preferred multiple learners fill these roles during the sessions.

After the opening statement was read, the first page of the case was given to all learners to read and discuss. All small groups went through the same case at the same time. Relevant imaging, such as radiographic studies and electrocardiograms, was displayed on a computer monitor using

PowerPoint (Microsoft Corporation) and in the individual case pages. After the facilitator assessed that all clinical questions had been thoroughly answered, the next page of the case was distributed. The only outside resources allowed were the American College of Physicians Medical Knowledge Self-Assessment Program 18 (ACP MKSAP 18) reference ranges for laboratory values (Appendix 5)[8] and standard medical equations. Interns were encouraged to take notes during the case on other questions requiring research to allow for self-learning following the session. Additionally, a list of learning objectives and teaching points was emailed to all interns, including those unable to attend the session, following completion of the case to encourage further independent learning and to equip learners with solid learning resources covering common diagnoses they would encounter.

After the fourth PBL session, the interns were surveyed using an anonymous PBL Assessment Survey (Appendix 6). The PBL leadership team created this 39-question survey to assess the learners' satisfaction with PBL case content, likeability/design, feasibility, effectiveness, and motivation/self-learning and to ask for ways to improve PBL sessions in the future. The survey was validated during the implementation of the first 15 surveys obtained in year 1 without the need for changes. Multiple authors initially reviewed the survey to determine content validity, and the survey proved to have adequate internal consistency (Cronbach α=0.68 with varying groups of questions). The survey was administered to all learners following completion of the PBL series. This study was granted exempt oversight by the Louisiana State University Health Sciences Center Institutional Review Board (IRB 538).

Outcomes

The primary outcomes were based on learner opinion that the PBL content was clinically relevant, challenged them to think critically, and aided in the management of patients. Secondary outcomes included likeability, feasibility, and effectiveness of the PBL sessions. Secondary outcomes also included PBL sessions motivating learners to pursue self-learning.

Statistical Analysis

SPSS Statistics, version 27 (IBM Corporation) was used for statistical analysis. For interpretation of the survey, we used descriptive statistics based on Likert scale and yes/no question mean values. These data were collected each July/August and analyzed during the following few months of that year.

RESULTS

Among 48 interns, all interns attended at least 1 session. Thirty-seven were categorical and 11 were preliminary interns, with 35 males and 13 females. Forty (83.3%) participants completed the survey.

Regarding the assessment of the content of the PBL sessions, learners were overall pleased with the content. They felt that it was clinically relevant, challenged them to think critically, and aided in the medical management of patients with those chief complaints (Table 1). The mean scores were reflected in several learners' answers to the free answer question following the first section: "For the PBL session that you found most beneficial, please describe why this session was the most beneficial." Representative responses follow.

It provided me with a diagnostic framework in an area where I previously had no well-organized approach.

Clinically relevant to late night on-call situations.

Further, learners who referred to the teaching points provided with the case found them useful in answering clinical questions.

Table 2 presents results from selected survey questions regarding likeability, feasibility, and effectiveness of the PBL curriculum. Overall, learners enjoyed PBL sessions; they did not prefer to use their time doing other residency-related work during the protected time for PBL sessions; and learners felt that PBL sessions were a more effective form of teaching than lectures. Although learners overall indicated that PBL sessions were a more effective learning modality compared to morning report, hospital rounds, and "chalk talks," the agreements with these statements were only slightly above the response corresponding to "the same." However, in the free text questions for the feasibility, effectiveness, and other sections of the survey, learners were enthusiastic about their PBL experiences. Representative responses follow.

I think it's very helpful to be able to think out loud and be able to make mistakes.

These are MUCH more effective than lectures.

I like the PBLs a lot. There's nothing else I could've done from 1-3:30 every other Friday where I would have learned more.

In years 2 and 3, we added questions to the survey to assess improved motivation and promotion of self-learning with PBL sessions. Therefore, only 25 residents answered these questions. Overall, 60% of the interns reported that they researched questions that came up during the PBL sessions. Moreover, after participating in PBL sessions, 60% of interns said they read about a topic they would not "have read about during intern year without exposure to PBLs."

DISCUSSION

This report demonstrates that a PBL curriculum can be integrated into GME and be well received. Although PBL curricula are common in undergraduate medical education, PBL is still rarely used at the graduate level, and limited data have been published on PBL curricula use in residency. Previous descriptions of PBL in residency report having the curriculum during one specific rotation of an internal medicine residency program.[9] A 2001 description of a PBL curriculum integrated in a pediatric residency reported that the curriculum enhanced self-directed learning among participants in comparison to residents who only received traditional lectures.[3] However, neither of these publications provided information on feasibility and likeability, nor did they provide guidance on how to replicate a PBL curriculum in other programs.

Through our implementation of PBL with our cohort of internal medicine interns, we found that the curriculum was well received. Learners felt the content was clinically relevant and that the active learning promoted by the PBL sessions

Table 1. Problem-Based Learning (PBL) Clinical Case Content Assessment, n=40

	Clinical Case			
Survey Question	**Chest Pain**	**Shortness of Breath**	**Abdominal Pain**	**Encephalopathy**
This PBL was clinically relevant.	4.74 (0.86)	4.79 (0.83)	4.73 (0.83)	4.96 (0.21)
This PBL challenged me to think critically.	4.70 (0.88)	4.67 (0.87)	4.77 (0.82)	4.83 (0.39)
This PBL aided in learning medical management of patients.	4.70 (0.88)	4.63 (0.88)	4.73 (0.83)	4.83 (0.39)
I found the teaching points and objectives helpful in answering clinical questions.	4.61 (0.89)	4.65 (0.88)	4.56 (0.92)	4.78 (0.42)

Notes: Response options were the following: 1=strongly disagree; 2=disagree; 3=neutral; 4=agree; 5=strongly agree. Data are presented as mean (SD).

challenged them to think critically and aided them in medical decision-making. Furthermore, the program was well-liked and a preferred method of learning over traditional lectures.

