Secondary Medication Administration and IV Smart Pump Setup

What every nurse needs to know.

ABSTRACT: Secondary infusion by large-volume IV smart pump is used extensively in the acute care setting for one-time or intermittent administration of medications such as antibiotics, electrolyte replacements, and some oncology drugs. Consistent and accurate delivery of secondary medications requires a full understanding of the system and setup requirements. Unfortunately, it is not uncommon for nurses to find a secondary medication only partially administered when their programming should have resulted in a complete infusion. This article discusses the technical requirements that every nurse should know when administering secondary medications using an IV smart pump.

Keywords: intravenous infusion, medication safety, secondary medication administration, smart pump

Critical care patients require many pumps for the delivery of life-sustaining medications. Photo courtesy of Jeannine W. C. Blake.

In the United States, secondary infusion by large-volume IV smart pump is used extensively in the acute care setting for one-time or intermittent administration of medications including antibiotics, electrolyte replacements, and some oncology drugs.[1] Consistent and accurate delivery of secondary medications requires that nurses have a full understanding of the system and setup requirements of the IV smart pump.[2-4] It is not uncommon, however, for nurses to find a secondary medication only partially administered when their programming should have resulted in a complete infusion.[3, 5]

TWO METHODS OF INFUSION

Two methods of secondary infusion are commonly used, each with benefits and potential complications, and both require appropriate software in the IV smart pump, along with nursing knowledge of the system setup and programming.

The head–height differential method, the most common—used by large-volume medical pumps such as BD Alaris, Baxter Sigma, B Braun Space, and Zyno Medical[6-10]—allows the administration of fluid from a secondary bag at a prescribed flow rate, followed by automatic resumption of the primary fluid.[3] "Head–height differential" refers to the difference between the top of the fluid level in the primary and secondary fluid containers.[11]

This method requires the user to lower the primary bag an adequate distance below the secondary bag in order to activate a one-way check valve in the primary tubing that will block the primary fluid from entering the pump during the secondary infusion.[12] Manufacturers provide a plastic hanger for lowering

the primary bag, which is typically nine to 14 inches long. Because the hanger is often folded in half in the packaging, it is important to fully extend it to achieve secondary flow at the programmed rate. When infusing at higher flow rates (generally 200 mL per hour or more), it may be necessary to use more than one hanger to avoid unintended simultaneous flow from the primary fluid during the secondary infusion.[13] (For an illustration of the head–height differential method setup, see Figure 1.[13])

If setup requirements are not met, the secondary medication may underinfuse, not infuse at all, infuse into the primary bag instead of the patient, or infuse concurrently with unintended primary infusion flow.[13] For example, when a partial dose of secondary medication is ordered, the nurse must ensure that, upon completion, the roller clamp on the secondary tubing is closed to avoid overdosing.

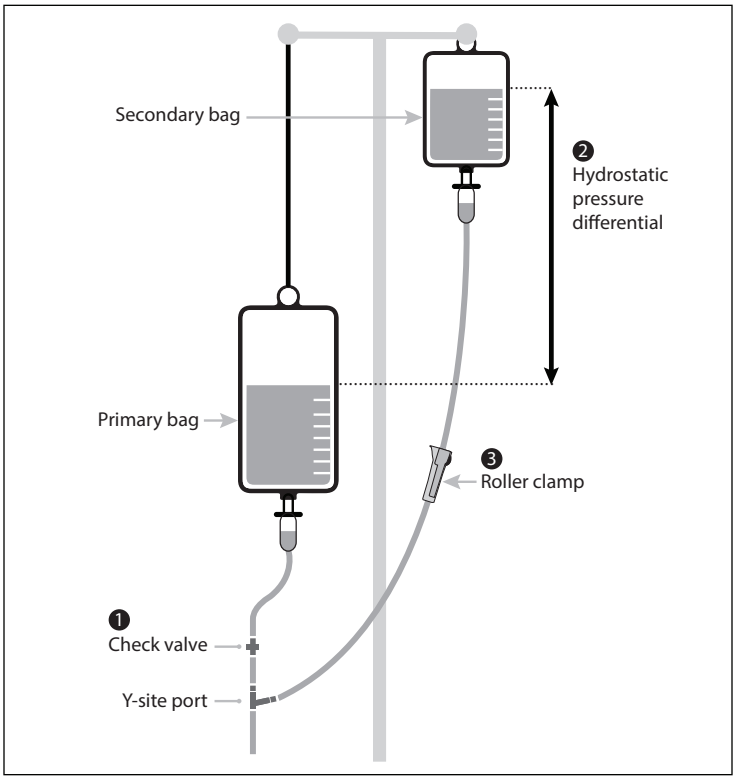
The cassette method, in contrast—used by the ICU Medical Plum series and the recently introduced Ivenix Infusion System[14, 15]—independently regulates both primary and secondary infusions, each at their prescribed flow rate.

