Integrating acid-base and metabolic panels across systems in an M1 classroom activity

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Introduction: The concepts of acid-base balance are often delivered in an isolated session associated with a single physiological system and disparate from metabolic considerations or clinical sequelae. Despite this, the expectation is that learners will provide effective patient-care in the clinical years that requires the integration of laboratory results, aspects of the clinical presentation and incorporation of multi-system responses to evaluate. We have developed an exercise that addresses this challenge by providing an activity for M1 learners to evaluate systems-based disturbances and associated biochemical changes that contribute to acid-base disorders in realistic clinical settings.

Methods: This 2-hour learning activity was delivered as a capstone session after students had received instruction in basic pathway biochemistry, respiratory, gastrointestinal, endocrine and cardiac physiology and the basics of acid-base balance in the context of respiratory and renal physiology respectively. Students were grouped (<6 students) and were given 4 patient case scenarios (Table 1) and 5 different sets of ABGs (Table 2) and abbreviated metabolic panels (Table 3). They were instructed match each case scenario (1-4) with one set of ABGs (A-E) and one metabolic panel (1-5).

Methods: Lesson Plan for session…

- 0 Introduction/Explanation
- 10 Matching Cases with Lab Values in small groups, using any resources and with faculty available to help
- 50 Break
- 60 Case 1 report and discussion
- 70 Case 2 report and discussion
- 80 Case 3 report and discussion
- 90 Case 4 report and discussion
- 100 Faculty led summary
- 110 End

Assessment: Qualitative and quantitative metrics were used to determine the efficacy of the activity. In a summative block NBME exam, performance on questions that aligned with the learning objectives of the activity were compared with performance on questions unrelated to the activity. Open comments from student evaluations allowed qualitative analysis of student satisfaction with the activity.

Results: 18 students (43% 0f the class) participated in the activity. This attendance was typical.

Table 1: Patient Case Scenarios

Case #1 Cholera Infection

Upon his return from Haiti a 28-year-old male health-worker has experienced profuse and watery diarrhea for the previous 5-hours. He arrives in the ED barely conscious, skin is cold and clammy with decreased turgor. Kussmaul respirations are present. Radial pulse was not palpable but heart rate was 160bpm when assessed by listening over the chest.

Case #2 Medically-induced Coma

A 24-year-old woman suffers a head-trauma in a car accident. She undergoes mechanical ventilation and is sedated. The patient is hemodynamically stable, and mechanical ventilation maintains arterial PCO_2 and PO_2 within normal limits. After 10 days normal ICU complications ensue - she is treated with antibiotics for compression sores and stomach contents are suctioned regularly to prevent ulceration and aspiration.

Case #3 Malnourished COPD

A 58-year-old man has a history of severe COPD (GOLD 3), treatment for which includes inhaled steroids. He arrives in the ED during an exacerbation of his condition. ABGs are taken on room air and a chest x-ray shows severe hyperinflation and evidence of bilateral lobar pneumonia. Most recent spirometry showed FEV_1 at 40% of predicted normal. Shortness of breath has dominated the patients life and body mass has fallen 15% over the last 12 months.

Case #4" Third trimester check-up

A 24-year-old woman attends a routine check-up in her third trimester of pregnancy. Pre-pregnancy BMI was normal and weight gain (24lbs) is as expected at 36 weeks. Pre-natal care has generally been intermittent due to lack of adequate health insurance. An active lifestyle has been maintained until shortness of breath has recently diminished her exercise capacity.

Table 2: ABG Panels (& Hematocrit)

ABG Results	Hematocrit (%)	pH	$PaCO_2$ (mmHg)	HCO_3 (mEq/L)	SaO_2 (%)
A	42	7.64	40	42	98
B	40	7.43	33	21	98
C	40	7.35	65	35	85
D	60	7.12	28	9	98
E	50	7.6	25	24	98

Table 3: Modified Metabolic Panels

Lab Results	Glucose (mg/dL)	BUN (mg/dL)	Albumin (g/dL)	Lactate (mmol/L)
1	180	22	5.8	2.1
2	187	8	3.1	0.8
3	110	16	2.9	1.6
4	90	11	2.7	0.5
5	152	14	4.2	0.2

NBME Exam Performance: The average student grade for related questions (n=13) was 80.92 ± 6.28% vs. 78.32 ± 3.59 for questions on all other block material (p= 0.607). While this increase was small (2.6%), it was three times larger than the gap seen nationally for the same questions (77.31 ± 6.90 vs. 76.47 ± 3.01, p=0.845).

Evaluations: Perceptions of the activity were overwhelmingly positive. The major theme appearing in open comments was that the activity allowed integration and application of material from multiple systems and multiple preceding blocks in a clinical setting. No negative comments surrounding the activity were reported.

Discussion: The activitsy required students to analyze clinical data, determine the relevance of laboratory values and integrate dysregulation of both metabolic and physiological pathways. Although the them increase in performance was not significant, this could be due to inclusion of assessment metrics from all students rather specifically on the subset (43%) of students that participated.

By altering the scenarios or adding additional laboratory values the session could easily be expanded for M2 – M4 learners by incorporating anion gap, pharmacology or patient management plans.

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