In the future, when we have a larger number of interns who have experienced the PBL curriculum, we will assess United States Medical Licensing Examination Step 1, 2, and 3 scores for current and previous interns to incorporate quantitative data regarding increased knowledge. Using Step 1 as a baseline comparison, we can determine if significant improvement was seen between Step 2 and Step 3 scores in classes exposed to PBL vs those not exposed to PBL. Hoffman et al used this technique to assess the PBL curriculum at the University of Missouri in 2006.[10]

Table 2. Assessment of Problem-Based Learning (PBL) Clinical Case Likeability, Feasibility, and Effectiveness, n=40

Assessment Category/Survey Question	**Mean (SD)**
Likeability	
I enjoyed the PBL sessions.[a]	4.69 (0.52)
Feasibility	
I would have rathered use my time for some other residency-related work or activity during this time.[a]	2.49 (1.15)
Effectiveness	
Since the PBL sessions, how often have you thought about the material discussed during PBLs when treating patients on wards?[b]	3.51 (0.70)
In your experience, how effective is PBL learning compared to lectures?[c]	4.36 (0.59)
In your experience, how effective is PBL learning compared to morning report?[c]	3.61 (0.80)
In your experience, how effective is PBL learning compared to hospital rounds?[c]	3.47 (0.84)
In your experience, how effective is PBL learning compared to brief lectures aka "chalk talks"?[c]	3.49 (0.74)

[a]Response options were the following: 1=strongly disagree; 2=disagree; 3=neutral; 4=agree; 5=strongly agree.
[b]Response options were the following: 1=never; 2=rarely; 3=sometimes; 4=often; 5=all of the time.
[c]Response options were the following: 1=much less effective; 2=less effective; 3=the same; 4=more effective; 5=much more effective.

Implementing a PBL program into a GME setting was more challenging than in other settings previously described because of the significant time demands of clinical duties and previously implemented protected learning time such as morning reports, noon conferences, and simulation laboratories. However, carving out 2 to 3 hours for 4 Friday afternoons in July and August for interns was feasible for our program because of the unwavering support of our program leadership. Further, creating cases addressing common chief complaints on wards and incorporating admission orders into the case catered to the unique needs of internal medicine interns.

Limitations include that this study was small, observational, and limited to a single university-based internal medicine program. Programs with more residents may be able to incorporate this curriculum more easily. Also, programs with different schedules may face different challenges. More research needs to be done on the feasibility and effectiveness of incorporating PBL and other forms of active learning within GME.

The current curriculum includes 4 cases designed for beginning interns, but we have started to expand the curriculum to include more complex cases for second- and third-year residents. We will then survey the residents to determine if they still think PBL is valuable to their learning. PBL may prove to be more impactful for learners early in their training who are looking to acquire clinical approaches to common problems. However, PBL may be just as beneficial or even more beneficial as learners gain more critical thinking skills as they progress through residency and look for more advanced exercises to practice these skills in a controlled environment. As with all educational endeavors within GME, there is a balance between service and education, and we must be mindful to allow learners to provide feedback on their learning experiences so that balance is not disrupted.

CONCLUSION

This observational study suggests that implementing a PBL curriculum in an internal medicine residency program intern year was enjoyable and possibly more effective than traditional lectures. Interns felt that the content, which was based on common internal medicine ward chief complaints, was clinically relevant, challenged them to think critically, and aided in the medical management of their patients. We hope this publication can assist other GME programs in adopting a PBL curriculum.

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This article meets the Accreditation Council for Graduate Medical Education and the American Board of Medical Specialties Maintenance of Certification competencies for Patient Care, Medical Knowledge, and Practice-Based Learning and Improvement.

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Appendix 1. Preview of Abdominal Pain Problem-Based Learning Case (Please email corresponding author for full case if interested.)

Abdominal Pain Case

Page #1

History of Present Illness:
Ms XY is a 62 y.o. female with a past medical history of adenocarcinoma of the colon with metastases to the liver diagnosed 6 months prior (on Folfuri/Avastin and status post liver wedge resection, cholecystectomy, and right hemicolectomy), dilated non-ischemic cardiomyopathy with reduced ejection fraction (20%), hypertension, hyperlipidemia, and right shoulder pain who presents to the ED with abdominal pain for one day. Pain is constant, rated as a 10/10, and generalized. Abdominal pain was preceded by odynophagia which began 5 days before hospital admission and has progressively worsened. She also experienced several (5-6/day) non-bloody loosely formed stools beginning 3 days prior to admission. She developed diffuse abdominal pain one day prior that rapidly progressed in severity prompting further evaluation in the Emergency Department.

Review of systems was pertinent for 3 day history of dysuria, one episode of non-bilious non bloody emesis, dental pain, and decreased PO intake. There is no associated shortness of breath, palpitations, chest pain, headache, vision changes, syncope, fever, or chills.

In regards to her malignancy, she was diagnosed 6 months prior with primary colon adenocarcinoma which metastasized to the liver. She was initially started on FOLFOX plus Avastin as neoadjuvant therapy. In total, she received 11 cycles (refused last cycle 2/2 side effects). CT abdomen showed significant improvement of liver metastases. Patient was transitioned to Avastin alone and referred to Surgical Oncology. She then underwent cholecystectomy, right hemicolectomy, and right hepatectomy. On repeat imaging she was noted to have multiple additional hypo densities within the liver. Patient was then started on FOLFIRI plus Avastin. She received 3rd cycle of this chemotherapy followed by Neulasta injection a week prior to admission.

Past surgical history:
Cholecystectomy
Liver resection
Colon resection
Mediport insertion
EGD

Family history
Mother – kidney disease
Father – hypertension

Social history
T: current ½ ppd smoker with a 39 pack year history
E: occasional
D: denies

Allergies
No known drug allergies

Home Medications:
Alprazolam 0.25 mg tablet PRN for sleep
Amitriptyline 25 mg tablet daily
Aspirin 81 mg EC tablet daily
B complex vitamins tablet daily
CARAFATE 100 mg/mL suspension,
Carvedilol 3.125 mg tablet BID
Dicyclomine 20 mg tablet Q8h
Gabapentin 600 mg capsule TID
Morphine 15 mg 12 hr tablet BID
Ondansetron 8 mg disintegrating tablet TID PRN
Oxycodone 10 mg Tablet immediate release tablet Q4h
Pyridoxine HCL daily Sennosides-docusate sodium 8.6-50 mg per tablet PRN

Questions:
1. What is the problem list?
2. What is your approach to abdominal pain, diarrhea and nausea/vomiting?
3. What do you want to know next?

