Radiopharmaceutical Inventory and Dispensing System Based Upon a Hand-Held Computer

Bruce H. Mock and Gary R. Conrad

Indiana University Medical Center, Indianapolis, Indiana and The University of Iowa Hospitals and Clinics, Iowa City, Iowa

We have developed an inexpensive, hand-held system that performs all numeric calculations necessary to prepare, control, and dispense all routine radiopharmaceuticals. Our hand-held system is especially suitable for any nuclear medicine hot laboratory which seeks to improve its inventory and dispensing process, but cannot justify the expense of a personal computer-based or dose calibrator-integrated system. In addition, our system was designed to augment, rather than replace, the existing record-keeping methods unique to each hot-lab. This report describes the features of our inventory control and dispensing system and outlines the various algorithms used by our program.

Computerized inventory control and dispensing systems provide perhaps the most efficient means of determining the available radiopharmaceutical activity and the volume required to dispense a particular unit dose. If data inputs are correct, these systems can rapidly perform the many time-dependent calculations germane to dispensing radiopharmaceuticals.

Of course, a computerized system will not be cost effective if hardware is too expensive or software too restrictive. Most inventory systems being marketed are either built within or interfaced to a dose calibrator, but the software cannot be run independently. Likewise, stand-alone inventory control programs are available which use a desk-top personal computer and printer*; however, the cost of these systems (software and/or hardware) is a significant fraction of the cost of a dose calibrator replacement or upgrade.

As an alternative, we have developed an inventory control and dispensing program ("HOT-LAB-R") that runs on an inexpensive hand-held computer. HOT-LAB-R provides up-to-the-minute inventories of most of the commonly used radiopharmaceuticals and performs calculations appropriate to the preparation of a unit dose. This report describes the features of HOT-LAB-R and the algorithms used in the system.

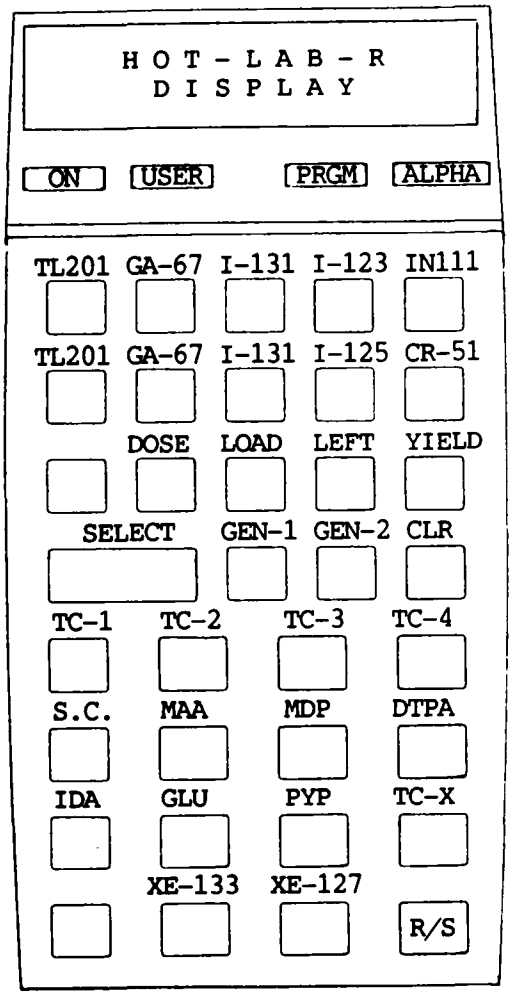

FIG. 1. Sketch of Hewlett Packard HP-41CX and keyboard layout. In practice, an overlay card shows the key assignments.

For reprints contact: Bruce H. Mock, PhD, Nuclear Medicine, UH-P16, Indiana University Medical Center, 926 West Michigan Street, Indianapolis, IN 46223.

