

Infusion Pumps in the Nuclear Cardiology Lab

The infusion pump has long been a necessity in the nuclear cardiology laboratory. The traditional pharmacologic stress agents used for patients who are unable to exercise to a sufficient level for imaging—approximately 50% of all patients referred to nuclear laboratories for stress imaging¹—are administered via timed infusion.² Current research is directed toward agents that can be administered as bolus injections,³⁻⁵ but until such agents are widely adopted, the infusion pump will remain an integral piece of equipment in nuclear cardiology.

OPERATION AND MAINTENANCE

Infusion pumps bring their own set of issues to the practice of nuclear cardiology. The correct type of pump must be purchased, with an upfront cost of approximately \$1000 or more, and it will eventually need to be replaced. Pumps also require some level of maintenance, in terms of mechanical function, battery monitoring/changing, and calibration, as well as extra supplies, such as syringes and tubing sets.

Finally, pumps must be programmed for each procedure. Pharmacologic stress agents are infused over a specified time period based on each patient's weight.⁶⁻⁸ Some agents require repeated dose escalations as the infusion proceeds.⁹

CHOOSING A PUMP: KEY FEATURES AND ISSUES

A number of pumps are available from different manufacturers, and each laboratory should determine which pump best fits their needs. Some professional organizations conduct workshops, for a fee, that can help laboratory staff understand current pump technology and make an educated decision regarding pump selection.⁹ Additionally, some healthcare systems are leasing pumps rather than buying them due to the evolving nature of the technology.¹⁰

Important factors to consider when choosing a pump for the laboratory include ease of use, infusion rate capabilities, syringe compatibility, and size/portability.^{11,12}

EASE OF USE

The pump should be easy to set up, and it should be easy to adjust infusion rates.¹¹ An LCD display will offer easy viewing, and volume-limit programming can provide a convenient cue of volume or dose delivery completion.¹²

INFUSION RATES

The pump must be able to perform at a wide range of infusion rates to ensure that patients of all weights receive the correct doses.¹¹ Some pumps are capable of a flow-range of 0.1 to 1200 mL/hour, which allows for accommodation of various infused pharmacologic stress agents.¹³

SYRINGE COMPATIBILITY

The pump must be compatible with the types of syringes used in the facility. Different brands of syringes may have varying diameters, and the pump must be adjustable to work with each.¹¹ Pumps with automatic syringe size sensing provide the flexibility to accept a wide range of syringe sizes, up to 60 mL.¹²

SIZE/PORTABILITY

Being of small, lightweight construction may also be a desirable infusion pump feature.¹² However, some smaller pumps have preset infusion rates and cannot accommodate the variety of patients referred for nuclear imaging,¹¹ so purchasers should be aware of the infusion rate range that is needed for their facilities.

THE EVOLUTION OF PUMP SAFETY

During the 1990s, infusion pump safety concerns emerged as a prominent issue in the healthcare industry, largely due to problems encountered with pumps that did not have a built-in free-flow protection mechanism.¹⁰ In 2000, the Joint Commission on Accreditation of Healthcare Organizations issued an alert on infusion pump safety risks.¹⁰ In 2003, the Joint Commission included an infusion pump safety requirement in their National Patient Safety Goals.¹⁰

Pump manufacturers quickly began to incorporate safeguards into new product designs and worked with healthcare providers to retrofit unprotected pumps.¹⁰ As a result, 2004 data showed nearly perfect compliance (99.9%) by the end of 2003.^{10,14} As of the National Patient Safety Goals for 2006, the Joint Commission has dropped the infusion pump requirement.¹⁰

The introduction of "smart" infusion pumps has also helped to increase administration safety.¹⁵ Smart pumps can store dosing guidelines in a drug library and apply them during pump programming to warn the user about potential drug administration issues.¹⁶ For example, upper and lower dosing limits can be stored in the pump, and an alert will sound if a user programs a dosage outside this range.¹⁵ Nurse interaction with the drug library is critical to maximize the smart pump's safety features.¹⁷

PUMP-RELATED MEDICATION ERRORS

In a study assessing wrong-dose incidents in a single hospital, infusion pump issues were identified as the cause of the error in 41% of cases.¹⁸ Errors in programming the pump represented the most common reason for wrong doses. These errors were thought to be the result of the complexity of the manual process and the use of nonstandard concentrations and dosing ranges.¹⁸ (As infusion pumps are used throughout hospitals, this study was not specific to nuclear labs or pharmacologic stress. However, the findings should hold relevance for healthcare professionals using infusion pumps.)