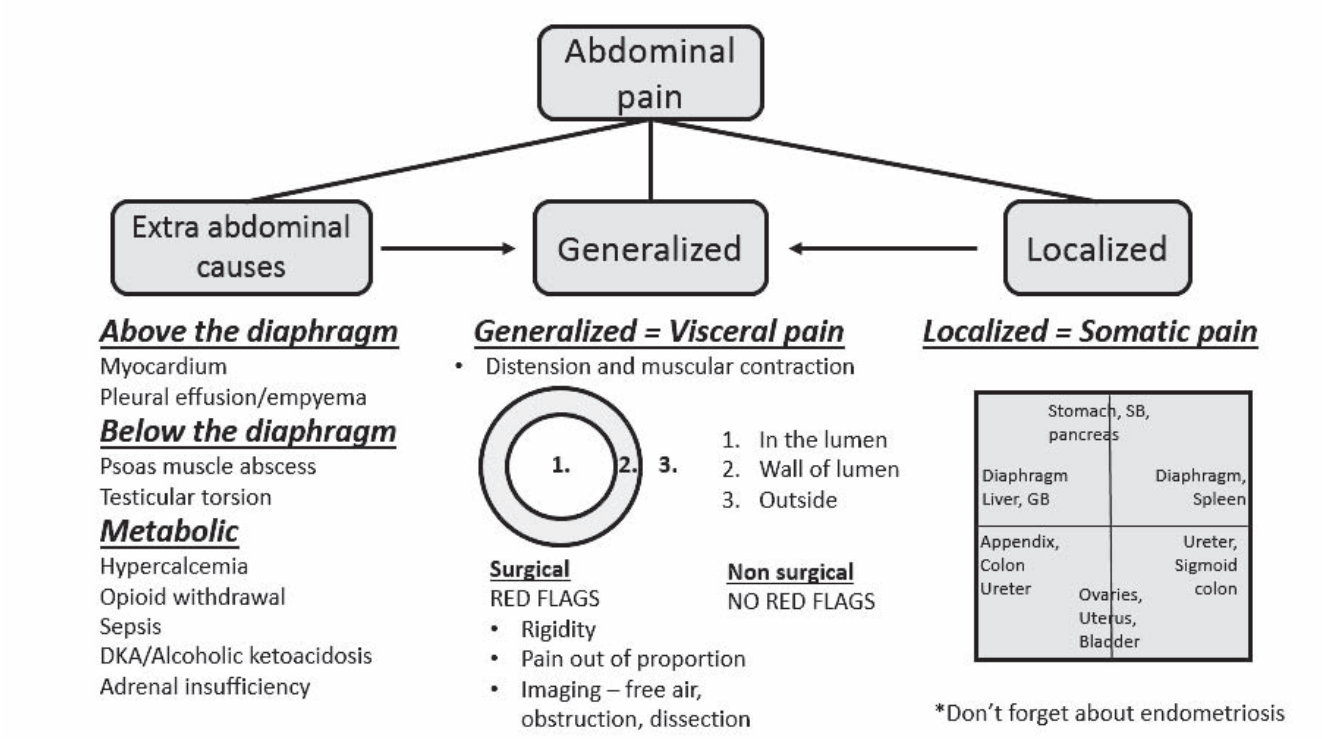
Appendix 1. Cont.

Page #1 Facilitator Guide

1. What is the problem list?
    a. Abdominal pain
    b. Nausea/Vomiting
    c. Diarrhea
    d. Decreased PO Intake
    e. Dysuria
    f. Dental Pain
    g. Pertinent chronic medical problems – Metastatic adenocarcinoma of the colon actively undergoing treatment, previous partial colectomy, HFrEF (20), HTN, HLD, chronic R shoulder pain
2. What is your approach to abdominal pain, diarrhea and nausea/vomiting?
    a. Abdominal pain
        i. See attached concept map
    b. Nausea
        i. See attached concept map
    c. Diarrhea
        i. See attached concept map
3. What do you want to know next?
    a. See next page on intern sheet

Appendix 1. Cont.

Abdominal Pain Case Teaching Points:



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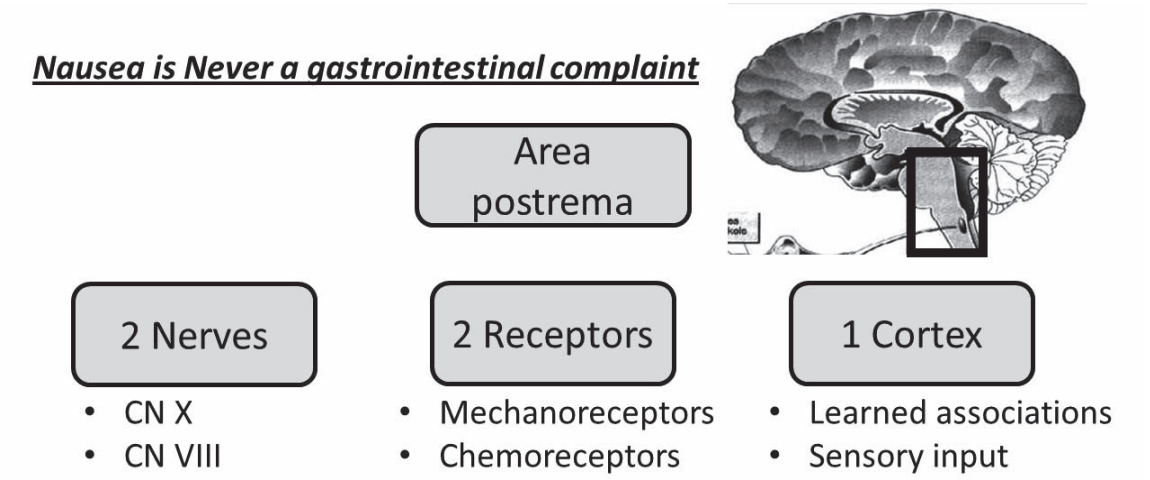

