RESEARCH ARTICLES

Use of an Audience Response System to Introduce an Anticoagulation Guide to Physicians, Pharmacists, and Pharmacy Students

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Objectives. To implement an anticoagulation guide (AG) and measure understanding with an audience response system (ARS). Secondly, to describe prescribing practices following AG implementation and survey pharmacy students' opinions of the ARS.

Methods. Medical and pharmacy residents, pharmacy students, and clinical staff pharmacists responded to 7 case-based multiple-choice questions related to anticoagulation with the ARS before and after an educational intervention. Following AG implementation, a retrospective medical record review measured prescriber adherence to the guide's warfarin initiation protocol (target adherence was 75%). A survey was administered to pharmacy students via the ARS.

Results. There were significant increases in the number of preferred responses given by physicians, pharmacists, and pharmacy students on an examination administered using an ARS after completing the educational intervention. Prescriber adherence to the warfarin initiation protocol was noted in 22 of 43 (51%) of the medical records reviewed post-intervention.

Conclusion. Use of an ARS improved understanding of the anticoagulation guide as evident by a significant increase in preferred responses on the post-education examination. A majority of pharmacy students surveyed responded that the ARS improved lecture involvement and understanding. However, target prescriber adherence to the warfarin initiation protocol was not achieved.

Keywords: audience response system, interactive learning, learning assessment, anticoagulation

INTRODUCTION

Lecturing is the primary method of educating health professionals and providing continuing medical education. Lectures are at least as effective as other methods at presenting information and providing explanations.[1] However, all methods of teaching have limitations; thus, a mixture of methods is needed to ensure the education of participants. One limitation of lectures is that they do not provide evidence of participants' understanding or ability to use new knowledge. In addition, lectures allow the learner to become passive. A variety of methods have been used to make lectures more interactive, such as the use of an audience response system (ARS).

An ARS has 3 main components: a personal response device, a receiver, and a computer with software to collect and compile responses. Personal response devices are most commonly the size of a remote control and have an electronic keypad numbered 1 thru 10 and labeled A thru E. The use of personal digital assistants to transmit responses has also been reported.[2] The response device transmits responses via a radio frequency or infrared beam to a receiver connected to the computer projecting the questions. Software allows the presentation of a question, display of a timer for participants' responses, and display of the number of responses received. The software also compiles the results into a format prescribed prior to the presentation, such as bar graphs or pie charts. The results can be presented immediately following the polling process or at the discretion of the presenter. Presentation of the responses and discussion of the results make the educational session more interactive.[3] In addition, assessment of participants' understanding and ability to apply newly acquired knowledge is possible.

The ARS technology was targeted as a method for providing education on a new hospital anticoagulation guide (Appendix 1). The need for an anticoagulation guide was identified via the adverse drug reporting system and observations of anticoagulation prescribing practices monitored by the clinical pharmacokinetics service. The University of Kentucky Chandler Medical Center (UKCMC) has utilized online adverse drug reaction reporting since 2000.[4] Over this 4-year period, warfarin has consistently been the most common medication

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reported in the adverse drug reporting system. Our institution defines adverse drug reactions as any response to a drug that is harmful and unintended and occurs at doses normally used in humans for prophylaxis, diagnosis, or therapy of disease, or for the modification of physiologic function. Reported adverse drug reactions related to warfarin included an elevated international normalized ratio (INR) and bleeding. Elevated INR is reported in our system to capture any related clinical sequelae and to monitor trends. Since 1999, the clinical pharmacokinetics service at UKCMC has monitored hospital patients receiving warfarin therapy who did not have a pharmacist on their primary team. This service observed that warfarin prescribing practices varied and lacked a consistent approach. To address this issue, an anticoagulation guide was developed and approved by the UKCMC Pharmacy and Therapeutics Committee. The guide contains a warfarin initiation protocol, heparin, and vitamin K guidelines, and target therapeutic international normalized ratios (INRs) for warfarin therapy based on indication. Initial implementation of the guide was targeted at internal medicine residents (the largest group of physicians prescribing warfarin at our institution), clinical staff pharmacists, pharmacy residents, and pharmacy students starting advanced pharmacy practice experiences (APPE) in the summer of 2004. The use of an ARS was identified as a potential method for measuring understanding of the guide. In addition, the use of an interactive learning method was anticipated to enhance the education provided and lead to a change in prescribing practices.