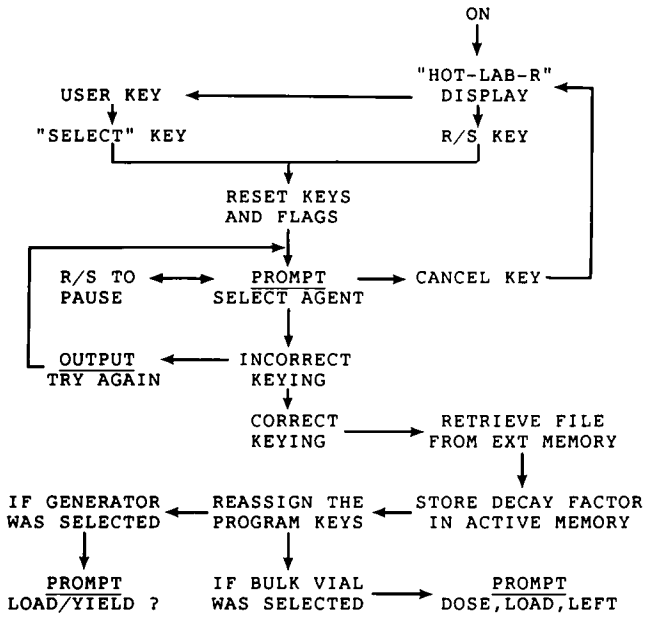

FIG. 2. Algorithm for initiating HOT-LAB-R and selecting a radiopharmaceutical agent.

When the HOT-LAB-R program is resident in memory, it automatically begins execution in the SELECT routine merely by turning on the HP-41CX (Fig. 2). Once the operator selects the desired agent, the program retrieves from extended memory the calibration data corresponding to that specific agent, automatically assigns the approprite decay constant (λ), and prompts the operator to choose from among the menu of functions listed in the display.

HOT-LAB-R currently provides two functions for managing ^{99}Mo/^{99m}Tc generators (Fig. 3). The LOAD function accepts generator calibration data, including the time and date of calibration and the activity (in mCi) of ^{99}Mo. The YIELD function computes the expected ^{99m}Tc activity at the time and date of the next elution, based upon the decay-corrected ^{99}Mo activity and the time since the last elution. Repeated use of the YIELD function permits the operator to determine when the generator will have sufficient ^{99m}Tc activity to justify a second or third elution. HOT-LAB-R does not update the time and date of last elution until the operator actually specifies that elution has occured.

HOT-LAB-R currently provides three functions for managing multi-dose vials of radiopharmaceuticals. The LOAD function accepts calibration data for an individual bulk vial (Fig. 4) and automatically calculates the ^{99}Mo/^{99m}Tc activity ratio (μCi/mCi) as required by NRC regulations. The LEFT function computes the expected activity remaining in the vial at any time and date (Fig. 4) assuming no further withdrawals in the interim. The DOSE function assists in the preparation of a unit dose (Fig. 5).

Several rapid checks are automatically performed in the DOSE routine, including activity remaining and ^{99}Mo contamination, if appropriate. However, the memory limitations prevent agent-specific expiration times from being cross-checked.

MATERIALS AND METHODS

HOT-LAB-R was written for the Hewlett Packard HP-41CX†, an advanced programmable scientific calculator that supports complex, interactive programs. With the full memory capacity of the HP-41CX, HOT-LAB-R can store inventory data for two ^{99m}Tc generators, four vials of sodium [^{99m}Tc]pertechnetate and eight vials of ^{99m}Tc labeled radiopharamceuticals, two vial sizes (1 lot) of ^{133}Xe, two vial sizes (1 lot) of ^{127}Xe, and ten vials of miscellaneous agents, including ^{123}I, ^{125}I, ^{131}I, ^{67}Ga, ^{201}Tl, ^{111}In, and ^{51}Cr.

HOT-LAB-R utilizes three unique features of the HP-41CX: (a) programmable key assignments, (b) a built-in clock/calendar, and (c) an alphanumeric liquid crystal display. The key assignments permit the operator to select a specific radiopharmaceutical or an individual function using a single keystroke (Fig. 1). Keys are automatically assigned by the program, thereby reducing the possibility of operator error. The built-in clock/calendar eliminates the need for repeated entry of the current time and date. When prompted for input of the time or date, the operator needs only to take the default response to specify the current value. The alphanumeric liquid crystal readout is used to display all prompts for data input, and eliminates the need to memorize the key sequences within each program.