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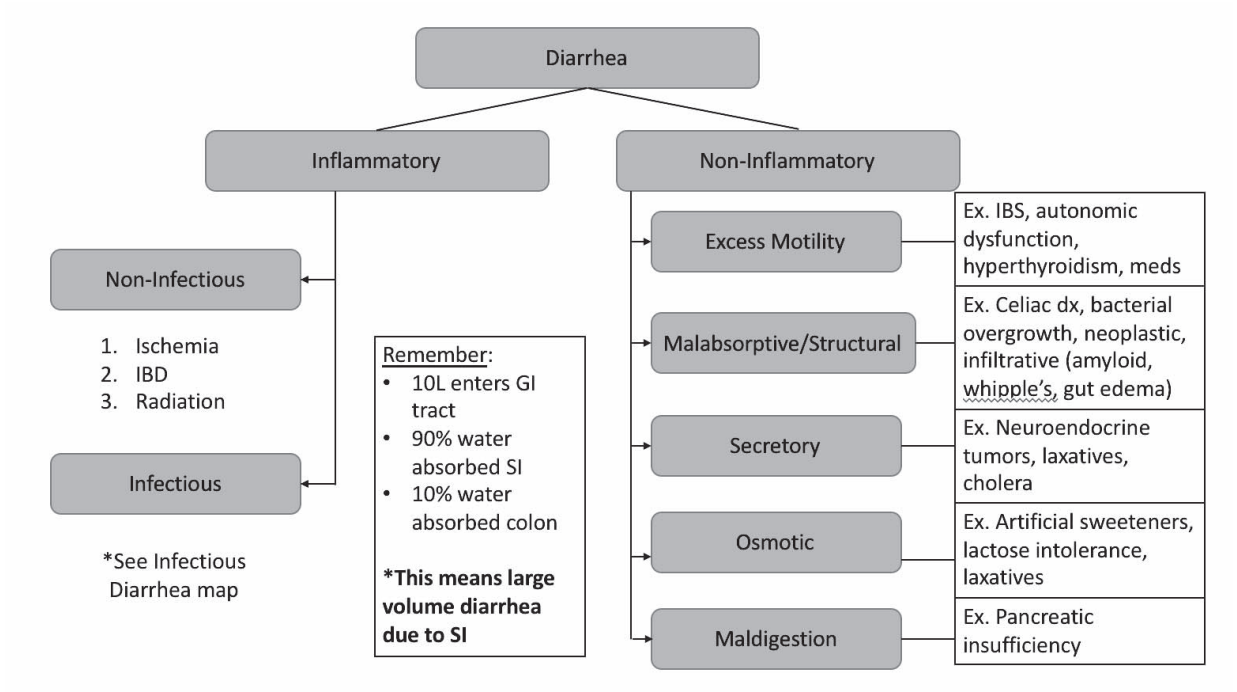
Appendix 1. Cont.



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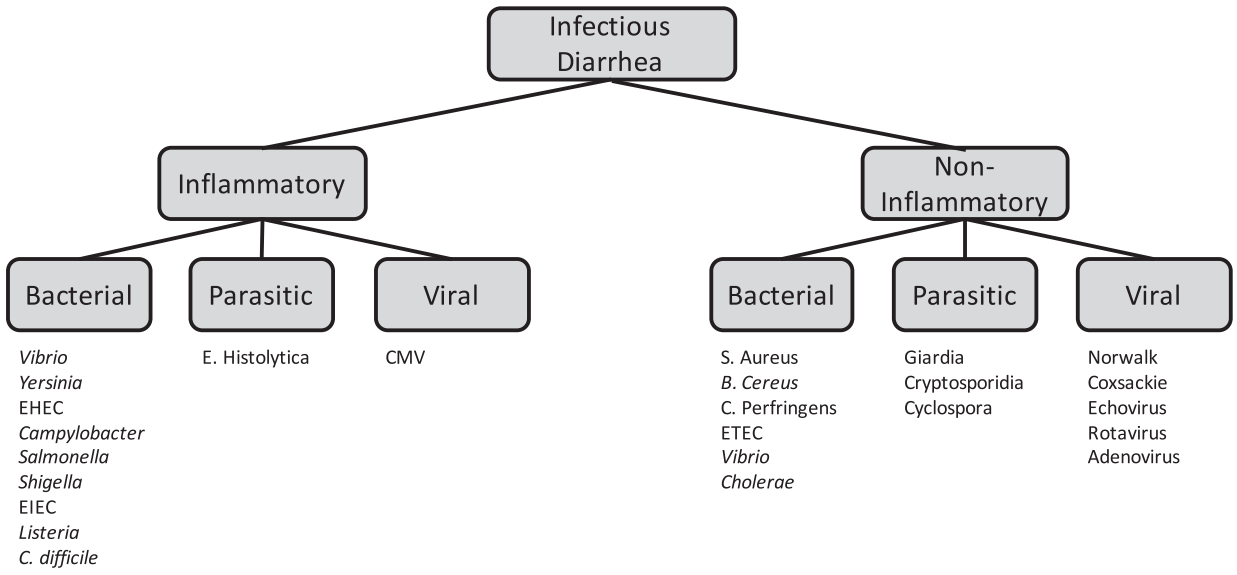

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Appendix 2. Preview of Shortness of Breath Problem-Based Learning Case (Please email corresponding author for full case if interested.)

Shortness of Breath Case

Page #1

HPI:
Patient is a 44 y.o. AA female with PMHx of HCV, anterior neck abscess s/p I&D, tobacco abuse and recent unprovoked submassive PE (a few months ago) on Eliquis who presented with shortness of breath. Pt reports she only began to have issues with shortness of breath 2 weeks prior to her admission for PE. Since discharge from that admission a few months ago, she has had progressively worsening dyspnea on exertion, shortness of breath and lower extremity edema. She has become profoundly more short of breath when walking across the room the few days leading up to admission.

Past Medical History: As stated above

Surgical History:
L knee surgery

Social:
T: Patient smokes between 0.5 to 1ppd
E: Denies alcohol use
D: History of THC use; however, she denies significant hx of IV drug use or other illicit substances.

