RESEARCH ARTICLES

Nuclear Pharmacy Instruction in Colleges and Schools of Pharmacy

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Purpose. This study was undertaken to determine the current status of instruction in nuclear pharmacy practice in colleges and schools of pharmacy.
Methods. A survey instrument was sent to the academic deans of the 91 colleges and schools of pharmacy accredited by the Accreditation Council on Pharmaceutical Educators (ACPE) in the United States, Canada, and Puerto Rico. The survey consisted of 10 questions about the teaching of nuclear pharmacy practice in the PharmD curriculum. Schools were asked whether instruction was offered and where in the curriculum instruction was included.
Results. Seventy-five (82.4%) schools responded. Of these, 45 (60%) offered no instruction in nuclear pharmacy. Among the 30 (40%) that did offer instruction in this area, the majority of instruction was focused on material important for the dispensing of radiopharmaceuticals. Only 10 programs reported teaching nuclear pharmacy content on material relevant to clinical pharmacy practice (eg, pharmacokinetic distribution or drug interactions). Importantly, the current level of instruction represents a sharp decline from 1981 when the first such survey was undertaken.
Conclusions. The majority of ACPE-accredited schools of pharmacy do not provide instruction in nuclear pharmacy to their students. Lack of knowledge of these agents is likely to have an adverse impact on the delivery of pharmaceutical care.
Keywords: nuclear pharmacy, pharmaceutical education, radiopharmaceuticals, curriculum.

BACKGROUND

Pharmacy education faces the challenge of incorporating an increasing number of specialized areas of practice into the curriculum. The desire to train competent generalists should be balanced against the need for students to graduate with knowledge of relatively specialized therapeutic and diagnostic agents that may affect patients within their practice setting. Depending on the training of faculty, fiscal conditions, and time constraints within a school of pharmacy, specialty areas may be omitted from the curriculum. An example of one such specialty practice area is nuclear pharmacy practice. In 1975, the American Association of Colleges of Pharmacy (AACP) approved a resolution advocating that all schools of pharmacy provide instruction in nuclear pharmacy practice to their students.[1] In 1978, nuclear pharmacy became the first specialty recognized by the Board of Pharmaceutical Specialties.[2,3] The first examinations leading to board certification were offered in 1982.[4]

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In 1981, the AACP surveyed the status of nuclear pharmacy education.[2] This study showed that while many universities (63 of 72 responding) offered some instruction in nuclear pharmacy, the extent varied widely from no instruction to PhD programs, and various levels of instruction in between. The 1981 survey did not attempt to determine where in the curriculum this instruction was covered. A second survey, performed in 1996, showed that instruction in nuclear pharmacy had decreased to 58 pharmacy programs (of 84 schools in the United States and Canada) offering some level of nuclear pharmacy instruction. This survey showed that although many schools offered instruction, most did so on an elective basis and had very low student participation. Although 39 programs reported that they included nuclear pharmacy in core courses, the survey did not attempt to classify the areas of the curriculum in which the instruction was offered.[1]

With the transition to the entry-level PharmD curriculum, schools of pharmacy are challenged with incorporating an increasing amount of material into a limited time frame. This survey was undertaken to evaluate the number of programs offering training in nuclear pharmacy practice and to evaluate its status within the curriculum.

METHODS

A survey was sent to the academic deans of the 91 ACPE-accredited schools in the United States, Canada, and Puerto Rico. Data were collected from November 2000 to March 2001. The survey consisted of 10 questions that focused on how nuclear pharmacy was incorporated into the curriculum at the time of the survey. (A copy of the survey may be obtained by e-mail from the author.) All schools initially received a cover letter, survey, and self-addressed stamped envelope. A second mailing was sent to nonresponding institutions.

Primary questions required a yes or no answer. Secondary questions were posed to determine the focus of nuclear pharmacy instruction and the courses in which it was discussed. For each required core curriculum course, specific questions regarding the nature of the material covered were asked. These questions addressed whether the material dealt with the areas of medical/health physics (ie, fundamentals of radiation, radiation dosimetry, instrumentation, etc.) or if it was directly pharmacy related (ie, synthesis of compounds, tracer methodology, agents utilized, drug interactions, etc). To avoid confusion, key terms were specifically defined for the respondents. In addition, the survey instrument inquired about any clinical experiences or special programs in nuclear pharmacy being offered (eg, certificates, residencies, PhD programs, etc).