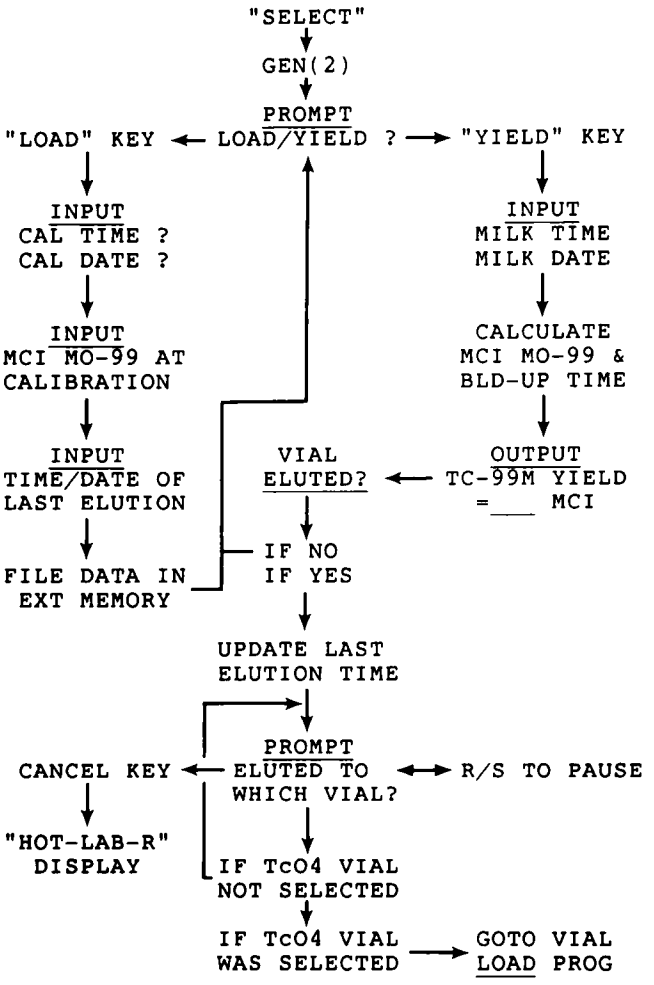

FIG. 3. Algorithm for managing ^{99}Mo/^{99m}Tc generators.

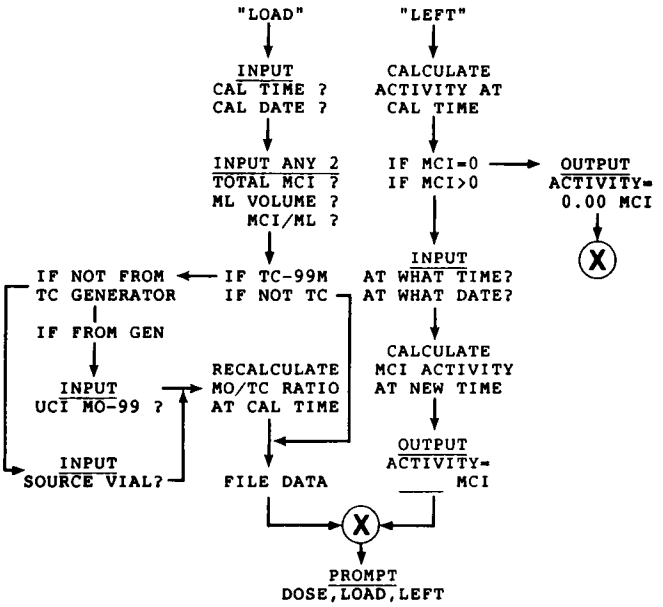

FIG. 4. Algorithm for managing multi-dose vials of radiopharmaceuticals: the LOAD and LEFT functions.

administration; (e) the program keeps track of ^{99}Mo contamination and warns the operator when such contaimination exceeds USP or NRC limits; and (f) the program displays messages and prompts so that the operator always knows how to respond to a program query.