Medications:
Zofran
Eliquis 5 mg BID

Family History:
History of DM and HTN in Mother.
Unknown medical hx in Father.
Denies any known hx of significant heart disease or coagulopathy.

Allergies:
Sulfa

Questions:
1) What is the problem list?
2) What is your approach to her chief complaint? Use this to form your differential diagnosis for this patient.
3) What do you want to know next?

Appendix 2. Cont.

Page #1 Facilitator Guide Page

1) What is the problem list?
    a. Shortness of breath
    b. H/O unprovoked submassive PE on Eliquis
    c. HCV
    d. Tobacco abuse
2) What is the differential diagnosis for her chief complaint?

**See attached, full concept map

<u>Approach to dyspnea/increased work of breathing:</u>

--Decreased pulmonary compliance
-Pneumothorax
-Pulmonary edema
-Chest wall disease (kyphoscoliosis, obesity)
-Pleural effusion
-Disease of lung parenchyma (infection, DPLD, etc)
-Diaphragm weakness

--Increased metabolic demand (respiratory compensation)
-Sepsis
-Hyperthyroidism
-Anemia/functional anemia
-Acidosis (DKA, ASA toxicity, shock)

--Increased airway resistance
-Foreign body
-asthma
-COPD
-RAD

--Increased physiologic demand (includes psychogenic causes)

--Increased dead space/VQ mismatch
-PE
-COPD

<u>Could also use an anatomic approach:</u>

--Heart (ACS, CHF, pericarditis/tamponade, valvular, etc.)

--Lung (PE, COPD, cor pulmonale, pleural effusion, pulmonary edema, PTX, PNA, decreased wall compliance, hepatopulmonary syndrome, diaphragm weakness, OSA/OHS, etc.)

--Airway problems

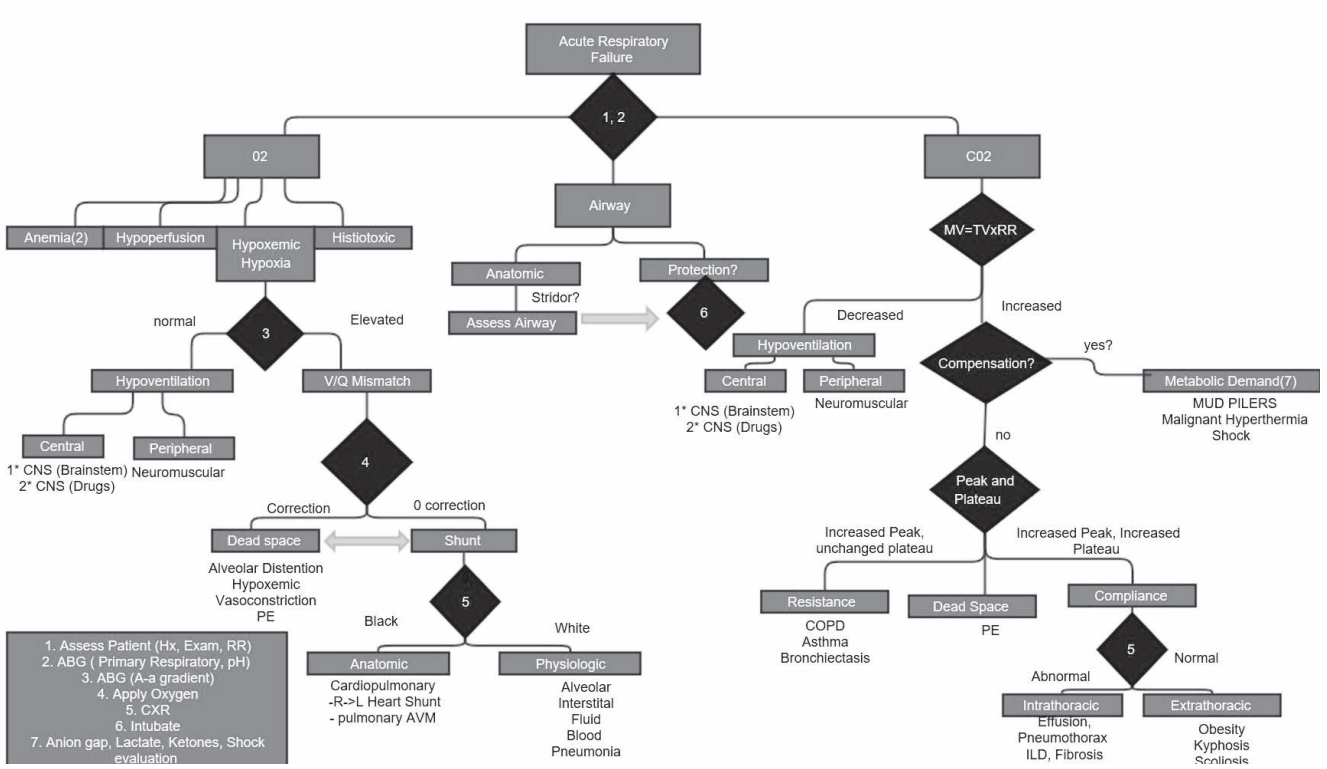
--Metabolic

3) What do you want to know next?
    a. See next page

Appendix 2. Cont.

SOB Case Teaching Points:

Concept Maps:



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Appendix 3. Admission Orders Sheet

ADMISSION ORDERS:

Admit: (service)

_____

Diagnosis:

_____

Condition: (stable, fair, guarded, etc)

_____

Vitals: (frequency)

_____

Activity: (with assistance, as tolerated, etc)

_____

Nursing: (foley, IV, incentive spirometry, etc)

_____

Diet:

_____

IV Fluids:

_____

Special: (seizure precautions, neuro checks, etc)

_____

Medications:

Allergies:

_____

Labs:

Appendix 4. Facilitator Opening Statement

Facilitator Opening Statement:

Welcome to your Problem Based Learning session, also known as PBL! You may want to know, "what is a PBL?". Well, PBL is a way of learning that incorporates patient vignettes and clinical problem-solving into learning about medicine. The PBL technique is used in a variety of educational settings. In medical education, it has been used in medical schools to teach the basics of medicine. Some medical schools even base their entire curriculum around PBL.

