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Drug Toxicity in Kidney Disease: A Standardized Patient Case for Clerkship Students

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Abstract

Introduction: A disconnect appears to exist for medical students between learning drug facts in a basic science context and applying those facts in a clinical context when they begin working with authentic patients. In patients with kidney dysfunction, dosages of medications that are renally eliminated often need to be adjusted, due to potentially toxic accumulation in the body. To gain insight into the thought processes and gaps underlying student thinking, we developed this standardized patient (SP) case featuring a patient with drug-related renal dysfunction. **Methods:** This activity was conducted in a simulation center, in a setting reminiscent of an emergency department. It took place over 2 days, with all 23 third-year medical students at our regional campus. After reporting to the simulation center at their assigned time, students completed four different medication scenarios. This specific case involved two parts. The first part, an SP-student encounter, was allotted 15 minutes, followed by 1 minute to walk to a computer station. For the second part, writing a SOAP (subjective, objective, assessment, and plan) note, 15 minutes were allotted. This was followed by 3 minutes for the SP to provide student feedback and 1 minute to rotate to the next station. In total, 35 minutes were allotted for each student to complete the case. **Results:** All third-year medical students at our regional campus completed this activity at the midpoint of their academic year. Students were well prepared to gather necessary background information from the standardized patient. However, few made the connection between the patient's symptoms and the way in which her medications were contributing. Nor did they recommend an appropriate course of action for medications that required adjustment. **Discussion:** From this activity, we gained insight into the student thought process with regard to medication management and have been able to develop new ways of revisiting basic science concepts in clinically relevant contexts to help bridge the gap between the basic and clinical components of pharmacology education.

Keywords

Chronic Kidney Disease, Pharmacology, Renal Dosing, Renal Failure, Renal Dysfunction, Dosage Adjustment, Methotrexate, Creatinine Clearance, Premature Closure

Educational Objectives

By the end of this session, the learners will be able to:

1. Perform a focused history and physical examination of a patient in the context of symptoms, medications, and past medical history.
2. Formulate an appropriate diagnosis for the patient, recognizing the underlying problem.
3. Create a thorough plan, including medication/dosage changes, to manage a patient appropriately.
4. Apply basic science concepts (renal physiology, calculating creatinine clearance, making dosage adjustments, and identifying adverse drug reactions) in a clinically relevant context.

Introduction

Chronic kidney disease (CKD) affects 13% of the adult population in the United States and commonly coexists with cardiovascular conditions.¹ Early stages of CKD are asymptomatic; symptoms typically develop only when estimated glomerular filtration rate (eGFR) falls below 30 mL/min/1.73m². Symptoms of

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All appendices are peer reviewed as integral parts of the Original Publication.

later stages of CKD include edema, muscle weakness, electrolyte abnormalities, and anemia (fatigue, reduced exercise capacity/quality of life, etc.). Managing these symptoms and associated comorbidities is often the purview of primary care providers.¹ Therefore, appropriate recognition and management of CKD are imperative to improve morbidity and mortality in these patients.

In patients with significant renal impairment, medications that are eliminated by the kidneys require dosage adjustments. These adjustments are based on markers of renal function such as eGFR or creatinine clearance (CrCL). Serum creatinine is the primary laboratory value that is used to determine if a dosage adjustment is necessary. A simple mathematical equation that takes into account a patient's serum creatinine levels, along with the patient's weight and gender, estimates the rate at which creatinine (a muscle by-product) is cleared by the kidneys. Armed with the knowledge of a patient's CrCL, health care providers can use electronic drug information tools to determine appropriate dosage regimens. Dosing adjustments in the presence of renal dysfunction may involve either reducing dosages or lengthening dosing intervals.²

Renal physiology has historically been a subject taught in medical schools during the basic science years. Similarly, pharmacology is also a discipline routinely learned during the early years of medical school. Yet the necessity for pharmacologic dosage adjustments in the presence of renal dysfunction may not always be apparent since the two disciplines may be taught as separate courses. Furthermore, the applicability of basic physiology and pharmacology concepts to authentic patients in clinical contexts may be lost among early trainees. In addition to recalling underlying pharmacology and physiology when the added complexity of a patient presenting with multiple complaints from unrelated organ systems is added to the scenario, successful problem identification also requires that analysis, synthesis, and evaluation competencies be mastered to determine the most appropriate course of action. Unfortunately, identifying the underlying cause for patients' complaints is often complex; mistakes, including misdiagnoses, are common.³

To investigate students' thought processes with regard to the gap that exists between the basic sciences and clinical training, particularly with regard to pharmacology and medication management, we wished to develop scenarios in which students were asked to apply basic science knowledge and principles in simulated clinical settings using standardized patients (SPs). This simulation is one of four patient scenarios that were used to assess medication management skills among all third-year medical students at our regional medical school campus. Successful completion of this specific case required students to apply basic science concepts (renal physiology, calculating CrCL, making dosage adjustments, and identifying adverse drug reactions) in a clinically relevant manner.