For the purposes of our survey, the terms “nuclear pharmacy” and “medical imaging” were broadly defined to include teaching of contrast agents (ie, iodinated contrast, magnetic resonance imaging contrast, etc) in addition to traditional radiopharmaceuticals.

RESULTS

Seventy five (82.4%) of the 91 schools of pharmacy replied to the survey. Of these, 51 (68%) characterized themselves as public schools, and 24 (32%) as private. The average class size reported by public schools was 83 students and by private schools, 117 students, with an overall mean of 97 students (one private institution did not state its class size).

Instruction in nuclear pharmacy was offered at 30 (40%) of the responding institutions, with the remaining responding institutions (60%) offering no instruction in nuclear pharmacy/medical imaging. Of the 30 institutions reporting that instruction in nuclear pharmacy was included in their curriculum, 20 (66.7%) were public schools and 10 (33.3%) were private schools.

Among responding institutions, instruction in nuclear pharmacy was offered in the form of a stand-alone elective at 22 schools, as a portion of an elective course at 4, as a stand-alone required core curriculum course at 5 schools, and as part of a required core curriculum course at 15. Some schools offered nuclear pharmacy instruction in more than one course (Table 1).

Table 1. Characteristics of Courses in Nuclear Pharmacy Instruction Offered by Colleges and School of Pharmacy

Variable	Percent
Curriculum distribution among institutions offering nuclear pharmacy (n=30)*	
Stand-alone elective	73.3
Part of elective	13.3
Stand-alone core curriculum	16.7
Portion of core curriculum	50.0
Course distribution if required as part of curriculum (n=15)*	
Pharmaceutics	46.7
Pharmacokinetics	13.3
Therapeutics	46.7
Medicinal Chemistry	6.7
Pharmacology	6.7
Principles of Drug Action	6.7

Position in Curriculum

For institutions requiring nuclear pharmacy practice as part of their curriculum, respondents were asked in which courses the material was covered. Content on nuclear pharmacy was included in a wide range of courses including pharmaceutics (n=7), pharmacokinetics (n=2), therapeutics (n=7), medicinal chemistry (n=1), pharmacology (n=1), and principles of drug action (n=1) (Table 1). Some institutions reported inclusion of nuclear pharmacy in more than one area of the curriculum.

In programs teaching medical imaging as part of their pharmaceutics sequence, measurement, detection, dosimetry, and physics of radiation comprised 60% of material covered, while the remaining 40% of material covered compounding and dispensing of agents used in medical imaging, the synthesis of labeled compounds, and tracer methodology. This was similar to the programs that included medical imaging as part of the pharmacokinetics sequence, where 66.7% of the material was on the measurement, detection, and physics of radiation, while the other 33.3% of material covered compounding, dispensing, and tracer methodology (Table 2).

Seven programs included nuclear pharmacy in the therapeutics sequence (Table 2). The physics, biological effects, and dosimetry of radiation comprised 30.4% of the materials covered. The use of imaging to assess therapeutic outcomes comprised 17.4% of the material covered. The majority of material (52.2%) covered drug interactions and the physiochemical properties of agents used in medical imaging. Of the 52.2% of instruction

Table 2. Number of Institutions Covering Material in Curriculum Sequence with Description of Material Covered