Here at LSU Internal Medicine in Baton Rouge, we developed an innovative PBL program for interns. These PBL sessions are meant to both improve both your clinical knowledge of the classic disease processes you will see on wards and your critical thinking skills. These PBL sessions are meant to be laid-back and a fun way to learn about medicine. The groups are small, but you will need to work with and rely on your fellow interns to complete the case. The groups will change from week to week to allow for different group dynamics. You will complete 4 cases in total that will provide a variety of medical knowledge.

Each case will last 1 ½-2 ½ hours, depending on how long it takes each team to get through the case. The goal is not to be fast, but to work through the process. You will get one page of the case at a time and will be allowed to move forward with the next page once you have answered the questions sufficiently. There will also be a facilitator in the room who is not an intern. The job of the facilitator is to help keep you on track, but 90% of the discussion should be amongst the interns.

Many questions will arise as you work through each case. You are encouraged to take individual notes of things you may need to look up after the case. You will have access to normal lab values and a sheet of paper to place orders. You will also have dry erase boards (we will be using the windows) to write down the group discussions of differential diagnoses, problem lists, and any other important details.

Does anyone have any questions before we get started?

If that is it, let's start with Page #1!

Appendix 5. Medical Knowledge Self-Assessment Program (MKSAP) Reference Ranges Sheet (Reprinted with permission of the American College of Physicians. Copyright 2018, American College of Physicians.[8])

REFERENCE RANGES

MKSAP® 18

U.S. traditional units are followed in parentheses by equivalent values expressed in S.I. units.

Hematology

Absolute neutrophil count–greater than 1500/μL (1.50 × 10^9/L)
Activated partial thromboplastin time–25-35 s
D-dimer–less than 0.5 μg/mL (0.5 mg/L)
Erythrocyte count–4.2-5.9 × 10^6/μL (4.2-5.9 × 10^{12}/L)
Erythrocyte sedimentation rate
Male–0-15 mm/h
Female–0-20 mm/h
Erythropoietin–5-36 mU/mL (5-36 U/L)
Haptoglobin, serum–50-150 mg/dL (500-1500 mg/L)
Hematocrit
Male–41%-51%
Female–36%-47%
Hemoglobin, blood
Male–14-17 g/dL (140-170 g/L)
Female–12-16 g/dL (120-160 g/L)
Leukocyte count–4000-10,000/μL (4.0-10 × 10^9/L)
Mean corpuscular hemoglobin–28-32 pg
Mean corpuscular hemoglobin concentration–32-36 g/dL (320-360 g/L)
Mean corpuscular volume–80-100 fL
Platelet count–150,000-450,000/μL (150-450 × 10^9/L)
Prothrombin time–11-13 s
Reticulocyte count–0.5%-1.5% of erythrocytes; absolute: 23,000-90,000/μL (23-90 × 10^9/L)

Blood, Plasma, and Serum Chemistry Studies

Albumin, serum–3.5-5.5 g/dL (35-55 g/L)
Alkaline phosphatase, serum–36-92 U/L
α-Fetoprotein, serum–0.6-6.6 ng/mL (0.6-6.6 μg/L)
Aminotransferase, alanine (ALT)–0-35 U/L
Aminotransferase, aspartate (AST)–0-35 U/L
Ammonia, plasma–40-80 μg/dL (23-47 μmol/L)
Amylase, serum–0-130 U/L
Bilirubin, serum
Total–0.3-1.2 mg/dL (5.1-20.5 μmol/L)
Direct–0-0.3 mg/dL (0-5.1 μmol/L)
Blood gases, arterial (ambient air)
pH–7.38-7.44
Pco_2–35-45 mm Hg (4.7-6.0 kPa)
Po_2–80-100 mm Hg (10.6-13.3 kPa)
Oxygen saturation–95% or greater
Blood urea nitrogen–8-20 mg/dL (2.9-7.1 mmol/L)
B-type natriuretic peptide level
Heart failure unlikely–less than 100 pg/mL (100 ng/L)
Heart failure likely–greater than 400 pg/mL (400 ng/L)
Calcium, serum–9-10.5 mg/dL (2.2-2.6 mmol/L)
Carbon dioxide, serum–See Bicarbonate
Chloride, serum–98-106 mEq/L (98-106 mmol/L)
Complement, serum
C3–55-120 mg/dL (550-1200 mg/L)
C4–10-40 mg/dL (100-400 mg/L)
C-reactive protein, blood–0-0.8 mg/dL (0-8.0 mg/L)
Cardiovascular risk prediction
Low risk–less than 1.0 mg/L
Average risk–1.0-3.0 mg/L
High risk–greater than 3.0 mg/L
Creatine kinase, serum–30-170 U/L
Creatinine, serum–0.7-1.3 mg/dL (61.9-115 μmol/L)
Electrolytes, serum
Sodium–136-145 mEq/L (136-145 mmol/L)
Potassium–3.5-5.0 mEq/L (3.5-5.0 mmol/L)
Chloride–98-106 mEq/L (98-106 mmol/L)
Bicarbonate–23-28 mEq/L (23-28 mmol/L)
Fibrinogen, plasma–150-350 mg/dL (1.5-3.5 g/L)
Folate, serum–4.0-20 ng/mL (9.1-45.3 nmol/L)
Glucose, plasma–fasting, 70-100 mg/dL (3.9-5.6 mmol/L)
γ-Glutamyltransferase, serum–0-30 U/L
Immunoglobulins
Globulins, total–2.5-3.5 g/dL (25-35 g/L)
IgG–640-1430 mg/dL (6.4-14.3 g/L)
IgA–70-300 mg/dL (0.7-3.0 g/L)
IgM–20-140 mg/dL (0.2-1.4 g/L)
IgD–less than 8 mg/dL (80 mg/L)
IgE–0-90 U/mL (0-90 kU/L)
Iron studies
Ferritin, serum–15-200 ng/mL (15-200 μg/L)
Iron, serum–60-160 μg/dL (11-29 μmol/L)
Iron-binding capacity, total (TIBC), serum–250-460 μg/dL (45-82 μmol/L)
Transferrin saturation–20%-50% (serum iron ÷ TIBC × 100)
Lactate dehydrogenase, serum–60-100 U/L
Lactate, plasma–0.5-1.6 mEq/L (0.5-1.6 mmol/L)
Lipase, serum–13-60 U/L
Magnesium, serum–1.5-2.4 mg/dL (0.62-0.99 mmol/L)
Osmolality, serum–275-295 mOsm/kg H_2O
Phosphatase, alkaline, serum–36-92 U/L
Phosphorus, serum–3.0-4.5 mg/dL (0.97-1.45 mmol/L)
Prostate-specific antigen, serum–less than 4 ng/mL (4 μg/L)
Protein, serum
Total–6.0-7.8 g/dL (60-78 g/L)
Albumin–3.5-5.5 g/dL (35-55 g/L)
Globulins, total–2.5-3.5 g/dL (25-35 g/L)
Rheumatoid factor–less than 40 U/mL (40 kU/L)
Triglycerides–less than 150 mg/dL (1.69 mmol/L), desirable
Troponins, serum
Troponin I–0-0.1 ng/mL (0-0.1 μg/L)
Troponin T–0-0.1 ng/mL (0-0.1 μg/L)
Urate, serum
Male–3.7-8.6 mg/dL (0.22-0.50 mmol/L)
Female–2.4-5.8 mg/dL (0.14-0.34 mmol/L)
Vitamin B_{12}, serum–200-800 pg/mL (148-590 pmol/L)

