Optimization of Radiopharmacy by Redesign

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The increased emphasis on radiopharmaceutical quality and the increase in the volume of patient examinations has necessitated the redesign of the physical and operational structure of our radiopharmacy. Changes in the physical structure included (A) the addition of a lead-lined wall, (B) construction of a lead-lined storage cabinet, (C) design and construction of a portable cabinet for the dose calibrator, records, and inventory sheets, and (D) a laminar flow hood. Operational changes included (A) the development of a rapid quality control chromatography system, (B) establishment of a permanent quality control record book, and (C) addition of a color-coded labeling system. Redesign has improved the quality of radiopharmaceutical dispensing, cell labeling, and quality control. Structural design was accomplished utilizing the existing floor space and at a relatively reasonable cost.

The function of an "in-house" radiopharmacy must change in order to accommodate new developments in nuclear medicine. Consequently, structural and operational design requires periodic review and updating. Radiopharmacy planning and implementation have been previously reported *(1,2)*. However, the authors have found no information in the literature on radiopharmacy redesign necessitated by the increased demand on an already operational facility.

The radiopharmacy at the Kansas University Medical Center was begun in 1971 and required modification only four years later. This article describes the procedures used to determine what changes were necessary and how these changes were implemented in order to maximize radiopharmacy operation.

Methods

The initial step in redesigning was to document the existing operation methods. This was accomplished by (A) photographing the radiopharmacy work area, (B) recording ambient radiation levels, (C) performing work load distribution analysis, and (D) studying the history of problem areas associated with dispensing and labeling. The second step involved interviewing physicians, nuclear medicine technologists, health physicists, and radiopharmacy personnel to identify other problem areas and to suggest possible solutions. Their recommendations were recorded and evaluated at a later date. On the basis of those recommendations and evaluations, suggested changes were formulated and represented to the nuclear medicine personnel for their response. Once an idea of what was both desirable and feasible was obtained, a timetable for initiating the various changes was developed. After implementation of the changes, the radiopharmacy was rephotographed and radiation measurements and surveys were taken to determine the operational effectiveness.

Discussion

Photographs of the initial radiopharmacy (Fig. 1) and subsequent evaluation of the floor plans (Fig. 2) identified several problem areas. The radiopharmaceutical dispensing area was open and did not provide either a sterile atmosphere for dispensing, kit preparation cell labeling, and quality control testing or adequate shielding from the nuclear instrumentation area and clerical functions. In addition, lack of shielding for generators created high ambient radiation levels, there was no separate storage space for generators in use, and unutilized floor and bench space was evident.

The physical arrangement of the radiopharmacy was redesigned (Figs. 3 and 4) in order to eliminate the previously identified problem areas. An area for clerical function was created by the construction of a partition consisting of a 1/8-in. lead plate between two laminated

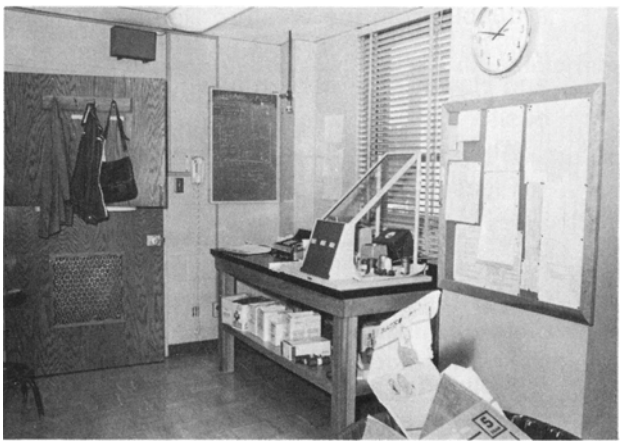

FIG. 1. Radiopharmacy before redesign.

