Changing Smart Pump Vendors: Lessons Learned

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ABSTRACT

Smart infusion pump technology is a mainstay in health care, and the integration and use of those pumps is crucial for patient safety. An institution purchasing smart infusion pumps has the ability to trial the various vendors before purchase, however literature that documents a conversion from one pump to another is lacking. This article describes the conversion from one smart infusion pump platform to another at a government institution and a large multisite facility. The differences in 2 smart infusion pumps are described as well as lessons learned following the conversion in both organizations.

Key Words—infusion pump, technology, patient safety, informatics, medication systems

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Prior to the 1970s, most intravenous medications were infused via gravity, with nurses counting drops per minute and adjusting roller clamps to achieve the desired infusion rates.¹ Early infusion pumps introduced additional safety by delivering a controlled flow rate that could be adjusted in specified increments. As medical management became more complex, smart infusion pumps were introduced to enhance safety. These pumps include a “brain” that houses software called a *drug library*.¹ The drug library may include limits related to safe doses, concentrations, and rates of administration. The pump alerts the end user to a soft limit (can be reviewed and overridden) or a hard limit (must be reprogrammed) specific to that medication.

Smart infusion pump technology is commonly used in health care to safely deliver medication therapies to patients. With various pumps available, an institution must perform a thorough analysis to determine the appropriate technology option to support its patient populations and practices. After implementation, the pump becomes an integral part of the patient care process. Programming and using

the pump becomes second nature for nurses; this, along with the significant financial investment, makes it likely the institution will use the pumps for years to come. An institution may decide to change pump platforms when the pump or its successor no longer meet the needs of the organization or when the pump is no longer made or supported by the vendor. After years of being embedded in the institution’s medication delivery process, what happens when the decision is made to transition to another pump? Are all smart infusion pumps the same? What are the implications for administration practices after transition?

Roudebush VA Medical Center and St. Vincent Indianapolis Hospital found themselves asking these questions when making a decision to convert from one smart pump vendor to another. Suggestions for initial implementation of smart infusion pumps have been well documented and provided some guidance for implementing a new pump.^{2,3} Despite additional project planning and implementation support from the vendor during conversion, changing from one pump platform to another presents unique challenges. This article provides additional guidance to

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a facility considering conversion from one vendor to another. At the time of conversion, interoperability was out of the scope for the facilities, and therefore it is not discussed in this article.

The Roudebush Veterans Affairs (VA) Medical Center in Indianapolis is a tertiary referral center for central and northeast Indiana and is a 259-bed teaching facility including medical and surgical intensive care units (ICU), medical/surgical units, a rehabilitation unit, and a 50-bed domiciliary. In 2012, the Indianapolis VA employed the Hospira Symbiq and LifeCare PCA devices. Following publication of The Joint Commission Sentinel Event Alert 49 (Safe Use of Opioids in Hospitals), current practice revealed continuous monitoring via capnography as an area for improvement.⁴ Around the same time, a national VA Workgroup, created by the Veteran's Affairs Central Office, National Center for Patient Safety and the National Acquisition Center, identified minimum recommendations for any infusion system purchased. The minimum requirements were single platform and single user device interface, dose error reduction systems, electronic drug library, quality improvement (QI) data extraction capabilities, wireless networking, consolidation of infusion data into the patient electronic record, and end tidal carbon dioxide (EtCO₂) integrated monitoring system. Consolidation of infusion data into the patient electronic record was not feasible at the time with any vendor, therefore, the CareFusion Alaris met the remaining recommendations and would allow a single pump to provide medication administration and EtCO₂ monitoring. Conversion began in late 2013.

St. Vincent Health is comprised of 22 facilities, including 3 tertiary care, 7 specialty (eg, women's services, cardiology, long-term acute care), and 8 critical access hospitals (CAH). By 2012, the largest hospitals, including St. Vincent Indianapolis (a 700+ bed teaching facility inclusive of trauma and solid organ

transplant programs), had implemented Hospira Symbiq and Plum A+ pumps. As the health system moved toward standardizing information technology platforms and clinical care, there was a desire for all facilities to use the same smart pump technology. Hospira had ceased manufacture of Symbiq in the intervening years, and the institution's decision was to move to Alaris across the health system in 2014.