A review of the literature pertaining to educational activities relevant to renal dysfunction identified one physician's 10 tips to entice trainees to pursue a career in nephrology and a review article describing online educational tools relevant to nephrology.^{3,4} However, we found no educational activities focusing on renal dysfunction and medication dosage adjustments or adverse effects. The idea for developing this case was based upon a case report involving medication toxicity as described in the dermatology literature.⁵

Our scenario was implemented as a low-stakes, formative assessment. Students were required to take a careful patient history, evaluate subjective and objective findings, activate clinical reasoning skills to identify the underlying problem, and formulate a plan to resolve the situation. A physical exam was also to be completed by the students; however, this was not formally assessed because there was no video recording available, only audio.

Methods

Given the desire to investigate the gap between the basic and clinical science knowledge and application of pharmacology, we wished to simulate a clinical setting. Thus, an SP methodology was chosen. Prior to initiating case development, input was sought from both internal medicine and family medicine physicians as well as faculty and staff within the simulation center at our main medical school campus. The case developer, a pharmacist and pharmacology faculty member, has previously completed a weeklong simulation instructor training course and now teaches in that course several times each year.

Logistics

This activity was conducted in a simulation center, in a setting reminiscent of an emergency department. It took place over 2 days, with all 23 third-year medical students at our regional campus. After reporting to the simulation center at their assigned time, students completed four different medication scenarios. This specific case involved two parts. The first part, an SP-student encounter, was allotted 15 minutes, followed by 1 minute to walk to a computer station. For the second part, writing a SOAP (subjective, objective, assessment, and plan) note, 15 minutes were allotted. This was followed by 3 minutes for the SP to provide student feedback and 1 minute to rotate to the next station. In total, 35 minutes were allotted for each student to complete the case.

Given the time constraints faced, four students completed the activity in a morning session, four in an early afternoon session, and four during a late afternoon session. The activity began at 9:00 am and finished at 5:45 pm. Therefore, the SP had 12 student encounters per day. A timekeeper was assigned to ensure that encounters were kept on time (instructions provided in Appendix J). In addition, a master schedule identified the minute-by-minute actions of the students (Appendix I) as they flowed through this and three additional stations. This scenario is represented in the blueprint as Case 2 and SOAP 2 (although Cases 1, 2, and 3 were on the same time schedule). While in our case we had only audio recorders and not video capability, an additional staff member would be ideal to manage the recording technology if conducted in centers where this is feasible.

Students knew in advance that they would be completing medication-related scenarios with SPs and were encouraged to bring any resources that they would typically consult for drug information to make the encounter as authentic as possible. At the beginning of the encounter, students were provided with a general overview of the patient they were about to encounter, including vital signs for the SP. Students were asked to perform a focused history and physical exam on the SP and to tell the SP what they believed was causing her problems. On account of resource limitations, index cards with verbal descriptions and/or color photographs were used to present findings to students that could not be replicated under the constraints with which we were faced. Students were given 15 minutes to accomplish this encounter.

Part two instructions informed students they would be writing a SOAP note. They were asked to list positive and negative findings from the history and physical that were used in developing their differential diagnosis, as well as asked to describe the most plausible diagnosis and outline their plan for the SP. Again, students had 15 minutes to write their note and submit it electronically. Appendix D contains the instructions for the first and second parts of the case. The SP used a checklist for student assessment (contained within Appendix E) to assess the student's ability to gather pertinent information from the SP regarding the situation and communicate the most likely diagnosis. This checklist was completed immediately after each student exited the room (the SP completed the checklist while students wrote their SOAP notes). After SOAP note completion, students reentered the SP room for 3 additional minutes to receive feedback. During this time, the SP provided students with a sense of the general strengths of the interaction as well as areas for improvement based upon how the student made the SP feel as a patient. Students were not given individualized feedback about their performance on checklist items; however, during the semester following the simulation encounter, additional clinical pharmacology concepts were added to their curriculum, and key principles identified as a direct result of this activity were reinforced.

SP Case

Details of the case scenario, including logistical information and details about patient presentation, are included in Appendices A and B.