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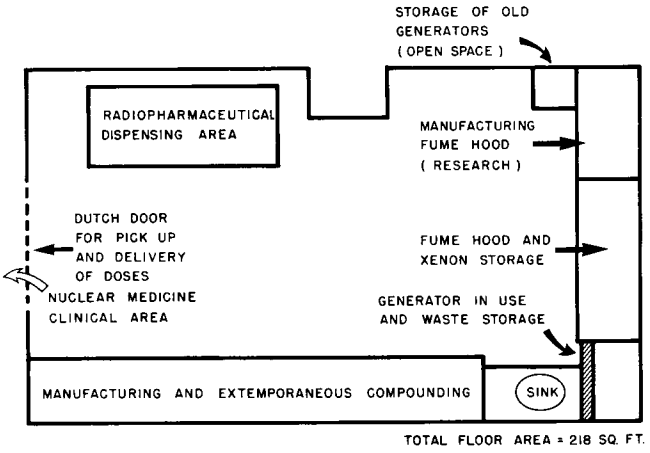

FIG. 2. Previous floor plan for radiopharmacy.

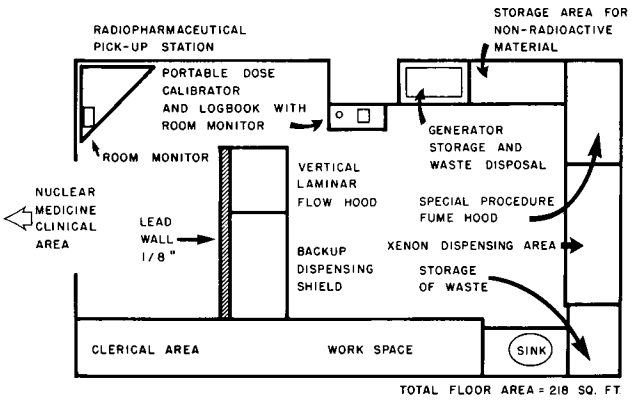

FIG. 4. New floor plan for radiopharmacy.

sheets of plywood. The installation of the partition also provided an area where nonradiopharmacy personnel (i.e., technologists and researchers) could order and obtain patient's doses or radioactive vessels without entering the dispensing area. An area radiation monitor was placed on the pickup shelf at the entrance to monitor background and personnel radiation levels.

The dispensing and storage area was relocated to the back two-thirds of the radiopharmacy. The dispensing area was equipped with a Bioquest® vertical laminar flow hood for the purpose of maintaining a sterile atmosphere for preparing and dispensing of labeled blood cells and radiopharmaceuticals. A shelf was provided below the hood for storage of items (i.e., syringes, gloves, etc.) necessary for radiopharmaceutical preparation and dispensing. An auxiliary leaded glass shield which can be used as a backup system, and for dispensing research materials not requiring sterilization, was placed adjacent to the laminar flow hood. A portable cabinet was built to accommodate a dose calibrator, an area room monitor, the daily log sheets, pigeonholes for completed log sheets, and a storage area of alcohol wipes and syringes for dispensing. The cabinet can be moved next to the hood for easy, convenient use in dispensing of the radiopharmaceuticals.

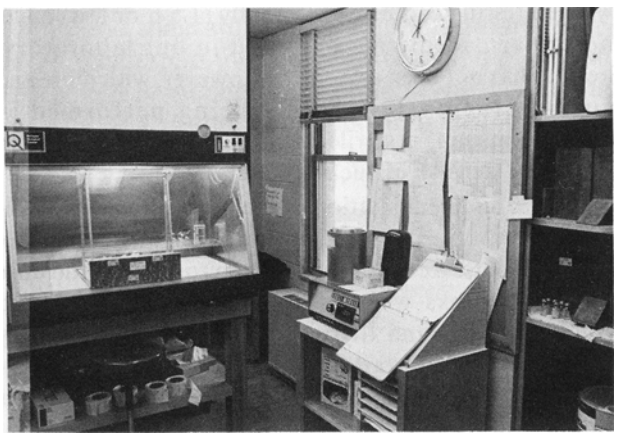

FIG. 3. Radiopharmacy after redesign.

The storage space was also expanded by the addition of a 1/8-in. lead-lined wall cabinet for generators and flood phantoms. This provides compact storage and reduces ambient room radiation levels. Also available is cabinet space for absorbant pads and other nonradioactive supplies.