Roudebush VA and the hospitals of St. Vincent health are members of the Infusion Pump Informatics¹ (IPI) community.^{5,6} Member hospitals upload alert data generated by their smart pumps to the IPI collaborative database for data sharing and comparative analytics (Figure 1). IPI supports data from several smart pump vendors, including Hospira and Alaris. Between 2012 and 2014, both Roudebush VA and St. Vincent hospitals uploaded Hospira data for alert analysis, drug library design, and metrics comparison. When these hospitals switched to Alaris pumps in 2014, they began uploading their Alaris device data. Because IPI offers a unified interface for data analysis across hospitals and vendors, the hospitals were able to use IPI to investigate, analyze, and graph data from both Hospira and Alaris smart pumps. During the transition, the hospitals could track and assess key indicators, such as alerts per month, top drugs, and override-to-reprogram ratios, with data from both vendors displayed on the same charts for comparison.

The greatest challenge encountered with switching from one pump vendor to another was the difference in the software that controls the pump. Tables 1 and 2 describe features of the Hospira and Alaris CareFusion platforms, including the PCA pump/module.

SYSTEM CONVERSION

Roudebush VA experienced a significant increase in the number of field limit alerts during the first 3 months of transition from the Hospira Symbiq to

Figure 1. Member hospitals use Infusion Pump Informatics (IPI) to investigate and analyze alert and compliance data. Users can compare data and metrics across different hospitals, even hospitals with different smart pump manufacturers.

Table 1. Features of Hospira and Alaris CareFusion platforms

	Hospira Symbiq	Hospira Plum A+	CareFusion Alaris
<i>Library build</i>			
Set up	40 clinical care areas (CCAs) 400 entries per CCA 16,000 total entries	18 CCAs 150 entries per CCA 16,000 total entries	30 “profiles” 1,500 entries per profile 2,500 total entries
Infusion limits	Based on duration Regular infusion limits Bolus limits	Based on duration Regular infusion limits	Based on dose and/or duration Regular infusion limits Bolus limits Concentration limits
Data entry	All entries on the same form Autosaves during build		Three types of entries: continuous, intermittent, and fluids. Syringe, PCA, EtCO2 and SpO2 also available. Saving is manual
Display	Default sort is alphabetical, but can be manually sorted during build		Sort is alphabetical with no manual manipulation.
Master library	Changes made in the master library can be applied to entries in some or all CCAs at one time.		Changes must be made to each entry in each profile.
<i>Pump functions</i>			
Library entry	In drug library when pump is turned on, user must exit to run infusion without benefit of library.	Must choose to enter library when pump is turned on; no additional effort to run infusion without benefit or library.	Must choose to enter drug or fluid library when pump is turned on; no additional effort to run infusion without benefit or library.
CCA / profile	Can use 2 CCAs simultaneously on the same pump. Can switch CCAs without powering down the pump.		Can use only one profile per pump. Must power down pump to change profiles.
Display	Most scroll up or down through the library list		Able to input letter for decreased scrolling
Special features	Multistep infusions: available Bolus: can be programmed only after infusion started Anesthesia mode: unavailable	Multistep infusions: unavailable Bolus: unavailable Anesthesia mode: unavailable	Multistep infusions: unavailable Bolus: can be programmed before or after infusion started Anesthesia mode: available
<i>Library updates</i>			
Process	Wirelessly updates groups of pumps sequentially.		Wirelessly updates all pumps simultaneously.
Library Version	Flashes on screen when pump is turned on.		Always displayed

Note: EtCO2 = end tidal carbon dioxide; PCA = patient-controlled analgesia; SpO2 = peripheral capillary oxygen saturation.

the Alaris CareFusion device (Figure 2). The facility used a standing Infusion Pump Workgroup to evaluate alerts and related nursing and pharmacy practice. The team met in February of 2014 to review the first 2 months of data and discuss improvements. The dramatic increase in alerts was attributed initially to end user training and issues with the library build. Specifically, in the month of go-live (December 2013), nurses who were unable to attend earlier training

used “live” pumps and created alerts for educational purposes. Also, the change in primary programming of intermittent infusions from milliliters per hour in Symbiq to time in minutes in Alaris represented a significant change in practice and created alerts as end users became familiar with the set-up.

