Original Article

Assessment of toxicology knowledge in the fourth-year medical students: Three years of data

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BACKGROUND: Pharmacology and toxicology are core content knowledge for physicians. Medical students should demonstrate understanding of general pharmacology and basic treatment of poisoning. The objective of this study was to measure the knowledge of the 4th-year medical students (MS4) on these topics over 3 years.

METHODS: A multiple-choice exam (15 questions) was administered to MS4 students in spring of 2010, 2011, and 2012. Questions were developed by medical toxicologists to evaluate basic knowledge in three areas: pharmacologic effects (PE), treatment of poisoning (TOP), and pharmacokinetics (PK). The students were grouped by intended specialties into pharmacologic intense (anesthesia, emergency medicine, internal medicine, pediatrics, and psychiatry), less pharmacologic intense specialties (dermatology, OB/GYN, ophthalmology, pathology, physical medicine and rehabilitation, radiology, and surgery) and by completion of a pharmacology or toxicology elective. Mean group scores were compared using ANOVA.

RESULTS: Totally 332 of 401 (83%) students completed the survey. Mean scores were stable over the three years, higher for students completing a toxicology rotation and for students entering a pharmacologically intense specialty.

CONCLUSION: The external validity is limited to a single medical school with incomplete participation and content was limited by the survey length. Consistent results over the three-year period and correlation of performance with completing a toxicology rotation and intent to enter a pharmacology intensive specialty suggest this survey may correlate with toxicology knowledge. Implementation of required core courses focused on toxicology may improve core content knowledge in fourth year medical students.

KEY WORDS: Medical student; Education; Toxicology; Knowledge

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INTRODUCTION

Toxicology is an often neglected component of medical school curricula; despite articles as far back as 1980 recommending the addition of toxicology to medical curricula, there is no Liaison Committee on Medical Education (LCME) requirement for specific toxicology elements as a component of medical education.^[1,2] Toxicology has long been a key component of Emergency Medicine residency education listed as part of the Emergency Medicine Model of Clinical

Practice, and educational interventions regarding toxicology have often focused on post-medical school graduates.^[3–6] This dearth of education for medical students is present despite unintentional poisonings accounting for over 192,000 deaths in 2012, worldwide, and resulting in 392,000 deaths from intentional ingestions.^[7] It is possible that a significant amount of toxicology knowledge is transmitted during clinical rotations. However, little data regarding medical student knowledge on toxicology subjects, or the influence of

specialty choice or elective rotations on that knowledge exists.

METHODS

Three toxicologists developed a multiple-choice exam of 15 questions (Figure 1) focused on three domains: pharmacologic effects (PE), treatment of poisoning (TOP), and pharmacokinetics (PK). These questions were subsequently vetted through deployment to educational faculty members to assess for internal consistency, prior to deployment. The group of educational faculty and toxicology faculty combined accounted for over 45 years of educational experience. Students in this particular medical school complete pharmacology during mid-second year of a four-year curriculum. Approximately 160 students are in a class per a year with variation in retention. The survey was deployed during a final week class for 4th year medical students, with no incentive delivered with the request for completion of the survey. This deployment was repeated for a total of three years, from 2010–2012. Responses required answering questions as to selected specialty type and whether the respondent had taken a pharmacology or toxicology elective. For analysis, specialty types were grouped into pharmacologic intense (anesthesia, emergency medicine, internal medicine, pediatrics, and psychiatry), vs. less pharmacologic intense specialties (dermatology, OB/GYN, ophthalmology, pathology, physical medicine and rehabilitation, radiology, and surgery), as well as having taken a pharmacology or toxicology elective. Each year was processed, and subsequently compared between years. Data was analyzed using ANOVA and Excel (Microsoft, Redmond WA).

RESULTS

Totally 332 of 401 (83%) students completed the survey, with no significant differences in percentage of

students answering per year. Mean scores were stable over the three years for all types of students. Students going into pharmacology intense specialties did better, on average, across all three tested domains. Students doing a pharmacology elective did better, on average, than the average student on the treatment of poisoning and pharmacokinetics, but were no better than the average student on pharmacologic effects. Students doing a toxicology rotation alone had higher scores across all three domains, although students doing both a toxicology rotation and a pharmacology rotation did worse than those doing just toxicology on the pharmacologic effects domain (Table 1).