SP Recruitment and Training Methods

Given that we needed to develop an SP program at our regional medical campus to conduct this activity, SPs were recruited from local theater groups and senior citizens centers and with newspaper advertisements. Recruitment materials are contained within Appendices C, G, and H. More than 80 prospective SPs were interviewed, at which time the needs and expectations of SPs were delineated. For this case, two individuals were selected.

To orient the SPs to the scenario and the role they were to portray, the case was sent to them to review 2 weeks in advance of training. At SP training, the case was read aloud with the SPs, with the faculty member communicating the rationale behind specific case components, emphasizing key points, and answering questions that the SPs raised. Next, the faculty member and the SPs engaged in role-playing the scenario. Each SP completed the checklist for student assessment (Appendix E) following the role-play activities. Discrepancies in checklist completion were discussed, and feedback was provided to the SPs. Role-playing continued with coaching and feedback provided to SPs until expectations were achieved. Any checklist items that were unclear were also discussed and corrected at this time. Since the trainer was also the case author, changes were made to the case when the SPs had appropriate ideas to incorporate. In addition, SPs were also given instructions for providing feedback to students following the encounters. Specifically, SPs were instructed to ask students how they felt the encounter went and provide both positive feedback to students and constructive comments regarding things that could be improved based upon how the students made the SP feel as a patient (e.g., reassured, uncomfortable, attentive, used complex medical jargon, respected their modesty, etc.). The SPs did not use a checklist or rubric as the basis for this feedback, since assessment of student interpersonal skills was not the goal of the case.

At the conclusion of training, one individual was selected as the primary SP. The other was a backup SP in case the primary SP had a conflict or illness on event dates. The primary SP was the only SP used for all 23 students who participated in the scenario; she was a retired nurse and familiar with medical terminology, patient interviews, and the overall patient care experience.

Case Implementation

Following all SP and student encounters, a single faculty member listened to audio recordings of each scenario. Some discrepancies between the SP's recall and the audio were noted. Specifically, sometimes the SP volunteered information relevant to the case without waiting for students to make a specific inquiry. Yet in these instances, the SP identified on the checklist that the student had completed the task. Thus, the audio was used as the definitive record as to whether the student (as opposed to the SP) had done the task or made the inquiry. In addition, the faculty member assessed students' notes using a rubric included within Appendix F.

Results

All 23 students at the regional campus have performed this scenario. [Table 1](#) illustrates data gathered from the SP-student interactions (as verified by the faculty member). [Table 2](#) illustrates data gathered by student SOAP notes.

Table 1. Summary From Standardized Patient Checklist and Instructor Audio

Item Assessed	N (%)
Patient history (history of present illness, past medical history, family history)	99 (50.3%)
Patient medication history	35 (81.4%)
Assessment/plan	7 (16.3%)

Table 2. Summary From Student SOAP Notes

Item Assessed	N (%)
Subjective	35 (25.4%)
Objective ^a	27 (23.5%)
Calculated creatinine clearance	2 (8.7%)
Assessment	7 (30.4%)
Identified medication-related problems	13 (18.8%)
Developed appropriate plan	33 (20.5%)

^aIncludes calculated creatinine clearance.

Students were most successful at obtaining the patient's medication history. The medication history included two components: the patient's current medication list as well as whether the patient had tried anything for the current symptoms. All students obtained the patient's current medication list, while a little more than half of the students asked if the patient had tried taking anything to ameliorate the symptoms.

While assessing information regarding the patient's history, students were most thorough at obtaining the patient's past medical history and less proficient at gathering information related to the history of the present complaint to create a clear picture of the patient's current medical problem(s). For the assessment component, the majority of students failed to relay information to the patient about underlying kidney dysfunction being responsible for the current situation. From the audio, it was apparent that only two students specified to the patient that methotrexate was the likely cause of most of her present symptoms. Instead, three students speculated that the underlying cause of the problems was a drug allergy, four suggested Stevens-Johnson syndrome or toxic epidermal necrosis, seven proposed drug interactions, and 10 students attributed the cause of the patient's problems to the recent substitution of a succinate salt rather than a tartrate salt formulation for the patient's beta blocker. While nine students did tell the patient that her kidney function was not optimal, they failed to make the connection between renal dysfunction and medication dosage reductions being necessary.

Overall, the SP did not have any specific complaints for how the students performed their interviews. The SP did, however, have some hearing difficulties, so she wished the students had spoken louder during the encounter due to background noise present in the room. She provided feedback to them regarding this.