Several differences between practice and the drug library design were identified from the initial alerts review. For example, standardized hydromorphone

Table 2. Features of Hospira and Alaris CareFusion PCA platforms

	Hospira LifeCare PCA	CareFusion Alaris PCA module
	<i>Library build</i>	
Infusion limits	Loading dose Continuous dose PCA dose Accumulated doses	Loading dose Continuous dose PCA dose Clinician bolus dose Accumulated doses
Safety features	Barcode scanner integrated into pump to determine drug/ concentration; cannot be overridden	Available PCA pause protocol with addition of SpO2 or EtCO2 modules that interrupts drug delivery until reset

Note: EtCO2 = end tidal carbon dioxide; PCA = patient-controlled analgesia; SpO2 = peripheral capillary oxygen saturation.

Figure 2. Reviewing total alerts by month at the Indianapolis VA for Hospira devices 2012-2013 and CareFusion Alaris devices 2014-2015. Drug library updates in 2014 were made in response to differences in library setup for care areas and medication entries, as well as differences in pump operation and nursing practice.

patient-controlled analgesia (PCA) order sets were used to build the drug library, however prescribers were modifying lockout times and doses from the standard order set, resulting in 143 alerts. Further, assumptions about metoprolol prescribing patterns were erroneous. Doses of 2.5 mg dose were widely used but had not been included in the drug library, resulting in 58 alerts. In total, review of alerts data resulted in 44 changes to the drug library implemented in March 2014.

The implementation timeline of Alaris pumps at St. Vincent Indianapolis was compressed following the release of capital because of competing priorities for IT and other resources. Because of this short timeline, a decision was made to forego a full drug library review with end users, assuming that the conversion from one smart pump library to another after several years of successful use would be simple. The differences in fundamental library design and the

significant changes in both initial set-up and shift in end user mindset required by these differences proved to be much more complex than anticipated. The consequences of making these assumptions were seen in the overall increase in the number of alerts and additional training needed for both simple and complex end user programming. Some examples are described below.

SYSTEM DIFFERENCES

The Hospira and CareFusion databases function differently in gross and fine respects. The Hospira drug library platform is duration-based whereas the CareFusion platform is dose-based. Simple things like the rate for a cefazolin infusion had to be converted from milliliter per hour to milligrams per hour. Hospira supports volume-based rates such as milliliter per hour or milliliter per kilograms per hour for medications, while CareFusion provides milliliter per

hour only for entries classified as fluids. This created a set of decisions points for agents such as albumin: Nurses consider this a medication not a fluid, but it is administered by a volume-based rate. Should albumin be built in the medication or fluid library (which are completely separate in the pump)? Hospira allows for multiple clinical care areas (CCAs) to be in use on the same pump. St. Vincent had elected to have an Adult Code and Pediatric Code CCA so that emergency medications could be easily located during a critical situation. Alaris allows only one profile to be in use at a time and the pump must be powered off and on to change profiles, thus code medications had to be incorporated into each profile for easy access during an emergency. Hospira requires that an infusion be started before the bolus is programmed and administered; CareFusion allows bolus programming first. This changed the process for several medications including low frequency, urgent agents (eg, alteplase). Additionally, Hospira allows multistep programming wherein sequential infusion rates can be entered at one time with the pumps automatically changing rates at the specified time point, and CareFusion does not. Again, this affected the process for a complicated emergency medication (ie, acetylcysteine). These changes are certainly surmountable; however, there is significant planning and training required to ensure a smooth transition and subsequent safe patient care.

As shown in **Table 1**, the limited number of profiles and significantly decreased number of total medications entries in Alaris (2,500) compared with Hospira (16,000) forced the combination of many units that had previously been divided. For example, St. Vincent Indianapolis Hospital had 12 separate CCAs in Hospira that merged into a single “med/surg” profile in Alaris. These areas, although generally using the same medications, have some unique patient types, policies, and practices that were difficult to support

in a single profile. Alaris pumps provide some decision support through the creation of “therapies” (ie, delineations within a drug listing to support different indications or dosing regimens) and “clinical advisories” (ie, notes to the user); however, more directed drug libraries by specific unit were more efficient in providing the users with only the information needed to care for their patient type and follow their unit policies and practices.

COMPLIANCE

Compliance with using the drug library decreased upon conversion from Hospira to CareFusion. St. Vincent had an average quarterly compliance of 98.6% compliance before the transition, but less than 90% following the change (**Table 3**). This was attributed to the lack of forced entry into the drug library on the CareFusion platform, as well as confusion over the term *basic infusion*. Nurses reported utilizing this feature for “basic” IV fluids instead of the intended use (ie, when the medication or fluid is unavailable in the library). This is continuously addressed through real-time identification and education at the bedside. Nursing leadership expressed having difficulty with assigning accountability for noncompliance when multiple patient care areas were aggregated into one profile. Therefore as a secondary outcome of the combination of many units into a single profile, compliance reporting became less meaningful.

IPI SYSTEM REPORTS

The IPI system provided ad hoc charts and reports for tracking, comparing, and assessing changes in alerts during the transition. The IPI “compare” feature can show the settings for care areas (profiles) and medication entries for both Hospira and CareFusion drug limit libraries (**Figure 3**). This allowed hospitals to select specific Hospira care areas

Table 3. St. Vincent drug library compliance

Hospira Symbiq compliance (%)		CareFusion Alaris compliance (%)	
4th quarter 2012	98.9	2nd quarter 2014	89.0
1st quarter 2013	99.0	3rd quarter 2014	88.0
2nd quarter 2013	99.1	4th quarter 2014	88.0
3rd quarter 2013	99.1	1st quarter 2015	86.0
4th quarter 2013	99.2	2nd quarter 2015	86.0
1st quarter 2014	99.3	3rd quarter 2015	86.0
2nd quarter 2014	95.4	4th quarter 2015	85.0

Figure 3. The Infusion Pump Informatics (IPI) “compare” feature provided a way for St. Vincent Indianapolis to more accurately compare alert totals from CareFusion Alaris devices to previous alert totals from Hospira devices – even across major changes in the drug limit library – by selecting specific profiles (care areas), medication entries, and infusion types.

and analyze the effect on alerts triggered (and nurse actions taken) when these care areas were combined into a single CareFusion profile. IPI also shows infusion types defined for Hospira devices (eg, Dose Rate, Dose Limit) and for CareFusion devices (eg, Continuous Dose, Primary Intermittent Dose, PCA Dose). As described above, medication entries and infusion types in the limit library and nurse workflow at the pump changed considerably due to these differences. With IPI, alerts resulting from the changes could be tracked and assessed by selecting specific drugs or infusion types to compare and investigate.

For example, Hospira pumps incorporate all 3 rates for acetylcysteine as a single multistep medication entry, whereas each rate is a separate medication entry on Alaris CareFusion pumps. The CareFusion medication administration workflow requires nurses to set the initial rate for the infusion (selecting medication entry for rate 1) and subsequently change the rate 2 additional times (selecting medication entries for rates 2 and 3) for the same infusion bag. Acetylcysteine generated 7 alerts over 2 years for Hospira pump infusions, but the change in workflow resulted in more than 350 alerts for CareFusion infusions since the transition (**Figure 4**). The IPI pivot table in **Figure 5** shows the values programmed by the nurses for acetylcysteine rate 1, which triggered 194 of the 370 acetylcysteine alerts. The CareFusion drug limit

Figure 4. The change in medication entries and nurse administration workflow resulted in a significant increase in alerts for acetylcysteine at St. Vincent Indianapolis. Of the 370 CareFusion Alaris alerts generated, 188 “below minimum” alerts were generated for rate 1.

library sets a Soft Min of 149 and Hard Min rates are not part of the library design. Nearly all of the programmed values that triggered these alerts were entered at target rates for acetylcysteine rate 2 (12.5) or rate 3 (6.25), far below the minimum set by the limit library for rate 1. Pivot tables generated in IPI for the 148 alerts triggered for acetylcysteine rate 2 show similar results: All but 3 alerts were “below minimum,” with programmed values entered at the target for acetylcysteine rate 3. As of this publication, operational strategies are being investigated.

When tracking how alert totals changed during the transition, it was important to know that Hospira pumps trigger only Field Limit alerts, while Alaris pumps trigger significantly more alert types, such as Rate Recalculation, Weight Change, and Drug Cancel. For this reason, it was useful that hospitals could select Field Limit as Alert Type with Override and Reprogram as Action Taken when reviewing the IPI monthly alert charts, so that a more accurate picture of the change in comparable alerts was presented (**Figure 6**). With the availability of detailed data comparisons between Hospira and CareFusion, the hospitals could more easily and accurately analyze the results of necessary changes. The analysis helped identify areas for nursing practice improvement and enhancements to drug library design.

LESSONS LEARNED

The change to the Alaris CareFusion devices at both sites has been positive. We would recommend the following actions for facilities considering a change from one vendor to another.

Figure 5. Pivot table for alerts triggered by programmed values for acetylcysteine rate 1 at St Vincent Indianapolis. The Soft Min for this medication is 149 and there is no Hard Min. Most alerts were triggered by programmed values at the target rates for acetylcysteine rates 2 and 3.

Figure 6. Due to differences in the way alerts are triggered by Hospira and CareFusion Alairs pumps, the most accurate comparison of total alerts before and after the transition can be shown in Infusion Pump Informatics (IPI) by selecting Field Limit for Alert Type and then selecting Override and Reprogram for Action Taken (accurate alert comparison on right) rather than selecting all for Alert Type and Action Taken (misleading alert comparison on left).

- Make time for a full-scale multidisciplinary review prior to go-live. Decisions were made at both sites in an ad hoc manner to have the data set ready for implementation; this contributed to increased alerts.
- Form a multidisciplinary team, including infrequent users such as radiology staff and respiratory therapists, to review alerts on an ongoing basis to identify practice changes. Rousebush VA made only 17 changes during the update in July of 2015, a decrease from 44 immediately after go-live.
- Set expectations for drug library compliance before implementation. Share this expectation during the training sessions.
- Integrate compliance data into hospital and department quality metrics so that it remains part of the conversation.
- Educate end users to validate the drug library name when programming the pump. Situations have occurred when another facility's pump transferred with a patient; this was discovered by reviewing the library name. Following the conversion at Rousebush VA and St. Vincents', all hospitals in our metropolitan area use the same infusion pump type.
- Educate end users to validate the profile when programming the pump. If the profile is not changed to best match the patient type, all drugs and dosing scenarios may not be available, which leads to end user frustration and increased alerts.

- Be prepared for increased alerts initially. Make changes based on the data and recognize that there will always be opportunity for improvement. Our access to before-and-after data via IPI was invaluable in supporting changes and decreasing workload to the data set owner. Sites without access to a similar program need to consider how they will access the data from the previous platform.
- Understand the differences in reporting metrics between the pump vendors and how that might affect your data analytics process.
- Interoperability was not a consideration due to each facility's EHR limitations; however, this would likely be an important factor as technology advances.

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REFERENCES

1. Vanderveen T. Smart pumps: Advanced capabilities and continuous quality improvement. *Patient Safe Qual Healthc.* 2007(Jan/Feb):1-12.
2. Wetterneck, TB, Skibinski KA, Roberts TL, et al. Using failure mode and effects analysis to plan implementation of smart IV pump technology. *Am J Health Syst Pharm.* 2006;63: 1528-1538.
3. Proceedings from the ISMP Summit on the Use of Smart Infusion Pumps: Guidelines for safe implementation and use. Philadelphia, PA: Institute for Safe Medication Practices. 2009. <http://www.ismp.org/tools/guidelines/smartpumps/prin-terVersion.pdf>.
4. The Joint Commission: Safe use of opioids. Sentinel Event Alert #49, August 8, 2012. http://www.jointcommission.org/sea_issue_49/. Accessed October 6, 2015.
5. Catlin AC, Malloy W, Arthur K, et al. Comparative analytics of infusion pump data across multiple hospital systems. *Am J Health Syst Pharm.* 2015;72:317-324.
6. Witz S, Buening N, Catlin AC, et al. Using informatics to improve medical device safety and system thinking. *AAMI Horizon.* 2014;48(suppl 2):38-43. ■