DISCUSSION

It is clear to the authors that additional education around toxicology is needed in medical school. Our study, however, was designed to show differences in knowledge in three different domains based on exposure and interest. The test itself has not been validated as a general knowledge test for toxicology, and as such, may not be reflective of medical student knowledge standards. In developing the assessment instrument, it is possible that the toxicologists may have been biased towards material that is commonly taught on toxicology rotations, thereby skewing results. Similarly, students who choose to do toxicology or clinical pharmacology rotations may retain more information taught at prior time periods, as opposed to material obtained during their rotation. Similarly, students going into pharmacologic intense specialties may do better on tests. In addition, it is possible that there was a selection bias, with students with more knowledge on the subject more likely to answer the survey.

What our evaluation does show; however, is that toxicology rotations are associated with increased knowledge of three different domains, while pharmacology electives are associated with increased knowledge of two of the domains. As expected, it also showed that students

Table 1. Data analysis

Group	Number	Mean (SD) overall score	Mean (SD) PE score	Mean (SD) TOP score	Mean (SD) PK score
All students	332	10.0 (2.4)	3.1 (1.2)	3.5 (1.0)	3.4 (1.1)
Year 1: 2010	108	10.2 (2.2)	2.9 (1.1)	3.6 (1.0)	3.7 (1.0)
Year 2: 2011	116	9.9 (2.3)	3.1 (1.2)	3.4 (0.9)	3.3 (1.2)
Year 3: 2012	108	9.8 (2.7)	3.1 (1.2)	3.3 (1.1)	3.3 (1.1)
Pharmacology intense	216	10.3 (2.2)	3.2 (1.1)	3.5 (0.9)	3.5 (1.1)
Less pharmacology intense	95	9.4 (2.7)	2.8 (1.3)	3.3 (1.0)	3.3 (1.2)
Both	10	11.2 (1.8)	3.3 (1.3)	4.1 (0.7)	3.8 (1.0)
Toxicology	35	11.6 (2.0)	3.7 (1.2)	4.0 (0.9)	3.9 (0.9)
Clinical pharmacology	86	10.1 (1.9)	3.0 (1.2)	3.5 (0.9)	3.5 (0.9)
Neither	201	9.6 (2.5)	3.0 (1.1)	3.3 (1.0)	3.3 (1.2)

Toxicology Question Set

Participation in this quiz is voluntary. This quiz is strictly for research purposes only and will not affect any grade on your transcript. Students who do participate are not required to place any unique identifiers on this document and individual student participation in the study will not be documented in any way.

Did you complete either of the following fourth year electives?

- ☐ Toxicology
☐ Clinical pharmacology

In what specialty did you match, or are planning on matching in? _____

1) Which of the following is the best piece of information for prognosticating acute Tylenol (Acetaminophen) Toxicity?

- A. Total grams of acetaminophen ingested
 B. Liver function test
 C. Four-hour serum level
 D. Serum creatinine and BUN

2) Activated charcoal would be expected to have significant absorption of which of the following substances?

- A. Lithium
 B. Ethanol
 C. Organic solvents
 D. Aspirin

3) Hemodialysis would be most helpful for a medication overdose with which of the following properties?

- A. Large volume of distribution, high protein avidity
 B. Small volume of distribution, low protein avidity
 C. Large volume of distribution, low protein avidity
 D. Small volume of distribution, high protein avidity

4) An ICU patient's lorazepam drip was stopped after one week of continuous infusion and he dose not awaken in the first 8 hours. What is the most appropriate explanation for this patient's continued somnolence?

- A. Decreased clearance in critically ill patient
 B. Idiosyncratic reaction
 C. Redistribution of medication
 D. Neurologic damage secondary to prolonged exposure to lorazepam

5) What is the main effect of hyperbaric oxygen in the patient with a carboxyhemoglobin concentration of 31%?

- A. Increases hemoglobin affinity for oxygen
 B. Increases partial pressure of serum O₂ allowing O₂ to competitively displace CO from hemoglobin and cytochromes
 C. Increases partial pressure of serum O₂ allowing for better oxygenation of tissue
 D. Prevents CO from precipitating out of serum and thereby prevents the bends and arterial gas embolism

6) Four-year-old child presents with a blood sugar of 14 mg/dL after swallowing an unknown medication from their diabetic mother. Which of the following medications is most likely responsible for the child's hypoglycemia?

- A. Insulin
 B. Metformin
 C. Glipizide
 D. Rosiglitazone

15) What is the common toxidrome observed in diphenhydramine toxicity

Toxidrome	Blood pressure	Heart rate	Temperature	Pupils	Bowel sounds	Skin
A	Hypertensive	Tachycardic	Hyperthermic	Mydriasis	Decreased	Diaphoretic
B	Hypotensive	Bradycardic	Hypothermic	Unchanged	Decreased	Flushed & dry
C	Hypertensive	Tachycardic	Hyperthermic	Mydriasis	Decreased	Flushed & dry
D	Hypotensive	Bradycardic	Hypothermic	Miosis	Decreased	Diaphoretic

7) A minimally responsive 25-year-old male is brought in by ambulance after being found down in a park with an empty bottle of antifreeze. Per EMS report, the patient has had myoclonic jerking and multiple episodes of emesis in route to the hospital. Laboratory analysis revealed an anion gap of 28, a serum osmolar gap of 80. Urinalysis was positive for hematuria and calcium oxalate crystals. By what mechanism does ethanol prevent toxicity in this exposure?