Such findings emphasize the need for all laboratory staff who use the infusion pump to be adequately trained, familiar, and confident in pump operation. Some pump manufacturers and marketers provide technical support and work with pharmaceutical companies to ensure that all users understand how to use the pump.¹³ Additionally, some institutions hold their own sessions to keep staff knowledgeable about current pump technology and correct operation.

In addition to human error, infusion pumps are susceptible to occasional mechanical failure. Product recalls have been initiated a number of times over the past few years for various defects that could potentially result in malfunction of buttons or improper dosing (either overinfusion or underinfusion).

PUMP MAINTENANCE

JOINT COMMISSION STANDARDS EC.6.10 AND EC.6.20

The Joint Commission requires that healthcare equipment is properly maintained. Although the infusion pump requirement has been dropped from their National Patient Safety Goals, facilities are still required to incorporate these devices into their equipment maintenance strategies under standards EC.6.10 and EC.6.20.¹⁰

The rationale for standard EC.6.10 states that:

“Laboratory equipment is a significant contributor to the quality of care. It is essential that the equipment is appropriate for the intended use; that staff be trained to use the equipment safely and effectively; and it is essential that equipment is maintained appropriately by qualified individuals.”¹⁹

Standard EC.6.10 addresses laboratories’ responsibility to manage equipment risks and outlines all required lab actions in this area, including¹⁹:

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| • DEVELOPING WRITTEN MANAGEMENT PLANS |
| • IDENTIFYING PROCESSES FOR SELECTING AND INSPECTING/MAINTAINING EQUIPMENT |
| • IDENTIFYING PROCESSES FOR MONITORING/ACTING ON EQUIPMENT HAZARD NOTICES/RECALLS |
| • IDENTIFYING PROCESSES FOR MONITORING/REPORTING DEATH OR SERIOUS INJURY/ILLNESS INCIDENTS INVOLVING A MEDICAL DEVICE |

Standard EC.6.20 addresses laboratories’ responsibility to maintain, test, and inspect their equipment, and outlines all required lab actions in this area, including¹⁹:

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| • DOCUMENTING A HISTORICAL RECORD FOR EACH INSTRUMENT/PIECE OF EQUIPMENT |
| • DOCUMENTING PERFORMANCE TESTING AND FUNCTION CHECKS AS WELL AS REPAIRS, PARTS REPLACEMENT, AND MAINTENANCE |
| • INSPECTING, TESTING, AND MAINTAINING EQUIPMENT, INCLUDING PREVENTIVE MAINTENANCE AND PERIODIC INSPECTION/TESTING |
| • TESTING/OPERATING INSTRUMENTS WITHIN TEMPERATURE/HUMIDITY REQUIRED FOR PROPER PERFORMANCE |

For information about Joint Commission requirements, visit jcaho.org.

USP GUIDELINES

Additionally, USP General Chapter 797 guidelines, which cover pharmaceutical compounding, recommend equipment maintenance.²⁰ One of the objectives under “Responsibility of Compounding Personnel” reads:

“Measuring, mixing, sterilizing, and purifying devices are clean, appropriately accurate, and effective for their intended use.”²⁰

While these USP guidelines are not enforceable by law, they represent best practices. Practitioners must decide for themselves how applicable these guidelines are for their practices and to what extent they should comply with them.²⁰ (For complete guidelines, see the *USP <797> Guidebook to Pharmaceutical Compounding—Sterile Preparations*.)

CONCLUSIONS

The infusion pump is standard equipment in the nuclear cardiology lab. Pharmacologic stress procedures have become increasingly common as fewer patients are unable to exercise to an endpoint adequate for nuclear imaging. The infusion pump plays a prominent role in these protocols, as traditional pharmacologic stress agents require weight-based, timed-infusion dosing.

Although pumps are used regularly and are not a major impediment to performing nuclear imaging procedures, they nonetheless carry issues of cost, training, and maintenance. The current direction in pharmacologic stress research involves agents that are administered as bolus injections, in either a weight-based or standard dose.³⁻⁵ In time, this may obviate the need for an infusion pump to perform such procedures.

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