Variable	n
Pharmaceutics (n=7)	
Physics of radiation	5
Health physics and dosimetry	2
Instrumentation to detect radiation	5
Measurement of radiation	6
Synthesis of labeled compounds	2
Compounding and dispensing	5
Tracer methodology	5
Pharmacokinetics (n=2)	
Physics of radiation	1
Instrumentation to detect radiation	1
Measurement of radiation	2
Compounding and dispensing	1
Tracer methodology	1
Therapeutics (n=7)	
Biological effects of radiation	2
Physics of radiation	4
Health physics and dosimetry	1
Imaging to assess therapeutic outcomes	4
Interactions with radiopharmaceuticals	5
Information on the properties of traditional radiopharmaceuticals	7
Contrast media	5
Ultrasound contrast	3
Positron emission tomography	3

material covering pharmaceuticals, traditional radiopharmaceuticals (ie, iodine, thallium, gallium, and technetium products) were discussed in 42.8%, while iodinated or paramagnetic contrast agents were discussed in 28.6%. The remaining 28.6% of material was equally divided between instruction on ultrasound contrast media and agents used for positron emission tomography (PET).

Only one institution covered radiopharmaceuticals, contrast agents (including ultrasound), and PET tracers in the pharmacology sequence. Radiation measurement, radiation physics, the synthesis of labeled compounds, and tracer methodology were covered in the medicinal chemistry course at one other school. Finally, the biological effects of radiation, radiation physics, traditional radiopharmaceuticals, and contrast agents (iodinated and paramagnetic) were included in the principles of drug action sequence at one school. Ten (13.3%) institutions offered specialized "tracks" in medical imaging as part of the PharmD curriculum.

Postgraduate Programs

A few institutions offered additional training in the field of nuclear pharmacy. Postgraduate education options, offered by 9 (12%) responding institutions, included a master of science degree in medical imaging or a related area (n=5), a doctor of philosophy degree program in medical imaging or a related area (n=4), or a residency in nuclear pharmacy (n=2). More than one postgraduate option in nuclear pharmacy was offered at some institutions. Furthermore, 9 (12%) institutions offered programs leading to certification in nuclear pharmacy.

Institutions Not Offering Instruction

Institutions that did not provide any instruction in nuclear pharmacy were asked if they planned on adding it to their curriculum. At the time of the survey, only 2 institutions had plans to add nuclear pharmacy instruction to their curricula in the next few years. The reasons cited for not adding nuclear pharmacy practice were a lack of qualified faculty members (n=27), lack of funding (n=13), time constraints within the current curriculum (n=25), and other reasons (n=8). Other reasons included a lack of interest and uncertainty of the need for instruction in nuclear pharmacy. Most institutions responded with more than one reason.

DISCUSSION

The intent of this survey was to determine the current state of nuclear pharmacy education in the 91 ACPE-accredited colleges and schools of pharmacy. By extension, our findings may offer insight into the challenges faced by other specialty areas of practice. Our findings suggest that far from the AACP's 1975 resolution to increase knowledge of this discipline, a sharp decline in inclusion of instruction in nuclear pharmacy has taken place (Figure 1).[1,2]

A limitation of our study was the lower response rate than that obtained in previous studies. Because of this, we

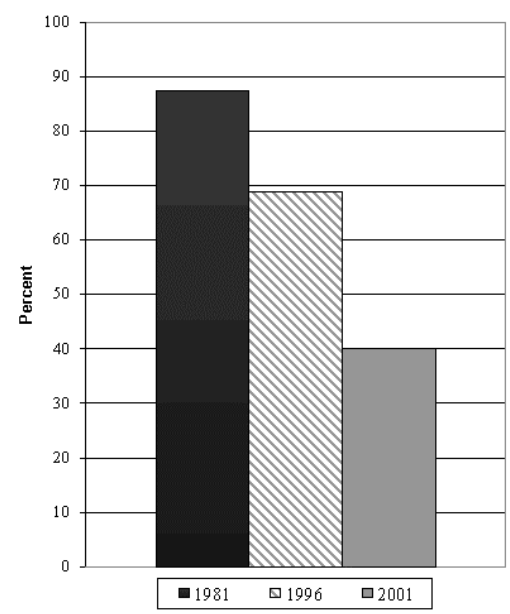

Figure 1. Percentage of AACP-accredited schools of pharmacy offering instruction in nuclear pharmacy practice.

used the results of the 1996 study to project what our results would have been if our non-responders (n=16) had replied to the survey and estimated that an additional 11 schools taught nuclear pharmacy, for a total of 41 schools rather than 30. Even if the unlikely assumption were made that the 16 nonresponding institutions were now all teaching nuclear pharmacy, the total number of schools offering instruction would still represent a decline from the total number of schools identified in previous surveys. When including these additional 16 institutions, almost one half (49.5%) of the pharmacy schools still do not teach nuclear pharmacy practice. Also, of the 7 new schools (all respondents) that have received ACPE-accreditation since the last survey, only 3 (42.9%) offer instruction in nuclear pharmacy.