Radiopharmacy and nuclear medicine personnel felt that the operational functions carried out in the back of the radiopharmacy were adequate; thus no changes were made. This area contains two fume hoods for storage of radioactive iodine and xenon as well as caustic materials. The fume hoods are equipped with air, vacuum, water, and electricity for any special research preparations or heating of radiopharmaceuticals such as sulfur colloid. A storage for radioactive waste is located next to the fume hoods. The area is lined with lead bricks for maximum personnel protection.

Workbench space is provided and equipped with a sink, heating bath, and centrifuge. The area above the workbench and desk is a four-shelf cabinet with glass sliding doors for storage of nonradioactive supplies. Located beneath the workbench is additional cabinet space and a small lead-lined refrigerator for storage of radioactive materials.

The redesign proved to reduce personnel radiation exposure and ambient room background, increase the operational efficiency, and improve quality control methods.

Radiation exposure levels were reduced as a result of the construction of generator storage cabinets and a lead partition which separates the clerical function area from the dispensing and preparation area. The average ambient radiation levels were 0.05 mR/h in the clerical area and 0.7 mR/h in the dispensing area after redesign, as compared to 2.45 mR/h in the entire room before the alterations.

Operational efficiency was improved by the addition of a preprinted color-coded labeling system (Fig. 5) which allows for improved accuracy in dose dispensing and administration. Under the former system, the referring phy-

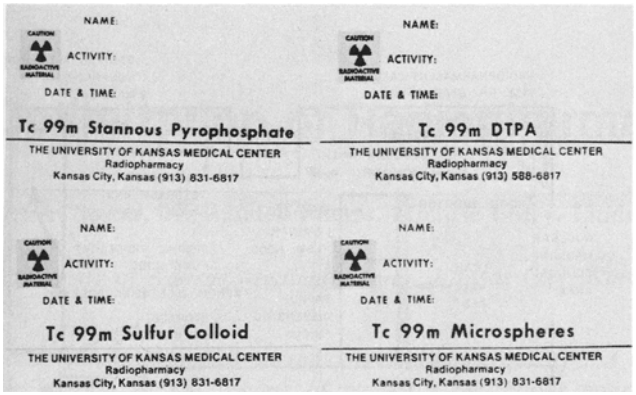

FIG. 5. Some new labels used: ^{99m}Tc-stannous pyrophosphate (color of stripe: red); ^{99m}Tc-DTPA (green); ^{99m}Tc-sulfur colloid (yellow); ^{99m}Tc-microspheres (grey).

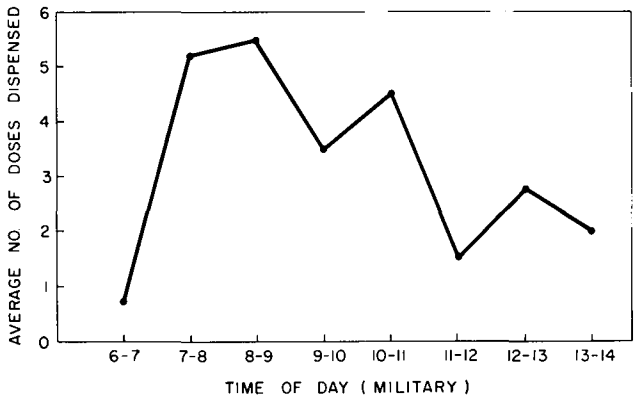

FIG. 6. Average number of doses dispensed vesus time of day.

sician would complete a requisition and send it to nuclear medicine for scheduling. An examination was scheduled and in most cases radiopharmacy would not see the requisition until a technologist requested a dose after the patient had arrived. The appropriate radiopharmaceutical was dispensed and labeled with tape containing such information as the patient's name, radiopharmaceutical, activity, date, and time. After the above information was recorded in the daily record book, the requisition and dose were returned to the technologist. This dispensing and dosing method proved to be inadequate, as administration of the wrong dose occurred approximately eight times a year.