- A. Competitively inhibits metabolism of ethylene glycol
 B. Increases excretion of toxic metabolites
 C. Binds and detoxifies toxic metabolites
 D. Decreases absorption of ethylene glycol

8) By what mechanism does N-acetylcysteine prevent toxicity in an acetaminophen overdose?

- A. Provides co-factor necessary for hepatic clearance
 B. Alkalinizes urine
 C. Binds to acetaminophen preventing further absorption
 D. Binds to acetaminophen in serum decreasing unbound acetaminophen and thereby acting as a carrier to the liver for detoxification

9) A 48-year-old man with significant alcohol abuse history presents to ED with minor alcohol withdrawal. The patient responds well to treatment in hospital. What is a desirable characteristic of an outpatient medication to prevent further withdrawal?

- A. Long serum half-life
 B. High potency
 C. High bioavailability
 D. Small volume of distribution

10) What is the classic metabolic finding, in salicylate toxicity?

- A. Mixed respiratory alkalosis-metabolic acidosis
 B. Mixed respiratory acidosis-metabolic alkalosis
 C. Combined respiratory and metabolic acidosis
 D. Combined respiratory and metabolic alkalosis

11) In aspirin overdose, what is most commonly done to increase drug clearance?

- A. Urine Alkalinization with Sodium Bicarbonate
 B. Urine Acidification with NH₄Cl
 C. Osmotic diuresis with Mannitol
 D. Furosemide diuresis

12) Which of the following medication is least likely to cause bradycardia in overdose?

- A. Propranolol
 B. Digoxin
 C. Diltiazem
 D. Amiodarone

13) What is the maximum daily dose for acetaminophen?

- A. 1 g
 B. 2 g
 C. 3 g
 D. 4 g

14) What is the most serious and often fatal complication of tricyclic antidepressant overdose?

- A. Adult respiratory distress syndrome (ARDS)
 B. Disseminated intravascular coagulation (DIC)
 C. Dysrhythmias and cardiovascular collapse
 D. Seizures

Figure 1. Toxicology questions set.

going into more pharmacologic intense fields were more likely to have increased toxicology knowledge.

CONCLUSIONS

The external validity of this study is limited to a single medical school with incomplete participation. The content was limited by the survey length and there is no gold standard for this knowledge area. Consistent results over the three-year period and correlation of performance with completing a toxicology rotation and intent to enter a pharmacology intensive specialty suggest this survey may correlate with toxicology knowledge specifically related to three domains studied PE, PK, and TOP. Implementation of required core courses or sections in required core courses like pharmacology focused on the field of toxicology may improve practical core content knowledge in fourth-year medical students. Further research defining standards of toxicology education in medical students needs to be studied.

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REFERENCES

- 1 Golberg L. Broader aspects of clinical toxicology. Clin Toxicol. 1980;16(3):365-70.
- 2 http://lcme.org/wp-content/uploads/filebase/standards/2016-17_Functions-and-Structure_2015-6-16.docx Accessed 05/17/2016
- 3 Counselman FL, Borenstein MA, Chisholm CD, Epter ML, Khandelwal S, Kraus CK, et al. EM Model Review Task Force, Keehbauch JN; American Board of Emergency Medicine. The 2013 Model of the Clinical Practice of Emergency Medicine. Acad Emerg Med. 2014; 21(5):574-98.
- 4 Kim H, Heverling H, Cordeiro M, Vasquez V, Stolbach A. Internet training resulted in improved trainee performance in a simulated opioid-poisoned patient as measured by checklist. J Med Toxicol. 2016;12(3):289-94.
- 5 Thompson TM. Medical toxicology education in a world of limited resources. J Med Toxicol. 2015;11(3):281-2.
- 6 Wong A, Vohra R, Ruha AM, Koutsogiannis Z, Graeme K, Dargan PI, et al. The Global Educational Toxicology Uniting Project (GETUP): an Analysis of the First Year of a Novel Toxicology Education Project. J Med Toxicol. 2015;11(3):295-300.
- 7 World Health Organization. <http://www.who.int/ipcs/poisons/en/> accessed 05/17/2016

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