Endocrine

Adrenocorticotropic hormone (ACTH), serum–9-52 pg/mL (2-11 pmol/L)
Aldosterone, serum
Supine–2-5 ng/dL (55-138 pmol/L)
Standing–7-20 ng/dL (194-554 pmol/L)
Aldosterone, urine–5-19 μg/24 h (13.9-52.6 nmol/24 h)
Catecholamines, fractionated, urine
Epinephrine–2-24 μg/24 h (10.92-131.04 nmol/24 h)
Norepinephrine–15-100 μg/24 h (88.65-591 nmol/24 h)
Dopamine–52-480 μg/24 h (339.56-3134.4 nmol/24 h)

Appendix 5. Cont.

Cortisol, free, urine—less than 50 µg/24 h (138 nmol/24 h)
Cortisol, serum, morning—5-25 µg/dL (138-690 nmol/L)
Dehydroepiandrosterone sulfate (DHEAS), plasma
Male—1.3-5.5 µg/mL (3.5-14.9 µmol/L)
Female—0.6-3.3 µg/mL (1.6-8.9 µmol/L)
Epinephrine, plasma (supine)—less than 75 ng/L (410 pmol/L)
Estradiol, serum
Male—10-30 pg/mL (37-110 pmol/L)
Female—day 1-10, 14-27 pg/mL (50-100 pmol/L); day 11-20, 14-54 pg/mL (50-200 pmol/L); day 21-30, 19-41 pg/mL (70-150 pmol/L)
Follicle-stimulating hormone, serum
Male (adult)—5-15 mU/mL (5-15 U/L)
Female—follicular or luteal phase, 5-20 mU/mL (5-20 U/L); midcycle peak, 30-50 mU/mL (30-50 U/L); postmenopausal, greater than 35 mU/mL (35 U/L)
Growth hormone, plasma—after oral glucose, less than 2 ng/mL (2 µg/L); response to provocative stimuli, greater than 7 ng/mL (7 µg/L)
Hemoglobin A_{1c}, blood—less than 5.7%
Luteinizing hormone, serum
Male—3-15 mU/mL (3-15 U/L)
Female—follicular or luteal phase, 5-22 mU/mL (5-22 U/L); midcycle peak, 30-250 mU/mL (30-250 U/L); postmenopausal, greater than 30 mU/mL (30 U/L)
Metanephrines, fractionated, urine
Metanephrine, unconjugated—90-315 µg/24 h (456-1597 nmol/24 h)
Normetanephrine—122-676 µg/24 h (666-3691 nmol/24 h)
Metanephrines, total—224-832 µg/24 h (1136-4218 nmol/24 h)
Metanephrines, fractionated, plasma
Metanephrine, free—less than or equal to 57 pg/mL (0.2964 nmol/L)
Normetanephrine, free—less than or equal to 148 pg/mL (0.8288 nmol/L)
Metanephrines, total—less than or equal to 205 pg/mL (1.066 nmol/L)
Parathyroid hormone, serum—10-65 pg/mL (10-65 ng/L)
Progesterone, blood
Male (adult)—0.27-0.9 ng/mL (0.9-2.9 nmol/L)
Female—follicular phase, 0.33-1.20 ng/mL (1.0-3.8 nmol/L); luteal phase, 0.72-17.8 ng/mL (2.3-56.6 nmol/L); postmenopausal, less than 0.2-1 ng/mL (0.6-3.18 nmol/L); oral contraceptives, 0.34-0.92 ng/mL (1.1-2.9 nmol/L)
Prolactin, serum
Male—less than 15 ng/mL (15 µg/L)
Female—less than 20 ng/mL (20 µg/L)
Testosterone, total, serum
Male (adult)—300-1200 ng/dL (10-42 nmol/L)
Female—20-75 ng/dL (0.7-2.6 nmol/L)
Thyroid iodine (^{131}I) uptake—10%-30% of administered dose at 24 h
Thyroid-stimulating hormone (TSH)—0.5-5.0 µU/mL (0.5-5.0 mU/L)
Thyroxine (T_4)
Total, serum—5-12 µg/dL (64-155 nmol/L)
Free—0.9-2.4 ng/dL (12-31 pmol/L)
Free T_4 index—4-11
Triiodothyronine (T_3)
Total, serum—70-195 ng/dL (1.1-3.0 nmol/L)
Free—3.6-5.6 ng/L (5.6-8.6 pmol/L)
Vitamin D
1,25-dihydroxy, serum—25-65 pg/mL (60-156 pmol/L)
25-hydroxy, serum—31-80 ng/mL (77-200 nmol/L)