The labeling system now in use is proving to be more accurate. In the first seven months using the color-coded labels there has been no instance of a patient receiving the wrong radiopharmaceutical. Under the new system the requisition is brought to the radiopharmacy the day prior to the scheduled study. The cost code numbers, the radiopharmaceutical, and the prescribed amount to be administered are typed on the requisition. At this time, two preprinted labels (Fig. 5), which are color coded for the radiopharmaceutical being used, are completed with the patient's name and the date of the examination. When the technologist brings the requisition to the radiopharmacy on the day of the examination, the dose is dispensed and the actual amount of activity and time are written on the labels. One label is attached to the syringe containing the radiopharmaceutical and the other is placed on the face of the requisition. The appropriate information is then placed in the daily record book and the dose delivered to the technologist.

The use of preprinted labels has not only reduced the number of incorrect injections and improved patient safety, but has reduced dispensing time since the labels are completed the day prior to the examination.

Major demand for radiopharmaceuticals occurs at the beginning of the work day (Fig. 6). The use of conventional chromatographic methods for determining radiochemical purity of ^{99m}Tc-labeled radiopharmaceuticals requires personnel time during one of the busiest times of the day. Consequently, after-the-fact chromatography testing or no testing except in cases of suspected radiopharmaceutical failure has been the usual practice. The column chromatography system developed by Perrson *(3)* provides a potential solution to this problem. The principle is to have a set of Sephadex columns with one column for each ^{99m}Tc preparation. An aliquot of each radiopharmaceutical is added to the appropriate column, followed by elution of the suitable solution. The set of columns is then imaged at the time the nuclear medicine technologist images the field flood source for quality control testing of the scintillation camera. A computer algorithm is used to evaluate radiochemical purity. [This system is still under development *(4).*]

A second addition to the quality control procedures was to use a thyroid probe to check ^{99m}Tc and ^{131}I radioactivity over the bladder of all persons handling these radioisotopes. Both radionuclides may be absorbed through the skin or lungs and appear in the urine. Thus, personnel contamination is revealed by 140- or 364-keV gamma rays imminating from the bladder (before voiding) of workers. This is performed preferably on Fridays, as any contamination will accumulate over the week.

The addition of the vertical laminar flow hood aided the quality control program in that limulus lysate pyrogen testing can be done rapidly (1.5 h or less) on all radiopharmaceuticals prepared in our laboratory. Sterility has not been a problem; however, with more and more biologic cell labeling being performed in radiopharmacies, a sterile laminar flow hood will help assure the sterility of such products.

The final implementation of the new design was the incorporation of a daily record book for quality control measurements. Results of sterility, pyrogen test, and dose calibrator checks with known standards are recorded weekly. Bladder and thyroid counts of radiopharmacy personnel are also recorded. Other results from chromotography or quality control tests are also reported in this record book.

The interior arrangement of the radiopharmacy was

redesigned to provide separation of clerical functions (i.e., typing labels, dose calculations, etc.) from preparation and dispensing functions (i.e., eluting generators, labeling tracers, filling and checking syringes, etc.). The floor space of the dispensing area was reduced in order to minimize individual movement and limit the number of persons in the area. Only individuals actually handling radioactive materials should be in this area and their time in the area should be only long enough to carry out the required task. Finally, the arrangement of equipment was such that the task can be completed in the shortest possible time.

References

1. Kawada T, Wolf W, Seibert S: Planning a radiopharmacy. *Am J Hosp Pharm* 31: 153-157, 1974

2. Porter WC, Ice RD, Hetzel KR: Establishment of a nuclear pharmacy. *Am J Hosp Pharm* 32: 1023-1027, 1975

3. Persson BRR: Gel chromatography column scanning: A method for identification and quality control of ^{99m}Tc radiopharmaceuticals. In *Radiopharmaceuticals,* Subramanian G, Rhodes BA, Cooper JF, et al., eds, New York Society of Nuclear Medicine, 1975, pp 228-235

4. Hladik WB, Study KT, Gallagher JH, et al.: Quality control of radiochemical purity—Development of a rapid feedback system. *J Nucl Med Technol* 5: 94-100, 1977