METHODS

The research project was granted exempt approval by the Institutional Review Board at the University of Kentucky. The Fleetwood Reply (Holland, MI) audience response system hardware and ComTec Group Response (River Edge, NJ) *Synthesis 2000* software were used.

Primary Objective

The primary objective was to introduce the anticoagulation guide and measure participants' knowledge using an audience response system (ARS). Three groups were identified for participation: internal medicine residents, clinical staff pharmacists and pharmacy residents, and third-professional year pharmacy students. The first session was presented to internal medical residents at their daily noon conference and was endorsed by the internal medicine residency director. The clinical pharmacist and pharmacy resident session was presented at the UKCMC weekly pharmacy grand rounds. The last session was presented to pharmacy students as part of the hematology section of an integrated therapeutics course taught during the third-professional year. The integrated therapeutics course is designed to integrate the advanced application of pharmaceutical sciences with patient care following an organ system/disease state approach that emphasizes the development and implementation of patient-specific pharmacotherapeutic treatment plans.

The sessions were designed according to published recommendations for using audience response systems.[5] Each session was led by the same pharmacist and was 50 minutes in duration. The first 7 minutes were spent orienting participants to the mechanics of how to use the ARS and the purpose of the session. Then 7 case-based multiple-choice questions (Appendix 2) were presented and participants responded via the ARS (labeled pre-education responses). Responses to these 7 questions were used to assess baseline anticoagulation knowledge. Next, the anticoagulation guide approved by the UKCMC Pharmacy and Therapeutics Committee in pocket card format was then distributed to each participant. A 12-minute lecture with slides of the individual components of the guide was presented. Education was provided on how to use the guide and where to find specific information. The participants were then presented the same 7 case-based multiple-choice questions and were asked to respond via the ARS using information from the pocket card (labeled post-education responses). The pre-education and post-education responses of the group were displayed cumulatively in bar graph format with the percentage of participants giving a specific response. The instructor for the session identified which response to each question was preferred based on the guideline (labeled preferred responses). A discussion with participants regarding the selection of non-preferred responses was led by the instructor to clarify use of the guide. A comparison of responses on the pre-education and post-education examinations was conducted using the paired Student's *t* test.

Secondary Objectives

A secondary objective was to measure prescribing practices after implementation of the guide. The warfarin initiation protocol contained within the guide was selected as the instrument for measuring prescribing practices. The warfarin protocol was designed for use with warfarin-naïve patients to whom warfarin was first administered during their hospital admission. The guide stratified patients based upon predicted sensitivity to warfarin (high, moderate, or low sensitivity). The warfarin sensitivity stratification was modeled after similar guides from other institutions and

Table 1. Survey Statements by Third-Professional Year Pharmacy Students Regarding Use of an ARS in a Continuing Education Session to Introduce an Anticoagulation Guide

The audience response system increased my involvement in the presentation.
The audience response system helped my understanding of the lecture material.
I enjoyed the use of the audience response system as used for this lecture.
I have enjoyed the use of the audience response system in other lectures.

*Possible responses included: strongly agree, agree, neutral, disagree, or strongly disagree.

sensitivity criteria available in the literature.[6-10] Criteria defining a high-sensitivity patient included a baseline INR greater than 1.5, age greater than 65 years, significant hepatic disease, decompensated heart failure, malnourishment, malabsorption syndrome/chronic diarrhea, cancer, albumin less than 2 g/dL, thyrotoxicosis, or a genetic polymorphism of cytochrome P450 2C9. Moderate-sensitivity criteria included a baseline INR 1.2 to 1.5, age 50 to 65 years, or concurrent use of specified cytochrome P450 enzyme inhibitors. Low-sensitivity criteria included a baseline INR less than 1.2, age less than 50 years, and no other sensitivity criterion. Based on the sensitivity classification, patients were to be started on 1 of 3 initiation regimens. High-sensitivity patients were to receive 2.5 to 5 mg of warfarin on day 1. Moderate- and low-sensitivity patients were to receive either 7.5 mg or 10 mg of warfarin on day 1, respectively. Subsequently, on days 2 through 7, the guide recommended a dose of warfarin corresponding to the patient's INR drawn each morning.

A retrospective medical record review of all warfarin naïve inpatients initiated on warfarin therapy under the care of internal medicine residents following implementation of the guide (from December 2003 to May 2004) was performed to measure adherence to the warfarin initiation protocol. The target threshold was 75% adherence, defined as selection of an initiation dose of warfarin that corresponded to the anticoagulation guide. Data collected from each patient record included age, medical history, concomitant medications, baseline INR, indication for warfarin, initiation dose of warfarin, assessment of all other guide criteria for warfarin sensitivity classification, resident and attending physician names, and the medical service to which the patient was assigned. All data were collected by the same investigator and analyzed using descriptive statistics.

Another secondary objective was to measure pharmacy student satisfaction with the use of the ARS for the continuing education presentation on anticoagulation. University of Kentucky pharmacy students in the third-professional year completed a survey related to the use of the ARS in their curriculum and were asked to rate 4 statements as strongly agree, agree, neutral, disagree, or strongly disagree (Table 1).

RESULTS

Primary Objective

Twenty-three internal medicine residents attended the educational session and 15 (65%) provided responses to all pre- and post-education questions. Of the 26 clinical pharmacists and residents at the pharmacy session, 24 (92%) provided responses to all of the questions. Of the 86 third-professional year pharmacy students, 83 (97%) provided responses to all of the questions. The primary reasons participants were not able to respond to all questions were tardiness to the session or early departure for patient-care issues. Those participants who were able to respond to all pre- and post-education questions were included in the data analysis. Each pre- and post-education response was tallied. A preferred response was given 1 point and a non-preferred response was given 0 points. Each pre-education and post-education participant data set was given a score of 0 to 7. The mean scores for each group to the pre- and post-education responses were respectfully: physicians (2.8 ± 0.9 and 5.9 ± 1.3; $p<0.0001$); pharmacists (3.8 ± 1.0 and 6.8 ± 0.4; $p<0.0001$); pharmacy students (2.5 ± 0.2 and 6.2 ± 0.2; $p<0.0001$).

Secondary Objectives

The retrospective medical record review identified 43 warfarin naïve patients initiated on warfarin therapy on services covered by internal medicine residents. Baseline demographic data were similar among adherent and non-adherent groups (Table 2). Prescriber adherence to the warfarin initiation protocol for the selection of initiation dose was 51% (22 of 43 patients), which was below the target rate of 75%. The primary reason for non-adherence was selecting a dose that was lower than recommended in the protocol 70% (15 of 21 patients). The dose selected for these patients in the non-adherent group was 5 mg. Data on patient-specific clinical outcomes were not available for all patients. Most patients were discharged prior to achieving a therapeutic INR. Therefore, an analysis of clinical outcomes was not performed.

The survey of the third-professional year pharmacy students showed that a majority agreed that the ARS increased their involvement in the presentation and helped with understanding of the lecture material and enjoyment of the lecture (Figure 1).

Table 2. Descriptive Data of Warfarin Naïve Patients Retrospectively Reviewed After Implementation of an Anticoagulation Guide

	Adherent (N=22)	Non-Adherent (N=21)
Mean age, y	63 ± 14.9	48 ± 15.9
Male	14	13
Female	8	8
Primary service		
Cardiology	5	3
Oncology	1	1
Internal Medicine	12	13
Neurology	4	4
Mean baseline INR	1.0 +/- 0.1	1.0 +/- 0.1
Mean starting dose	5.9 +/- 1.8	6.3 +/- 1.8
2.5mg	0	0
5mg	17	15
7.5mg	2	1
10mg	3	5
Guideline sensitivity classification		
High	17	5
Moderate	2	11
Low	3	5
Anticoagulation diagnosis		
Atrial fibrillation	8	7
Deep venous thrombosis	5	8
Pulmonary embolism	6	5
LV dysfunction	1	0
CVA	1	1
Apical thrombus	1	0

DISCUSSION

Traditional methods of medical education have failed to successfully impact prescribing practices and health care outcomes.[11] Identification of a method that successfully changes prescribing practices and outcomes is important. To our knowledge, this is the first published study to combine traditional education methods with an ARS to implement an anticoagulation guide and to describe prescribing practices. The audience response system as a tool to enhance lectures has been described previously in the literature.[3,12-14] A report by Eggert and colleagues[12] describes the use of an ARS in a clinical decision-making journal club held weekly for internal medicine residents. The primary objective of the journal club was for the attendee to apply the evidence presented to a clinical decision about a specific patient. At the journal club, the ARS was used to ask resident participants multiple-choice questions related to a clinical decision. Participants provided answers before and after the presentation of literature-based evidence. In all 15 journal club meetings studied, the residents were uncertain about the correct answer prior to the presentation of evidence, as evidenced by no single answer capturing >75% of total responses. During 60% of the conferences, audience opinion converged after presentation of the evidence. Convergence was defined as a single preferred response by >75% of participants. The ARS was able to measure participant knowledge before and after the presentation of evidence and led to an overall consensus. The authors also concluded that the immediate feedback from the ARS provided the opportunity for deeper discussions and follow-up questions.

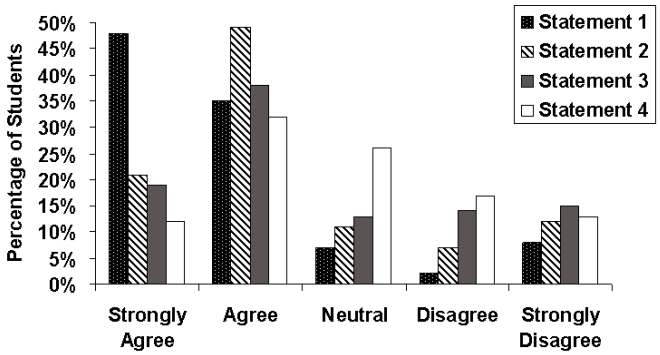

Figure 1. Survey responses of third-professional year pharmacy students to the following statements: (1) The audience response system increased my involvement in the presentation. (2) The audience response system helped my understanding of the lecture material. (3) I enjoyed the use of the audience response system as used for this lecture. (4) I have enjoyed the use of the audience response system in other lectures.

A study by Uhari and colleagues[3] describes the use of an ARS for 33 of 63 pediatrics lectures for fifth-year medical students. The participants were given a 15-question survey related to lecture satisfaction. The survey was administered using the ARS at the beginning and end of the semester. A total of 36 of 40 students (90%) completed both surveys. Most students reported that the ARS improved their activity during lectures, enhanced learning, and made asking questions easier.

A report by Homme and colleagues[13] describes the use of an ARS in a pediatric residency training program's board review conferences. The ARS improved attendance by 50% and participation in the conference improved compared to that observed when paper-based or hand-raising polling methods had been used. A report by Brezis and colleagues[14] describes the use of the ARS for lectures presented to nearly 500 physicians and 400 medical students. The ARS was implemented to allow for non-threatening realization of knowledge gaps and recognition of misconceptions. The authors concluded

that the ARS facilitated probabilistic thinking and that most participants felt the ARS improved participation in the lecture to a great or very great degree.

Our survey of third-professional year pharmacy students provided similar results to those described by Uhari and collegues.[3] The majority of students agreed that the ARS improved activity during lectures and enhanced learning. The pharmacy students in our study had used the ARS previously in other courses in the pharmacy curriculum. One proposed reason for the positive response to the ARS may be related to the class demographics. The majority of the students in this survey would be classified as "Generation X." The audience response system addresses some of the educational preferences of Generation X by incorporating technology and providing immediate feedback.[15] As this generation begins to comprise a larger segment of professional schools and practice, technology like the ARS may be an important component of the educational arsenal.

Despite the positive reports found on the ARS in the literature, the use of the audience response system is not without limitations. The audience response system is portable, but does require training for set up and development of questions with the software. In addition, lecture time must be budgeted to allow for responses to questions, presentation of the results, and discussion. The questions and responses are limited to multiple-choice and true or false questions. Therefore the audience response system is primarily a tool for collection and presentation of questions and responses. The utility of ARS is significantly limited when not accompanied by an additional method of education. The role of the ARS is to enhance this primary method of education via audience participation and the provision of feedback. The use of an ARS is applicable to a variety of educational settings where audience participation and assessment is desired.

Despite the positive data describing the utility of the ARS, no description related to the effect on long-term outcomes was found in the literature. One secondary objective of our study was to describe the impact of the ARS on compliance to the anticoagulation guide (specifically warfarin initiation) by evaluating prescribing practices. The majority of physicians polled during the pre-education assessment chose an initiation dose of 5 mg of warfarin for each of the patient cases presented, regardless of the patient's sensitivity to the drug. When the same cases were presented post-education, however, these physicians were able to use the guide to select a dose of 2.5-5 mg, 7.5 mg, and 10 mg, for high-, moderate-, and low-sensitivity patients, respectively. Although the physicians were able to demonstrate understanding and the ability to use the guideline at the educational session, this knowledge apparently did not translate into changes in prescribing practices. The major limitation to success for this objective was the low attendance of physicians at the educational session. Only 23 of 80 internal medicine residents attended the session, despite encouragement by their residency director. In addition, participation was limited to resident physicians, and did not include attending physicians. The guide was made available in pocket card format to residents who did not attend the session and the guide was promoted by pharmacy services staff. The guide was also published in the Medical Center's drug information newsletter, *Current Topics*, which is distributed to all medical staff. Another limitation was that data collection was completed via a retrospective review of medical records. To maintain confidentiality, specific responses were not linked to a physician by name and attendance at the session was not taken. A comparison of guideline adherence between physicians who attended the session and those who did not was not possible. Lastly, multiple variables determine a learner's ability to retain and use new knowledge. This study did not include conducting a control group educational session without an ARS to determine whether the ARS was the primary variable that affected learner understanding or prescribing practices.

CONCLUSIONS

This study was an innovative use of an ARS to implement a practice guide, to educate pharmacists and pharmacy students, and to describe its effect on outcomes. The ARS was an effective tool used to introduce a new anticoagulation guide and measure the pre- and post-educational understanding of the guide by medical residents, pharmacists, pharmacy residents, and pharmacy students. Ensuring the understanding and ability to use new guidelines is an important component of assessing adherence to guidelines.

The implementation of the guide with the ARS failed to have the desired effect on prescribing outcomes as related to warfarin initiation. In the future, this technology is predicted to become less expensive and thus more widely available. Further study of the ability of the ARS to improve learning and impact outcomes is warranted. Future studies may help to elucidate the optimal use and role for ARS technology.

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Appendix 1. Warfarin Anticoagulation Initiation Dosing for Warfarin Naïve Patients

Day	INR	Warfarin High Sensitivity*	Warfarin Moderate Sensitivity†	Warfarin Low Sensitivity‡
1	Baseline INR	2.5-5mg	7.5mg	10mg
2	<1.5	2.5-5mg	7.5mg	7.5-10mg
	1.5-1.9	2.5mg	2.5mg	2.5mg
	2-2.5	1-2.5mg	1-2.5mg	1-2.5mg
	>2.5	0	0	0
			Continue to Day 3 for all Patients	
			Warfarin Dose for All Patients	
3	<1.5		5-10mg	
	1.5-1.9		2.5-5mg	
	2-2.5		0-2.5mg	
	2.6-3		0-2.5mg	
	>3		0	
4	<1.5		10mg	
	1.5-1.9		5-7.5mg	
	2-2.5		2.5-5mg	
	>3		0-2.5mg	
5	<1.5		10mg	
	1.5-1.9		7.5-10mg	
	2-2.5		2.5-5mg	
	>3		0-2.5mg	
6	<1.5		7.5-12.5mg	
	1.5-1.9		5-10mg	
	2-2.5		2.5-5mg	
	>3		0-2.5mg	
7		Make adjustment based on total weekly dose (Increase or decrease dose by 10%-25% depending on current INR and target INR)		

*High-sensitivity patient: baseline INR greater than 1.5, age greater than 65 years, significant hepatic disease, decompensated heart failure, malnourishment, malabsorption syndrome/chronic diarrhea, cancer, albumin less than 2 g/dL, thyrotoxicosis or a genetic polymorphism of cytochrome P450 2C9. †Moderate-sensitivity patient: baseline INR 1.2 to 1.5, age 50 to 65 years, or concurrent use of specifiedcytochrome P450 enzyme inhibitors. ‡Low-sensitivity patient: baseline INR less than 1.2, age less than 50 years, and no other sensitivity criterion.