The Society of Nuclear Medicine estimates that 10 to 12 million nuclear medicine procedures are performed annually in the United States. Each procedure, whether diagnostic or therapeutic, requires administration of a radiopharmaceutical. Additionally, many procedures require the administration of an adjunct "therapeutic" pharmaceutical (eg, adenosine for cardiac perfusion studies).[5] Typically these are prepared and dispensed by pharmacists: a fact that was recognized by the Commission to Implement Change in Pharmaceutical Education.[6] In addition to the above procedures, worldwide, an additional 60 million radiology studies (eg, computerized tomography scan) requiring administration of iodinated contrast media are conducted annually.[7] Use of paramagnetic enhancement agents (eg, gadolinium) in magnetic resonance imaging is likewise increasing and will account for additional diagnostic pharmaceutical doses. Based on this rate of utilization, the original 1975 recommendations appear to be sound and the current trend suggests that schools of pharmacy are in danger of underteaching an entire class of pharmaceuticals.

Some insight comes from the point of contact within the curriculum of schools that offer such instruction. In most curricula, instruction focuses on radiation physics and material related to preparation and safe handling of radioactive products. While these are important elements for specialty practitioners, these have little bearing on most pharmacists who will encounter patients undergoing these procedures for diagnosis or treatment of oncologic, neurologic, or cardiac disorders. Relatively few curricula (n=9) include instruction in more traditional areas of clinical pharmacy practice such as pharmacokinetics, drug interactions, or even use of these tests to assess therapeutic outcomes (Table 2). Often such instruction is included in modular sequences organized by organ system or pathophysiologic states. Unfortunately, clinical faculty members do not appear to be familiar with these procedures and may be reluctant to include them in their instruction. Moreover, very few tertiary drug information sources contain information about imaging agents.[8] Conversely, nuclear pharmacy practitioners have become increasingly isolated from the "bedside," with radiopharmaceuticals increasingly distributed from central nuclear pharmacies without access to pertinent clinical information.[9]

Nuclear medicine physicians and radiologists not cross-trained in other disciplines (such as cardiology or neurology) receive little additional training regarding therapeutic pharmaceuticals; nuclear medicine technologists receive virtually no instruction regarding therapeutic pharmaceuticals. Because the curricula of medical schools likewise include little instruction regarding radiopharmaceuticals, clinical pharmacy has been in a unique position to provide information regarding the biodistribution of radiopharmaceuticals, as well as to predict and evaluate interactions between diagnostic and therapeutic pharmaceuticals. The decline in the level of instruction suggests that this opportunity is being lost.

Incentive to correct this deficiency may come from outside of the academic ranks. The standards of the Joint Commission on Accreditation of Healthcare Organizations require that pharmacists review all medication orders, including those used in imaging procedures.[10] In many institutions, imaging-related drugs bypass the requirement for pharmacist review, leading to gaps in the review of allergies, interactions, and outsourcing.[8,11] If the profession is challenged to fulfill its monitoring responsibility for this class of pharmaceuticals, colleges and schools of pharmacy will likewise be challenged to provide basic instruction in this area.

CONCLUSIONS

The majority of ACPE-accredited colleges and schools of pharmacy do not provide instruction in nuclear pharmacy to their students, and there is a trend towards decreased instruction in nuclear pharmacy. With large numbers of patients currently undergoing medical imaging procedures, pharmacists are not using their opportunities to improve patient outcomes due to their lack of instruction about agents that are commonly employed. Schools of pharmacy should reevaluate their curricula and looks for ways to include clinically relevant instruction regarding these agents.

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