With this method, a cassette containing internal flow control valves operated by a pump actively directs flow from the primary or secondary bags, thus avoiding the need for the primary bag to be lowered. (For an illustration of a typical cassette method setup, see Figure 2.)

The cassette method, unlike the head–height differential method, detects a closed roller clamp during secondary infusion (which would prohibit the flow of the secondary fluid), triggering an alarm that notifies the user.[13] In addition, this method eliminates the risk of unintended simultaneous flow from the primary bag during the programmed secondary infusion. Cassette-regulated flow provides a solution to the most common errors that occur with the head–height differential method.[1]

The cassette method isn't free of potential complications, however. If the secondary volume is programmed to deliver less than the actual fluid volume in the secondary bag, the infusion will require reprogramming to complete delivery. Conversely, if the secondary volume is programmed to deliver more than the actual fluid volume, air will reach the cassette, causing an air-in-line alarm that will need to be manually cleared and the line back-flushed prior to resuming either the primary or the secondary flow. The recently approved Ivenix pump offers an "until empty" default feature designed to address this issue: once air is detected in the secondary inlet, the pump automatically reverts back to the primary, allowing the patient to receive the entire dose at the programmed rate and duration. This eliminates the air-in-line alarms and the need to back-flush air bubbles out of the cassette.[15]

Figure 1. The Head–Height Differential Method Setup



Components for secondary medication administration using the head-height differential method include a one-way check valve and Y port in the primary tubing (1), a minimum head–height differential (as specified by each pump manufacturer in their operating manual) between the primary fluid level and the secondary fluid level *throughout the duration of the secondary infusion* (2), and a roller clamp on the secondary tubing (3), which should be open during secondary infusion and priming but closed during primary infusion. High flow rates and large secondary bags may require an increase in the head–height differential to achieve secondary flow.[13] Figure used with permission of Karen K. Giuliano.

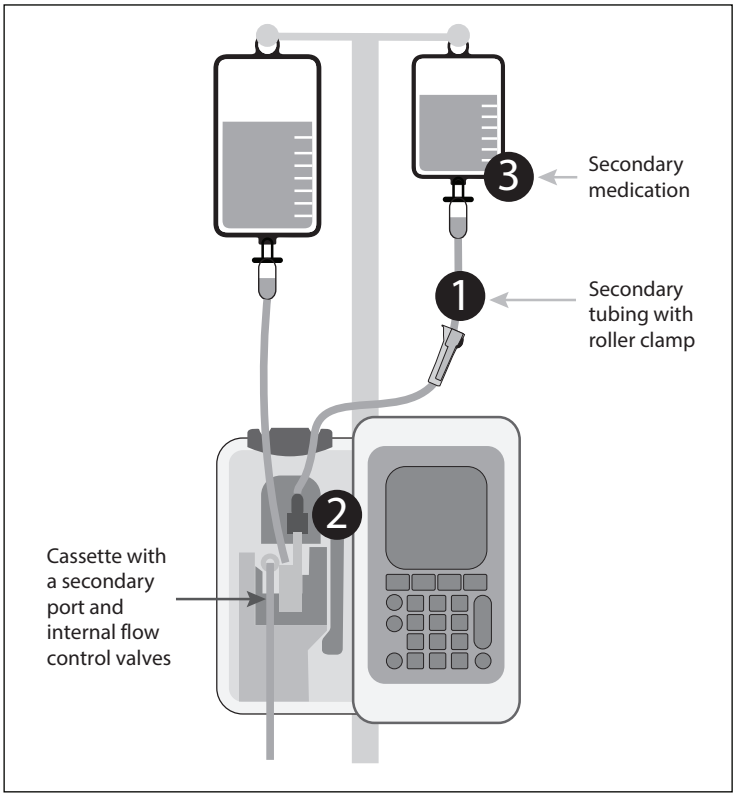
COMMON ERRORS

Because secondary infusion requires multiple manual steps and an exact setup—especially when using the head–height differential method—it is vulnerable to errors.[3, 12] Several common errors are discussed below.