Appendix 2. Pre- and Post-Education Assessment Questions (Preferred Responses Italicized)

1. A 77 year-old man is hospitalized for newly diagnosed atrial fibrillation. PMH is significant for hypertension that is currently being treated with hydrochlorothiazide 25 mg daily and metoprolol 25 mg twice daily. Based on his age and a history of hypertension the decision to anticoagulate with warfarin has been made. Baseline INR is 1.09. All other pertinent labs are WNL. Ht. 5'10", Wt. 45 kg. What starting dose of warfarin would you choose?

A. Warfarin 2.5 mg

B. Warfarin 5 mg

C. Warfarin 7.5 mg

D. Warfarin 10 mg

Rationale- Patient meets high risk criteria: age >65 and potential malnourishment weight = 45 kg (IBW=73kg).

2a. A 60 yo woman is to start warfarin for postoperative prophylaxis after elective total knee replacement. PMH is significant for osteoarthritis treated with acetaminophen 500-1000 mg four times daily as needed. Baseline INR is 0.99. All other pertinent labs are WNL. Ht. 5'5", Wt. 100 kg. What starting dose of warfarin would you choose?

A. Warfarin 2.5 mg

B. Warfarin 5 mg

C. Warfarin 7.5 mg

D. Warfarin 10 mg

Rationale- Patient meets moderate risk criteria; age 50-65, potentially on high doses of acetaminophen.

2b. The same 60 year-old woman starts warfarin for post-operative prophylaxis after total knee replacement. On day 1 she is given warfarin 7.5 mg po at 1700. On day 2 her AM labs report an INR of 1.7. What dose of warfarin would you choose on day 2?

A. Warfarin 2.5 mg

B. Warfarin 5 mg

C. Warfarin 7.5 mg

D. Warfarin 10 mg

Rationale- Per moderate risk factor pathway; if Day 2 INR is 1.5-1.9, give warfarin dose of 2.5 mg.

3a. A 28 year-old woman is admitted to the hospital for the treatment of a proximal deep vein thrombosis. PMH is non-significant. Baseline INR is 1.01, Ht. 5'7", Wt. 65kg. What starting dose of warfarin would you choose?

A. Warfarin 2.5 mg

B. Warfarin 5 mg

C. Warfarin 7.5 mg

D. Warfarin 10 mg

Rationale- Patient meets low risk criteria; age <50 and no other risk factors.

3b. The same 28 yo woman was started on enoxaparin 1mg/kg SQ q 12h and warfarin for the treatment of her venous thromboembolism. When would you discontinue her enoxaparin injections?

A. After a total of 5 days of enoxaparin therapy.

B. When INR reaches target of (2-3).

C. When INR reaches target of (2.5-3.5).

D. When INR is ≥ 2 for 2 consecutive occasions at least 24 hours apart.

Rationale- Patient has a venous thromboembolism (DVT) and target INR is 2-3; however bridge therapy with a heparin should be continued until INR is ≥ 2 for 2 consecutive occasions at least 24 hours apart.

4. A 67 yo male is hospitalized for pyelonephritis. He received 5 days of TMP/SMX DS po twice daily prior to admission and was changed to levofloxacin 250 mg po daily. He is receiving chronic warfarin therapy for a mechanical valve prosthesis. He presents with an INR of 7.2 and hematuria.

A. Continue warfarin therapy at a lower dose.

B. Omit a dose and administer vitamin K 1.25 to 2.5 mg PO and resume therapy at a lower dose when INR is therapeutic.

C. Hold warfarin therapy and administer vitamin K 3.75 to 5 mg PO and resume therapy at a lower dose when INR is therapeutic.

D. Hold warfarin therapy and administer vitamin K 10 mg by slow IV infusion (1mg/min) diluted in D5W or NS.

Rationale- Patient has an INR of 5 to 9 and hematuria; however not a significant bleed requiring urgent surgery.

7. The peak anticoagulant activity of warfarin due to Factor II inhibition is seen in how many hours?

A. 12-24 hours

B. 24-48 hours

C. 72-96 hours

D. 96-144 hours