Urine

Albumin-creatinine ratio—less than 30 mg/g
Calcium—100-300 mg/24 h (2.5-7.5 mmol/24 h) on unrestricted diet
Creatinine—15-25 mg/kg per 24 h (133-221 mmol/kg/24 h)
Glomerular filtration rate (GFR)
Categories of Chronic Kidney Disease (from KDIGO)
Stage G1—greater than or equal to 90 mL/min/1.73 m^2
Stage G2—60-89 mL/min/1.73 m^2
Stage G3a—45-59 mL/min/1.73 m^2
Stage G3b—30-44 mL/min/1.73 m^2
Stage G4—15-29 mL/min/1.73 m^2
Stage G5—less than 15 mL/min/1.73 m^2
Albuminuria categories
A1 (Normal)—less than 30 mg/g
A2 (Moderately increased)—30-300 mg/g
A3 (Severely increased)—greater than 300 mg/g
Protein-creatinine ratio—less than or equal to 150 mg/g
Uric acid—250-750 mg/24 h (1.48-4.43 mmol/24 h) (varies with diet)

Pulmonary

Forced expiratory volume in 1 second (FEV_1)—greater than 80% of predicted
Forced vital capacity (FVC)—greater than 80% of predicted
FEV_1/FVC—greater than 0.70

Cerebrospinal Fluid

Cell count—0-5/µL (0-5 × 10^6/L)
Glucose—40-80 mg/dL (2.2-4.4 mmol/L); less than 40% of simultaneous plasma concentration is abnormal
Pressure (opening)—70-200 mm H_2O
Protein—15-60 mg/dL (150-600 mg/L)

Hemodynamic Measurements

Cardiac index—2.5-4.2 L/min/m^2
Left ventricular ejection fraction—greater than 55%
Pressures
Pulmonary artery
Systolic—20-25 mm Hg
Diastolic—5-10 mm Hg
Mean—9-16 mm Hg
Pulmonary capillary wedge—6-12 mm Hg
Right atrium—mean 0-5 mm Hg
Right ventricle
Systolic—20-25 mm Hg
Diastolic—0-5 mm Hg

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MK9001

Appendix 6. Problem-Based Learning Assessment Survey

Please enter your unique identifier ___ ___ ___ ___

(The day of your birthday and the last two digits of your social security number. EX. If your birthday is July 5, 1980 and your social security number is 123-456-8899 then the identifier will be 0599)

Problem Based Learning (PBL) Assessment Survey

The goal of this survey is to improve PBL sessions for the future and further identify a role for PBL in this residency program. It should only take a few minutes to complete. This is an anonymous survey. Please be honest in your responses. Your participation is appreciated.

Content

	Chest Pain	Shortness of Breath	Abdominal Pain	Encephalopathy
Please mark each PBL session you were able to attend with an x.				
Please answer questions #1-4 with the following scale: 1=strongly disagree; 2=disagree; 3= neutral; 4=agree; 5=strongly agree				
1. This PBL was clinically relevant.				
2. This PBL challenged me to think critically.				
3. This PBL aided in learning medical management of patients.				
4. I found the teaching points and objectives helpful in answering clinical questions. (If you have not referred to the materials mentioned in the above question, please leave this question blank.)				
For each PBL session, please answer yes or no (even if you did not attend the session)				
Have you referred to the teaching points and objectives sent to you via email after the PBL session?				
Rank the PBL sessions from 1 to 4, with 1 being most helpful and 4 being least helpful. Only rank those attended.				
Which PBL session did you find most beneficial?				

For the PBL session that you found most beneficial, please describe why this session was the most beneficial.

_____

Appendix 6. Cont.

For questions numbered 1 through 4 above, please explain why you 'disagree' or 'strongly disagree' with any statement.

Likeability/Design

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
I enjoyed the PBL sessions.					
I liked the assignment of roles.					
I liked the way the facilitators conducted the sessions.					
I liked the time of day/week for the PBL sessions.					
I thought the length of time it took to complete a PBL session was appropriate.					
I thought the group size was appropriate.					
I liked working with different interns each week.					

Please describe how anything ranked less than "neutral" could be made better.

Feasibility

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
The expectations of each PBL were made clear at the beginning of each session.					
The amount of information provided to me was appropriate for the time frame allotted.					
Having the PBL sessions every other week was ideal.					
I would have rathered use my time for some other residency-related work or activity during this time.					

Please describe how anything ranked less than "neutral" could be made better.

Appendix 6. Cont.

Effectiveness

	Never	Rarely	Sometimes	Often	All of the time
Since the PBL sessions, how often have you thought about the material discussed during PBLs when treating patients on wards?					
Since the PBL sessions, how often have you thought about the material discussed during PBLs when treating patients in clinics?					

Please describe how anything ranked less than "sometimes" could be made better.

_____

	Much Less Effective	Less Effective	The Same	More Effective	Much More Effective
In your experience, how effective is PBL learning compared to lectures?					
In your experience, how effective is PBL learning compared to morning report?					
In your experience, how effective is PBL learning compared to team-based learning?					
In your experience, how effective is PBL learning compared to hospital rounds?					
In your experience, how effective is PBL learning compared to brief lectures aka "chalk talks"?					

Please describe how anything ranked less than "the same" could be made better.

_____

Appendix 6. Cont.

Motivation and Self-Learning

1. Did you research questions that came up during the PBL sessions? (circle one)

   Yes/No

2. After participating in PBLs, did you read about a topic that you don't think you would have read about during intern year without exposure to PBLs? (circle one)

   Yes/No

Other

1. List at least one change you would make to the PBL sessions.

   _____

2. List at least 3 chief complaints you would you like to see future PBL cases based on?

   _____ _____ _____

3. Would you be inclined to participate if we had PBL sessions on a more regular basis? (circle one)

   Yes/No

4. Would you like to participate in creating PBL sessions for interns in the future? (circle one)

   Yes/No

5. What do you plan on doing after residency? (circle one)

   Hospitalist Outpatient Fellowship Inpatient/Outpatient Combination

   Other (please specify) _____

6. Do you plan on incorporating teaching residents and medical students into your practice? (circle one)

   Yes/No

7. Any other comments: