Smart infusion technology: a minimum safety standard for intensive care?

Linda J Murdoch, Victoria L Cameron

Abstract
There is overwhelming evidence that medication errors present a risk to patients. This risk is highest in the intensive care unit (ICU) setting and even greater when medications are administered via an infusion pump. Standard pumps will not alert for, or prevent, drug calculation, drug unit, button push, or multiple of ten errors when medication delivery data is inputted. However, the literature suggests that smart pumps programmed with hard (unchangeable) limits can significantly reduce drug errors at the point of administration. Staff at St George’s Hospital paediatric ICU wanted to implement an infusion pump system that would be immediately effective in reducing medication errors at the point of administration. This article presents an overview of the relevant literature together with clinical examples from the authors’ ICU, which demonstrates their experiences with smart pumps. It is the authors’ firm belief that smart infusion technology sets a new minimum safety standard for intensive care.

Key words: Infusion pumps • Intensive care • Medication errors • Patient safety

The term ‘smart pump’ was originally adopted by the Institute for Safe Medical Practices (ISMP) to describe an infusion pump with an associated drug library that contains correct parameters for all medications to be delivered by the pump (Snodgrass, 2005). If a programming entry is attempted outside the pre-set parameters, the pump denies the instruction and alerts the clinician, thereby preventing the error. As long as the smart pump is programmed with hard (unchangeable) limits, or the user does not override any soft (changeable) limits, the pump can potentially prevent the implementation of a medication error outside these preset limits, therefore increasing patient safety.

Standard infusion pumps are reliable if regularly serviced and maintained, but they will only deliver whatever dose/time/concentration has been programmed into it. So the wrong touch of a button can programme a dose of 100 mg/hour instead of 10 mg/hour, or set the time of infusion for 1 hour rather than 10 hours. A clinician would never give 100 tablets to a patient instead of a correct dose of one tablet, and yet 100-fold errors can be made when giving intravenous (IV) drugs via an infusion pump (Thurman et al, 2004; Hicks and Becker, 2006).

In this article the authors review and analyse the literature surrounding the potential for improved patient safety with the introduction of smart pumps and support this with some clinical examples from St George's Hospital paediatric intensive care unit (ICU).

Current state of affairs
A review of the literature will leave the reader in no doubt that medication errors present a risk to patients in terms of morbidity and mortality (Table 1). As Smith and Haig (2005) put it, ‘safety is like peeling an onion; the more you look, the more you find, and each layer makes you cry’.

The Institute of Medicine (IOM) found that hospitalized patients are at risk of at least one medication error per patient day (Aspden et al, 2007), and many commentary papers paint a picture of prolific medication error incidence, using phrases such as, ‘the single leading cause of medical injuries’, or ‘principal contributors to adverse events causing significant harm to hospitalized patients’ (Reves, 2003; Apkon et al, 2004). However, as the literature is explored, further complexities in assessing the level of medication errors become clear.

Under reporting is a recognized phenomenon that affects both incidence and prevalence studies. Schneider (2004) estimated that as few as 1 in 100 medication errors are reported, and Jha et al (1998) demonstrated that the per cent of voluntarily reported severe adverse drug events (ADEs) was significantly lower than that of severe ADEs picked up by computer monitoring or intensive chart review (4% compared with 49% and 60% respectively of 281 severe ADEs in 21,964 patient-days).

Medication error rates vary depending on medical area, and tend to be at their highest in the ICU. This is not entirely surprising because of the increased number of drugs given to ICU patients, and because most of these are given by IV infusion. Cullen et al (1997) found that the rate of preventable and potential adverse drug events was nearly twice as high in ICUs as in non-ICUs (P<0.01), and that the medical ICU rate was significantly higher than the surgical ICU rate (25 events compared with 14 events per 1000 patient days, P<0.05). A Norwegian study found that more than twice as many errors occurred in the ICU than the postoperative unit, even though more than 20 times the number of study patients came from the postoperative area (Flatten and Hervoy, 1999). Data from other studies show that 92% of infusion pump related errors in three hospitals occurred in ICU (Williams and Maddox, 2005) and that 59% of all reprogramming alerts occurred in the ICU, compared with less than 5% in medical and surgical wards (Long, 2004).

Another factor is the potential severity of medication errors. In a study in the United States (US), the incidence of actual ADEs and potential ADEs from 4031 adult admissions over a 6-month period was 5.6% and 6.5%
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<tr>
<th>Date</th>
<th>Author(s)</th>
<th>Journal</th>
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<tr>
<td>1995</td>
<td>Bates et al</td>
<td>JAMA</td>
<td>Incidence of actual ADEs and potential ADEs from 4031 adult admissions over a 6-month period.</td>
<td>Incidence of actual ADEs and potential ADEs was 5.5% and 6.5% respectively. 1% of these were fatal, 12% life-threatening, 30% serious and 57% significant.</td>
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<td>1997</td>
<td>Cullen et al</td>
<td>Crit Care Med</td>
<td>Study to compare frequency and preventability of adverse and potential adverse drug events in ICUs and non-ICUs. 4031 adult admissions stratified from 11 medical and surgical units, including two medical and three surgical ICUs.</td>
<td>Rate of preventable and potential ADEs nearly twice as high in ICUs as non-ICUs (P&lt;0.01). Medical ICU rate was significantly higher than the surgical ICU rate.</td>
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<td>1998</td>
<td>Jha et al</td>
<td>J Am Med Inform Assoc</td>
<td>Review of severe ADEs picked up by voluntarily reporting (VR), computer monitoring (CM) or intensive chart review (CR)</td>
<td>VR = 4%; CM = 49%; CR = 60% (of 281 severe ADEs in 21,964 patient days)</td>
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<td>1999</td>
<td>Flaatten and Hevroy</td>
<td>Acta Anaesthesiol Scand</td>
<td>Anonymous registration of medication errors in 9366 patients between October 1995, and November 1996</td>
<td>More than twice as many errors occurred in ICU than postoperative unit, even though over 20 times the number of study patients came from the postoperative area. 32% of all medication errors were infusion related.</td>
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<td>2000</td>
<td>Ross et al</td>
<td>Arch Dis Child</td>
<td>Paediatric study that monitored more than 129,000 admissions in 5 years</td>
<td>Medication errors occurred in 0.15% of admissions - 56% of these were IV and 8% were 10-fold errors</td>
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<td>2001</td>
<td>Kaushal et al</td>
<td>JAMA</td>
<td>1120 American paediatric patients (10,778 medication orders) assessed over 6 weeks.</td>
<td>5.7% drug error incidence and 1.1% incidence of medication errors with significant potential for injuring a patient. 54% of potential ADEs involved IV drugs.</td>
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<td>2002</td>
<td>Eskew et al</td>
<td>Hosp Pharm</td>
<td>Projection of smart pump data for 1 year</td>
<td>In a 1-year period for a hospital that uses 1000 infusion pumps, the use of smart pumps would result in approximately 18,500 alerts and 4000 programming changes</td>
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<td>2002</td>
<td>Dean et al</td>
<td>Qual Saf Health Care</td>
<td>A United Kingdom study of 36,200 medication orders</td>
<td>Prescribing error rate = 1.5%, with 0.4% potentially serious errors.</td>
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<td>2003</td>
<td>Taxis and Barber</td>
<td>BMJ</td>
<td>Prospective ethnographic study using disguised observation of nurses who prepared and administered IV drugs in 10 hospital wards.</td>
<td>40% of 430 IV drug doses had at least one error, including 70% of IV bolus doses that were administered too rapidly. 1% were potentially severe.</td>
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<td>2003</td>
<td>Hicks et al</td>
<td>Report†</td>
<td>Review of 1846 medication errors involving infusion devices</td>
<td>8.7% medication errors resulted in harm. The majority of errors were due to incorrect programming.</td>
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<td>2004</td>
<td>Malashock</td>
<td>Hosp Pharm</td>
<td>8-month review of drug infusions covering 14,000 patient days</td>
<td>157 smart pump alerts resulted in discontinuation of initial entry. Seventeen of these could have been lethal had the ADEs not been intercepted.</td>
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<tr>
<td>2004</td>
<td>Long</td>
<td>Proceedings*</td>
<td>Interdisciplinary data from an 18-month US study of 183 smart infusion pumps</td>
<td>59% of all reprogramming alerts occurred in ICU compared with less than 5% in medical/surgical wards</td>
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<td>2004</td>
<td>Pratt</td>
<td>Proceedings*</td>
<td>Assessment of 1117 alert events from a smart pump</td>
<td>61% of events occurred in ICU, compared with 22% in system linked through a wireless network medical and surgical units. 'Dose above maximum' was the largest category of alerts (33%).</td>
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<td>2005</td>
<td>Husch et al</td>
<td>Qual Saf Health Care</td>
<td>Point prevalence study to compare medication, dose and infusion rate on IV pumps with the prescribed dose and rate. 426 medications were observed.</td>
<td>66.9% of IV infusions pump medications had one or more errors associated with their administration</td>
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<td>2005</td>
<td>Williams and Maddox</td>
<td>Am J Health Syst Pharm</td>
<td>An assessment of infusion pump related errors in three hospitals</td>
<td>92% of errors occurred in adult critical care patients</td>
</tr>
<tr>
<td>2006</td>
<td>Hicks and Becker</td>
<td>J Infus Nurs</td>
<td>73,769 IV-related medication errors identified in a national medication error reporting programme between 2000 and 2004</td>
<td>5.03% (2000) to 2.92% (2004) of IV-related medication errors resulted in harm</td>
</tr>
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ADE = Adverse drug event; ICU = Intensive care unit; IV = Intravenous; †In: Schneider PJ (2004); ‡Summary of information submitted to MEDMARX in the year 2002. The quest for quality, USP Centre for the Advancement of Patient Safety, Rockville, MD.
respectively (Bates et al, 1995). However, 1% of these were fatal, 12% life-threatening, 30% serious, and 57% significant. If medication errors have a disproportionate potential to cause harm then the consequences from even a small percentage of errors are likely to be serious. In one 8-month review of drug infusions covering 14,000 patient days, 157 smart pump alerts resulted in discontinuation of the initial entry with subsequent reprogramming to a different infusion rate. Seventeen of these could have been lethal had the ADEs not been intercepted (Malashock et al, 2004).

Of all the different drug errors, those involving the IV route make up one of the largest categories and appear to carry the greatest risk. Kaushal et al (2001) found that 54% of potential ADEs involved IV drugs, and Taxis and Barber (2003) found that 49% of 430 IV drug doses had at least one error, including 70% of IV bolus doses that were administered too rapidly. Of these, 1% were potentially severe.

Even though IV medications, as a whole, carry the greatest risk, the sub-category that is associated with an even higher potential for error and an even greater severity outcome is continuous IV infusions. Calculations involved in delivering continuous infusions are more complex and more prone to error than those involved in intermittent dosing. There is an increased potential for error when instructions are entered into a device (such as an infusion pump) that will carry out those instructions no matter how erroneous they are. Errors are likely to be sustained over the duration of the infusion, error detection may be delayed, and medications administered by continuous infusion tend to be more potent (such as vasoactive substances, sedatives and narcotics), which means that medication errors have a higher likelihood of causing harm (Apekson et al, 2004).

The potential for drug errors associated with infusion pumps is particularly high because they are designed to be highly flexible in terms of parameters, such as drug dose and patient weight. An infusion pump may be used to treat a 150 kg adult one week and a 1 kg infant the next. Hence, a typical infusion pump will be required to cover doses for adult patients weighing 35-200 kg, and paediatric patients weighing between 1-120 kg. When pumps with no limits are able to cover large dose ranges, this will increase the chance of dose errors being made that are 10, 100, or even 1000 times the prescribed amount.

Eskew et al (2002) cite several examples that demonstrate the error potential of infusion pumps. In one, a neonatal nurse reset an IV device that was infusing at a rate of 0.8 ml/hour. While resetting the infusion volume the nurse inadvertently pressed the time function key instead of the volume key, and in so doing programmed an incorrect infusion duration. The shorter duration time recalculated the infusion rate to 189 ml/hour, resulting in a 236-fold over-infusion. In another example, a physician ordered a

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Table 2. Smart infusion pump studies and results summaries

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<th>Date</th>
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<tr>
<td>2003</td>
<td>Kinnealey et al</td>
<td>Report</td>
<td>Report on smart pump electronic drug library implementation in ICU and theatre</td>
<td>50% reduction in the number of drug administration errors involving syringe pumps</td>
</tr>
<tr>
<td>2004</td>
<td>Olsheutz</td>
<td>Proceedings*</td>
<td>Audit of drug errors after introduction of a smart pump system</td>
<td>Smart pump system prevented 26 overdoses involving high and moderate risk medications in the first 2 months of operation. 12.4% of all warnings resulted in errors being averted when the original data entry was changed as a result of the drug library alert.</td>
</tr>
<tr>
<td>2004</td>
<td>Pratt</td>
<td>Proceedings*</td>
<td>Evaluation of wireless smart pump system with soft limits</td>
<td>Clinicians overrode 95% of 1117 alerts</td>
</tr>
<tr>
<td>2004</td>
<td>Long</td>
<td>Proceedings*</td>
<td>18-month study of 183 smart pumps</td>
<td>Several instances of overdosing due to soft limits</td>
</tr>
<tr>
<td>2004</td>
<td>Rothchild et al</td>
<td>Proceedings*</td>
<td>Effectiveness with drug library enabled compared with effectiveness with drug library disabled</td>
<td>Pre-programmed drug library bypassed in 25% (571) of instances. The rate of preventable ADEs would have decreased by 36% if pump limits had not been overridden.</td>
</tr>
<tr>
<td>2004</td>
<td>Hatcher et al</td>
<td>J Nurs Adm</td>
<td>50 smart pumps tested at the Vanderbilt University Medical Centre</td>
<td>900 alert messages resulted in 99 potential infusion errors being averted during an 8-month period</td>
</tr>
<tr>
<td>2004</td>
<td>Malashock et al</td>
<td>Hosp Pharm</td>
<td>8-month review of drug infusions covering 14,000 patient days</td>
<td>Smart pumps identified 17 potential errors that could have been lethal if the initial entry had not been discontinued</td>
</tr>
<tr>
<td>2004</td>
<td>Maddox</td>
<td>Proceedings*</td>
<td>Study of 525 IV smart pumps in two tertiary care referral hospitals</td>
<td>Smart pumps prevented near misses in 7.2% of all identified events</td>
</tr>
<tr>
<td>2005</td>
<td>Williams and Maddox</td>
<td>Am J Health</td>
<td>Random analysis of 100 IV smart infusion devices</td>
<td>506 alert events, 88% of which were overridden (443) even though 73% (370) indicated an overdose</td>
</tr>
<tr>
<td>2005</td>
<td>Larsen et al</td>
<td>Pediatrics</td>
<td>Analysis of number of errors the year before changing to smart pumps (2002) compared with the year after (2003)</td>
<td>Continuous infusion errors decreased by 73% after the introduction of smart pumps. Error rate decreased from 3.1 to 0.8 per 1000 doses. Number of 10-fold errors decreased from 0.41 to 0.08 per 1000 doses.</td>
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</table>

ICU = Intensive care unit; IV = Intravenous; *In: Schneider (2004)
nitroglycerin infusion with the dosing units specified as micrograms per minute (mcg/min). The nurse infusing the infusion pump was accustomed to nitroglycerin being prescribed in mcg/kg/min and programmed the infusion device using weight. The 70-kilogram patient received a 70-fold overdose of IV nitroglycerin.

In the Flaiten and Hevroy study (1999), data from 9366 patients showed that 32% of all medication errors were infusion related and, even though it was only a point prevalence study of 426 instances, Husch et al (2005) identified that 66.9% of IV infusions pump medications had one or more errors associated with their administration. In a review of 1846 medication errors involving infusion devices, Hicks et al (2003) found that 8.7% resulted in harm. The majority of errors were due to incorrect programming. The situation is more extreme in the ICU because of the number of IV lines per patient. If a ward-based patient has an IV line, a typical scenario may be that they have a maintenance infusion running together with intermittent bolus doses of an IV drug. A typical patient in the ICU may have five or six infusions running at one time, including inotropes, vasopressors and sedatives, and so the risk is magnified.

Categories of infusion pump errors
A review of infusion pump errors in the literature provides an indication of error types associated with the use of standard infusion pumps. These can be categorized into four main areas, although there is some overlap between categories.

Multiple of ten errors
These occur when an infusion is set up with a dose or time that is a multiple of 10 higher or lower than the correct prescription. Eskew et al (2002) cited one example where the amount of morphine was entered as 100 mg in 100 ml instead of 1000 mg per 100 ml. When the infusion device calculated the infusion rate based on the incorrect data input, the patient received a 10-fold overdose.

Unit errors
These are mistakes involving units of dose, weight or time, rather than simply the addition or omission of a number of zeros. One example is a unit error related to an insulin infusion in a paediatric ICU. The infusion should have been set up in units/hour, but was instead calculated in units/kg/hour, resulting in a 67-fold overdose (Hatcher et al, 2004).

Calculation errors
These occur where a mistake is made in calculating dose, rate or both. Examples are a vecuronium infusion that was calculated at 4.357 mg/kg/hour instead of 0.05 mg/kg/hour (Malashock et al, 2004), and an insulin infusion that was correctly set to infuse at 7 units per hour, but miscalculated at the next dose to infuse 7 units over 5 hours (Hicks and Becker, 2006).

Push button errors
These occur when the user presses a wrong button on the device when programming the infusion. The most common error is pressing the zero instead of the decimal point. In one example the infusion rate for a neonate was to be increased from 3.2 to 3.4 ml/hour. The nurse unintentionally pressed the zero in place of the decimal point, resulting in an infusion rate of 304 ml/hour instead of 3.4 ml/hour (Eskew et al, 2002). In another case, Hatcher et al (2004) cite an instance where a nurse incorrectly entered 205 instead of 2.5 to deliver an 82-fold overdose of nitroprusside to a 3.3 Kg infant (Hatcher et al, 2004).

The benefit of smart pumps
None of the above errors would be detected or prevented by standard infusion pumps. A smart pump, with hard limits, would prevent all of the above examples if the drug parameters entered into the pump were outside the limits of the drug library database (Table 2).

In one study the introduction of a smart pump system prevented 26 overdoses involving high risk and moderate risk medications in the first 2 months of operation. When the smart pump system was introduced, data demonstrated that 12.4% of all warnings resulted in errors being averted when the original data entry was changed as a result of the drug library alert (Obsdelt, 2004). When 50 smart pumps were tested at the Vanderbilt University Medical Centre, the smart pump systems produced 900 alarm messages that resulted in 99 potential infusion errors being averted during an 8-month period (Hatcher, 2004), and in another study smart pumps prevented near misses in 7.2% of all identified events (Maddox, 2004)

Smart pumps can have soft and/or hard limits, and there has been much discussion in the literature about the risk/benefit profile of each setting. Soft limits can be overridden by the clinician operating the pump, whereas hard limits cannot. In theory, soft limits provide more flexibility, allowing clinicians to make the ultimate decision about parameters, such as infusion dose and rate. In practice, however, they can negate the whole purpose of having a drug library, which is to prevent clinicians from straying outside preset limits deemed to be within appropriate drug safety protocols.

A 19-year-old woman with a pulmonary embolus after caesarean section was prescribed an IV heparin bolus dose of 5000 units followed by a heparin infusion at 1000 units/hour. Following administration of the bolus dose the infusion was commenced and the pump inadvertently programmed to run at 1000 ml/hour instead of 1000 units/hour (20 ml/hour). By the time the error was discovered, the patient had received more than 17000 units (a 5000 unit loading dose and 12000 units from the infusion) in less than an hour. A smart pump with soft dosing limits for heparin had been used, but the nurse had bypassed the dose-checking technology and had used the pump in standard mode (Institute for Safe Medical Practices (ISMP), 2007).

When a wireless smart pump system with soft limits was evaluated for effectiveness, Pratt (2004) found that clinicians overrode 95% of 1117 alerts warning the user that requested drug delivery was outside programmed limits. Only 57 alerts were not overridden, and 13 of these led to avoidance of harm when pumps were reprogrammed.

When comparing results for pre- and post-smart-pump introduction, Larsen et al (2005) analysed the number of errors reported in the year before changing to smart pumps (2002) compared with the year after (2003). Hospital-wide errors reported with continuous medication infusions decreased by 73% after the introduction of smart pumps. The error rate decreased from 3.1 to 0.8 per 1000 doses, and the number of 10-fold errors decreased from 0.41 to 0.08 per 1000 doses. Kinnealey et al (2003) found that when a smart pump drug library was implemented in the ICU and operating room environments, there was a 50% reduction in the number of drug administration errors involving syringe pumps, as indicated by clinician reports. Finally, when data from 18 institutions using smart infusion technology were analysed, it was found that, in an average 350-bed hospital, IV medication safety systems avert a potentially life-threatening IV programming error every 2.6 days and a potentially significant IV error every 1.9 days (Maddox, 2004).

Only one study has found smart pump technology to be of limited benefit, but this was a point prevalence survey that reviewed
The case for smart infusion pumps at St George’s paediatric ICU

In view of compelling evidence that smart pumps minimize the risk of infusion pump-related drug errors, and provide a stand-alone system that is immediately effective at the point of administration, the authors decided to introduce a smart pump system at St George’s paediatric ICU (The Orchestra Workstation with Base Intensive, Module DPS syringe pump and Module MVP volumetric pump, Fresenius Kabi AG, Germany). A review of some errors that occurred before introduction of the smart pump system, and of drug administration mistakes that were recently prevented by the smart pumps, reveals more about the type of medication errors that this infusion pump system is able to detect and stop.

Examples of errors that occurred prior to smart pump introduction

An atracurium infusion was set up in mcg/kg/min rather than mcg/kg/hour. The patient received 60 times the correct dose for 20 minutes. The basic principles of smart infusion technology would not permit this programming error, as the unit parameters for individual drug infusions are pre-determined in the drug library.

A standard infusion pump was programmed with 200mg of morphine in 50ml diluent instead of 20mg in 50ml, although the latter was in fact the concentration in the syringe. This resulted in the patient receiving a significant under dose of morphine.

The smart pump system would prevent such a programming error as it is outside the concentration range within the drug library. An undiluted salbutamol infusion, appropriate for delivery through a central line, was administered to an asthmatic patient via a peripheral cannula resulting in a local burn injury. The smart pump system would produce a warning message that peripheral solutions must be diluted.

A phenytoin infusion was reconstituted in 5% dextrose. However, phenytoin should not be diluted in dextrose solutions because of precipitation of phenytoin acid. With the smart pump system a warning message would appear to alert the clinician to dilute in sodium chloride.

Examples of errors prevented since the introduction of the smart pump

A patient receiving a clonidine infusion for sedation was not sufficiently sedated, so the doctor requested a bolus of clonidine. The smart pump drug library prevented administration of this bolus. IV boluses of clonidine are contraindicated as this can cause profound hypotension, and therefore the ability to give bolus doses has been disabled via the drug library.

A 10-year-old child on continuous venous haemofiltration was receiving a heparin infusion. The infusion was charted as 1100IU instead of 11 000IU in 50ml diluent, resulting in the filter clotting on two separate occasions prior to error detection. Since the introduction of the drug library this error is no longer possible, because the incorrect concentration is below the permissible range for haemofiltration.

A heparin loading dose and infusion was prescribed for a patient on continuous venous haemofiltration. The load is 1000IU/kg, which for a 10.2kg infant is 1000IU. But a dose of 10 000IU was prescribed. When programming the infusion pump this load was not allowed as it was outside drug library permissible limits. A potentially large dose error was averted.

Conclusion

When looking to upgrade infusion technology in St George’s Hospital paediatric ICU, safety of drug administration and a reduction in infusion pump drug errors were of paramount importance. Systems relying on human monitoring and awareness were unlikely to provide the incremental level of increased safety that were required. The authors also recognized that traditional infusion pumps do not incorporate any measure of fail-safe system that can monitor and police clinicians’ input instructions. Additionally, there were no other medication error safeguard systems, such as computerized physician order entry and bar code medication administration; therefore, there was a clear need for a stand-alone system that would be immediately effective at the point of administration.

After reviewing the literature and available options, it became clear that a smart pump system with a customized drug library and hard drug limits would provide an effective solution for the authors’ ICU. Qualitative data from their ICU has demonstrated drug errors that would have been prevented by a smart pump system, together with errors that have been prevented since the system has been in place. The authors’ audit data confirms that there has been a substantial reduction in the number of critical incidents involving infusion systems in their paediatric ICU, and those involving medication dose errors are now rare.

In view of the background research, and in the light of first-hand clinical experience, the authors now firmly believe that smart infusion systems with hard limit customized drug libraries, provide a new minimum safety standard for intensive care related to infusion pump drug error reduction.


Hicks RW, Cousins DJ, Williams RJ (2003) Summary of information submitted to MEDMARX in the Year 2002. The Quest for Quality, USP Centre for the Advancement of Patient Safety, Rockville, MD


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KEY POINTS

- There is overwhelming evidence that medication errors present a risk to patients.
- The risk is highest in the intensive care unit and even greater when medications are administered via an infusion pump.
- The term 'smart pump' is used to describe an infusion pump with an associated drug library that contains correct parameters for medications to be delivered by the pump.
- The literature suggests that smart infusion technology programmed with a drug library with hard (unchangeable) limits can significantly reduce drug errors at the point of administration.
- The authors believe that smart infusion technology provides a new minimum safety standard for intensive care.


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