Failure to open the secondary clamp (head–height differential method). If the roller clamp is inadvertently left in the closed position, no alarm—audible or visual—will be set off and the fluid will be pulled from the primary bag at the programmed secondary flow rate.[3]

Clinical example. A patient undergoing total hip replacement was ordered to receive a preoperative

Figure 2. A Typical Cassette Method Setup



Components for secondary medication administration using the typical cassette method setup are a secondary set with a roller clamp used during priming (1), a cassette with a secondary port and internal flow control valves (2), and the secondary medication (3). Figure used with permission of Karen K. Giuliano.

dose of cefazolin for surgical site infection prophylaxis 30 minutes before surgery. In the preoperative area, the primary IV line was infusing normal saline (NS) at 75 mL per hour and cefazolin was set up to be delivered via secondary infusion. When the patient was called for surgery, the nurse discovered that none of the cefazolin had infused because the roller clamp was still in the closed position. Although the cefazolin infusion was started during transport to surgery, this deviation from best practice placed the patient at increased risk for a postoperative surgical site infection.

Check valve failure (head–height differential method). The use of primary tubing without a check valve or with a failed check valve can cause the secondary bag to backflow into the primary bag instead of into the patient. If undetected, a mixture of the secondary and primary fluids will be delivered within an incorrect time frame and at a faulty flow rate.[3]

Clinical example: The patient was receiving a primary infusion of NS at a KVO ["keep vein open"] rate from a 1-L bag previously used for a 500-mL bolus. The secondary infusion had been started 15 minutes earlier, with 1g/250 mL vancomycin programmed to infuse over one hour. The nurse noticed that the vancomycin infusion appeared to be flowing freely into the drip chamber, with more than half the 250 mL already gone after only 15 minutes. Unsure of what was happening, the nurse stopped the pump to ensure no further harm could come to the patient. But even with the pump stopped, the vancomycin continued to flow and the nurse saw that the fluid level of the primary bag, which had previously contained only 500 mL, was now rising. It became clear that the secondary flow of vancomycin was infusing into the primary bag instead of the patient, requiring the nurse to collaborate with the medical team to decide how best to address dosing this medication.

Slow or delayed completion of the secondary infusion (head–height differential method). Incorrect system setup or any restriction in the secondary fluid path—including inadequate head–height differential, kinked tubing, high fluid viscosity, high secondary flow rates, and partial opening of needle-free connectors—may result in undetected simultaneous flow from both the primary and secondary bags, slowing the flow of the secondary bag and resulting in incomplete or delayed completion of the secondary medication.[3]

Clinical example: The laboratory report of a patient with a significant cardiac history indicated a critically low potassium level of 2.3 mEq/L, necessitating an initial order of 80 mEq potassium replacement. The patient had a central line in place and could therefore receive infusions of 20 mEq/50 mL potassium every hour for four hours. To avoid cardiac complications, it was important the potassium level be replaced in a timely manner. The primary bag of 250 mL of NS was hung on a doubled-over blue bag hanger. The first run of potassium, programmed to infuse at 50 mL per hour, was set up as a secondary infusion and hung above the primary bag on the IV pole hook. After completion of the potassium administration, 5 mL of NS was programmed to infuse at 50 mL per hour, followed by an alarm to notify the nurse it was time to hang the next bag of potassium. When the alarm sounded and the nurse brought in the next bag, she saw that only half the previous bag had been infused, delaying the infusion of all subsequent bags and requiring the nurse to update the medication administration record to reflect the actual administration times.

Air in line (cassette method). When using a cassette-based IV smart pump, accurate program-

ming of the volume to be infused (VTBI) is necessary to avoid time spent troubleshooting, back-priming, and/or reprogramming to complete the infusion.[3]

Clinical example: A 38-year-old woman was being treated with a chemotherapy regimen of docetaxel and cyclophosphamide for breast cancer. At the outpatient center, the infusion was set up with NS as the primary line and docetaxel as the secondary line. NS was used as a flush at the end of the docetaxel infusion. To ensure the entire dose of docetaxel was administered as ordered over a two-hour period, and to account for a possible overfill, the nurse programmed the VTBI as 510 mL even though the drug was prepared in a 500-mL bag. Approximately one and a half hours later, the IV smart pump showed an air-in-line alarm. To continue the treatment, the nurse had to clear the alarm and flush the air out of the cassette twice before the next chemotherapy infusion of cyclophosphamide could begin. This troubleshooting and back-priming, coupled with two interruptions, added 20 minutes to this patient's treatment, delaying the initiation of infusion for other clinic patients.

Secondary infusion based on volume (head–height differential method). Programming the secondary VTBI determines the duration the pump will run at the secondary flow rate.[13] After the VTBI is complete, the flow rate will revert back to the primary rate, whether or not the secondary has been completely administered. Mistakenly believing that programming the secondary pump's VTBI will limit how much of the secondary container is delivered can result in medication overdosing.

Clinical example: A 74-year-old man was recovering from a liver resection. His morning laboratory results showed a phosphate level of 1.7 mg/dL, which prompted the acute care NP to order replacement with 21 mmol of potassium phosphate (KPhos). Since the pharmacy only stocked bags of 15 mmol/250 mL KPhos, the nurse needed to administer one full bag plus a partial bag, and set up the infusion as a secondary to run through a central line, with the first bag programmed to infuse over four hours at the maximum rate of 62.5 mL per hour. Following the completion of this first bag, the nurse hung the second bag, and programmed 100 mL VTBI, which was the volume calculated to administer the remaining 6 mmol of KPhos. Once the 100 mL infused as programmed, the pump automatically reverted to the primary infusion rate of 150 mL per hour but continued to infuse fluid from the secondary bag of KPhos. This resulted in the patient receiving the complete 15 mmol of KPhos from the second bag instead of the 6 mmol. Furthermore, the additional 9 mmol was infused at a faster rate (150 mL per hour versus 62.5 mL per hour) than recommended. Fortunately, this unintended additional dose did not harm the patient, but it did require the nurse to report the medication error.

CONCLUSION

Nurses are required to continually balance complex patient care tasks with the administration of various potent IV infusions.[16] In the critical care setting, for example, nurses routinely care for patients who require 10 or more IV smart pumps infusing simultaneously.[16] And on medical–surgical units—where patients are less acutely ill than in critical care—it is common for one nurse to care for five to seven patients whose treatment includes multiple IV infusions in conjunction with numerous additional tasks. While IV smart pumps, with their drug libraries and dose error reduction systems, have been associated with reductions in medication administration errors, they have not eliminated the potential for mistakes, many of which may lead to adverse events.[17,18]

In its most recent guidelines for optimizing IV smart pump safety and accuracy, the Institute for Safe Medication Practices recommends that secondary medications be administered via systems that do not require a head–height differential.[11] This suggestion is also included in the latest recommendations issued by the Infusion Nurses Society.[19]

Given the numerous opportunities for errors, it is important for nurses to stay vigilant and educated regarding secondary infusion setup requirements. These knowledgeable and well-informed frontline nurses should in turn always be included as key stakeholders when new devices are being considered and evaluated for clinical use. ▼

Karen K. Giuliano is codirector of the Center for Nursing and Engineering Innovation and an associate professor at the University of Massachusetts Amherst. Jeannine W.C. Blake is a doctoral student in the College of Nursing at the University of Massachusetts Amherst. Robert Butterfield is principal at RDB Consulting in San Diego. As an IV infusion device researcher, Giuliano has consulted for ICU Medical, Alaris, and Ivenix. *The authors wish to acknowledge Loyda Braithwaite, MSN, RN, an oncology NP at the University of Wisconsin Carbone Cancer Center, for her assistance with the oncology case example.* *Contact author: Karen K. Giuliano, kkgiuliano@umass.edu.* *The authors have disclosed no potential conflicts of interest, financial or otherwise.*

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