HOT-LAB-R has undergone a three-year process of development and testing at our separate institutions. During this period, HOT-LAB-R has integrated easily with our individualized record-keeping systems, and has performed well in different clinical practices. HOT-LAB-R clearly reduces the time necessary to prepare a unit dose, and, in our opinion, reduces the likelihood of a dispensing error.

The HP-41CX is a durable, easy-to-use computer that runs independently of any external power source or peripheral device. This hand-held computer is therefore truly portable; it can be removed from the hot laboratory, held next to the phone, transported to a satellite facility, or locked in a drawer at night. The HP-41CX contains nonvolatile memory so that all of the software and inventory data is retained during power-off. The HP-41CX is also flexible, serving both as a complex programmable computer and as a scientific calculator. When the HOT-LAB-R program is resident in memory, the operator needs only to press a single key to enter the calculator mode. HOT-LAB-R is structured so that all inventory data reside in extended memory. If the operator decides to run a separate program, HOT-LAB-R can be written to magnetic cards or be downloaded to extended memory; down-loading or up-loading does not alter the radiopharmaceutical inventory data.

HOT-LAB-R can be used in any radiopharmacy or hot-laboratory with an established record-keeping system. HOT-LAB-R is probably best utilized as a fixed device to perform all of the inventory and dispensing transactions of the radiopharmacy. However, the calibration data of an individual bulk vial Instead, a limit of 24 hr was provided for all ^{99m}Tc-agents as a practical alternative to no time limit at all.

To assist in the precalibration of unit-doses, HOT-LAB-R displays the volume and activity required *at the current time* to dispense the desired dose. After manually entering the current unit-dose activity, HOT-LAB-R computes the actual dose volume obtained and decrements the bulk vial volume accordingly. HOT-LAB-R then displays the actual dose activity *at the time and date of administration.*

Unique LOAD, LEFT, and DOSE functions are provided for managing single-dose vials of ^{133}Xe and ^{127}Xe (Fig. 6). HOT-LAB-R maintains two different vial sizes for each gas, but space limitations require that each vial of a given agent be calibrated for the same time and date.

RESULTS AND DISCUSSION

The attributes of HOT-LAB-R can be summarized as follows: (a) the program maintains inventory data on nearly every radiopharmaceutical routinely dispensed in diagnostic practice; (b) the program predicts the theoretical ^{99m}Tc yield of a generator at any elution time; (c) the program calculates the remaining activity of a given radiopharmaceutical at any operator-specified time and date; (d) the program calculates the volume required to dispense a unit dose at any time and date of