When students wrote their SOAP notes, they collectively summarized only a fraction of the subjective and objective items that were deemed relevant to the case (Table 2). It is particularly noteworthy that only two individuals calculated a CrCL value for the patient. While approximately half of the students noted in some form that methotrexate was involved with the current symptoms, they often failed to completely connect the dots and make necessary changes to the patient's medications in their description of the treatment plan.

Discussion

Based upon the results of this activity, it appears that cumulatively our students were reasonably proficient at gathering data necessary to ascertain a patient's past history. However, students were less likely to apply basic science concepts to clinical care. For example, nine students recognized from the patient's laboratory values that her kidney function was poor. However, few students (only two) took the next step and calculated the patient's CrCL, which is an important component in clarifying the extent of renal dysfunction and often the basis for which medication dosage adjustments are made. Thus, it is not enough only to recognize that kidney dysfunction is present; one must also know what to do with that information.

Furthermore, it was the exception, rather than the rule, that students correctly identified the underlying cause of the SP's problems. Nearly half (43%) of the students incorrectly attributed the cause of the patient's problems to the last medication change that had been made (e.g., change in a medication formulation). Interestingly, during case design, this was not intended to be a red herring; it was simply intended to be consistent with standards of care when the heart failure diagnosis has been made. This narrow view of the patient's situation was surprising. In medical education, we must help students expand

their thinking beyond consideration of only a new drug as potentially problematic; they also need to consider a new context for existing (i.e., old) drugs. In this case, the new context was declining renal function resulting in toxicity associated with renally eliminated medications.

Students were also quick to dismiss the patient's problems as a drug interaction or a drug hypersensitivity without specifying to the patient which medication pairs were interacting or to what medication she might be allergic. Furthermore, these latter students failed to realize the gradual onset of the symptoms would likely rule out a drug-induced hypersensitivity reaction as an underlying cause of the patient's current complaints.

Since the majority of students did not seem to put the pieces of this scenario together to generate an accurate assessment of the situation, it is no surprise that room for improvement was also noted with regard to creating an accurate plan, primarily relating to making appropriate dosage adjustments of renally eliminated medications.

We implemented this medication-related scenario to gain insight into the gaps that exist for students when linking basic science pharmacology concepts to clinical applications. As a result, we have incorporated many pharmacologic concepts into an integrated medical science thread for all third-year medical students across all of our campus locations. The aim is to challenge students to revisit the importance of the basic sciences in clinical care. In developing the new medical sciences curricular thread, this SP scenario has been converted into a paper case that is assessed and reviewed by interprofessional teams of students (MD, NP, and PharmD learners). It is interesting to note that when students solve the scenario in teams, regardless of the exact disciplines represented, it is rare for a group to fail to identify the underlying problem. Allowing students to work in groups has demonstrated clear advantages in terms of teamwork and problem-solving capabilities, since each individual on the team is armed with different viewpoints, knowledge, and expertise.⁶ In fact, having pharmacy student participation in these activities has reinforced the importance of calculating CrCL before looking at a patient's drug list. To pharmacy providers, a CrCL value is treated as a vital sign. Thus, this SP case might be useful as an interprofessional education learning activity in which both medical students and pharmacy students solve the scenario together while learning with, from, and about each other's discipline. In clinical care, medication-related errors in emergency department settings are 13.5 times more likely to occur in the absence of an emergency department pharmacist.⁷ Even in primary care, when medical charts of patients with poor renal function are reviewed by pharmacists, nearly every patient is found to be taking at least one medication that requires a dosage adjustment.⁸

One limitation to this assessment was the lack of a formalized grade given to participants. During the time that students completed this scenario, they were enrolled in 10 different clerkships. Thus, there was not a single course or clerkship to which a grade could have been consistently applied. Although students were required to attend, there were no repercussions for effort that was not put forth in solving this patient scenario. Nonetheless, we assume that students did their best and that their performance would not have been substantially different if receiving a formal grade. Yet since assessment drives learning, this must be considered as a possibility.

In the future, we will revisit the way in which we train our SPs to provide student feedback. Specifically, we will develop a brief checklist regarding student behaviors that SPs can specifically address with students when providing feedback.

Overall, this case required identification and management of a common medical situation. It is necessary for future prescribers not only to recognize the condition but also to be proficient at developing an appropriate plan to address it. Student performance supports the need for additional curricular emphasis on identifying causes underlying renal dysfunction and making appropriate medication dosage

adjustments. Furthermore, this endeavor demonstrates that having students revisit basic science concepts during their clinical years of education is warranted.

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Ethical Approval

This publication contains data obtained from human subjects and received ethical approval.

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