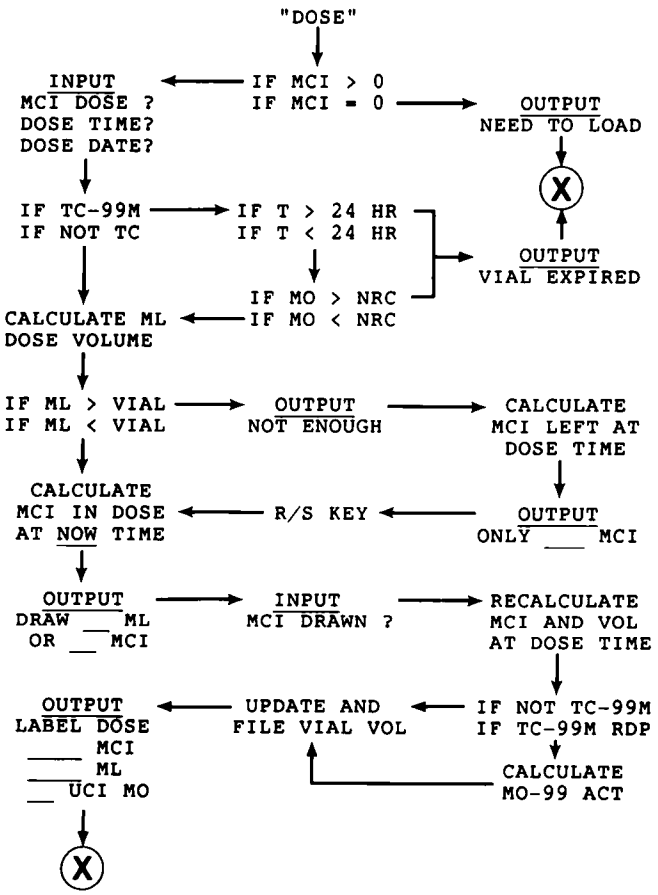

FIG. 5. Algorithm for managing multi-dose vials of radiopharmaceuticals: the DOSE function.

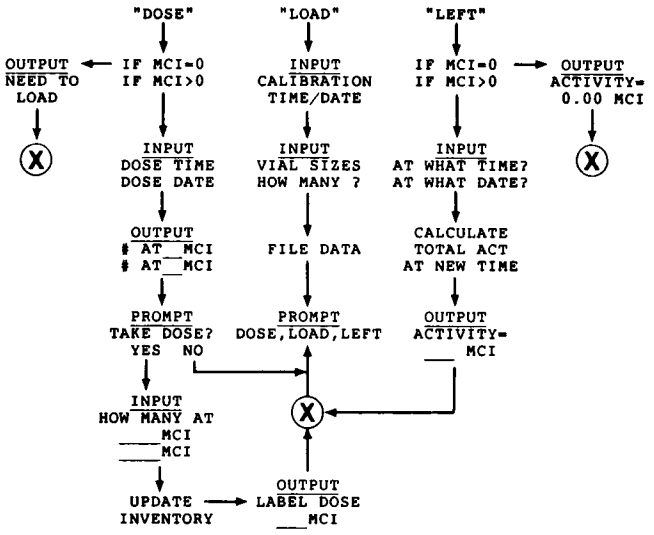

FIG. 6. Algorithm for managing single-dose vials of ^{133}Xe and ^{127}Xe.

does not have to be loaded until the operator first dispenses a unit dose from that vial. This attribute enables HOT-LAB-R to be utilized as a personal device for the physician, technologist, or radiopharmacist who is uniquely responsible for dispensing a particular agent. Even if several doses have already been dispensed from a given bulk vial, the loading of calibration parameters and the computation of the residual vial activity is a relatively simple task.

Although HOT-LAB-R is a very efficient program, current technology limits the features that can be incorporated into a hand-held device. HOT-LAB-R does not have an elaborate scheme for detecting or correcting data entry errors. HOT-LAB-R dose not maintain the supplier name and lot number of each radiopharmaceutical, and does not print unit dose labels, vial labels, dispensing reports, or generator elution records. Finally, HOT-LAB-R will not read assay data from a dose calibrator, nor will HOT-LAB-R anticipate radiopharmaceutical orders based on consumption or dispensing practices. These features are current or potential attributes of personal computer-based or calibrator-integrated systems, and must be purchased at 20 to 40 times the cost of the HP-41CX.

In summary, HOT-LAB-R is an inexpensive system‡ for performing all of the routine numeric calculations involved in the maintenance and the dispensing of radiopharmaceuticals. HOT-LAB-R is suitable for any laboratory whose personnel have an established method of record-keeping, and who seek to improve their dispensing process, but cannot justify the time or expense necessary to adopt a personal computer-based or dose calibrator-integrated system.

Editor's Note: The HOT-LAB-R‡ program is currently available as shareware from the author at the reprint address. A similar program, the CRC-PC, is now available from Capintec, Inc., Ramsey, NJ.

NOTES

*Nuclear Medicine Information Systems, Nuclear Medicine Consulting Firm, Greenville, PA.
†Hewlett Packard, Corvalis, OR.

REFERENCE

1. Dillman LT, Von der Lage FC. Radionuclide decay schemes and nuclear parameters for use in radiation-dose estimates. *MIRD Pamphlet No. 10.* New York: Society of Nuclear Medicine; Sept. 1975.