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Parenteral Drug Administration Errors by Nursing Staff on an Acute Medical Admissions Ward During Day Duty

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Abstract

Background: Parenteral therapy is a route of administration for drugs which are poorly absorbed via the oral route and it can provide a rapid response during an emergency. However, poorly prepared and/or administered parenteral therapy can cause potential harm to patients such as thrombus formation, severe hypersensitivity reactions and infection. Very few studies have investigated the incidence of medication errors associated with parenteral drug administration.

Objectives: To determine the error rate during preparation and administration of parenteral medications by nursing staff and to propose strategies to reduce the error rate during parenteral administration.

Methods: A direct, disguised observation technique was used. The first author (JB) observed and recorded errors that occurred during the preparation and administration of parenteral medications on an admissions ward between 8.00am and 4.30pm from Monday to Friday for a 4-week period during December 1998. The staff were told that the observer was timing the administration; therefore they were not aware of the true nature of the study. This study was approved by the hospital audit committee.

Results: Drug administration was witnessed for a 4-week period providing 107 opportunities for error. 27 errors were observed which equated to an error rate of 25.2% [95% confidence interval (CI) 17.0 to 33.5%] including wrong time errors. Excluding wrong time errors, the most frequently occurring type of error, reduced the error rate to 10.3% (95% CI 3.8 to 14.9%).

Discussion: The error rate was lower than reported in the literature, this may be due to different methodologies, small sample size or effective nursing training and operating procedures. In the observed hospital, only nursing staff who have completed a training package are allowed to administer parenteral medications.

Conclusion: Based on our small study, and 2 previous small studies, we can conclude that parenteral medication administration errors are common in the UK; however, these studies are too small-scale to detect rare and serious errors.

In a recently published report, the UK Department of Health estimated that in National Health Service (NHS) hospitals alone adverse events in which harm is caused to patients occur in around 10% of admissions (850 000 per year) and cost the service an estimated £2 billion a year in additional hospital stays. The report recommended that mechanisms should be developed to provide a systematic approach to reporting, assessing and learning from the errors or service failures.[1]

Medication errors are understudied in the UK; there is no national system of reporting in place. Indeed, the most well known UK medication error reporting systems are run by pharmacists and encourage the health professional to report the error on a no fault basis so that the health professionals can learn from the mistakes.[2]

The majority of medication error studies published previously excluded the administration of parenteral medicines when assessing medication administration error rates. However, poorly prepared and/or administered parenteral therapy can cause potential harm to patients such as thrombus formation, severe hypersensitivity reactions and infection. Only a handful of studies have investigated parenteral medication administration errors specifically.[3-6] Only 2 of the above studies were conducted in the UK.[4,5] As suggested by the UK Department of Health, work in the study of medical errors and adverse events in the UK health services is still in its infancy.[1]

Aim and Objective

The aim of this study was to determine the error rate during the preparation and administration of parenteral medications by nursing staff on an acute admissions ward during day duty and to propose strategies to reduce the error rate during parenteral administration.

Methods

Definitions

In this study a medication error was defined as a dose of medication that deviated from the physician's order as written on the patient's chart.[7]

The total opportunities for error was defined as the total number of doses ordered plus the number of unordered doses given.

The error rate was calculated as the number of actual errors divided by the total opportunities for error. The 95% confidence interval (CI) was also calculated.

Whenever mixtures of drugs were prescribed each separate drug was considered to constitute one opportunity for error.

The following operational definitions (adapted from the definitions used by Barker and McConnell[8]) were used in this study.

(i) Wrong dose error: any dose either above or below the correct dose by more than 10%.

(ii) Unauthorized drug error: administration of a dose of medication that was never ordered for the patient.

(iii) Omission error: failure to give an ordered dose before the next dose was due. When the patient refused the dose no error was recorded. It was not possible to determine the time that a prescription was written, therefore omission errors were only recorded once the first dose had been given. No attempt was made to track unadministered prescriptions once the patient had been transferred from the admissions ward, no error was recorded unless the next dose was due while the patient was on the admissions ward.

(iv) Wrong route error: administration of a dose by a different route than that ordered by the physician.

(v) Wrong dosage form error: administration of a dose in a different form than that ordered by the physician when the physician specified or implied a dosage form.

(vi) Deteriorated drug error: the administration of any dose that, in the judgement of the observer, showed visible signs of deterioration or, by virtue of the time since preparation, would be expected to have deteriorated.

(vii) Wrong time error: the administration of a dose 1 hour or more earlier or later than prescribed.

(viii) Wrong base solution content: the use of the

wrong base solution (i.e. not the base solution on the patient's chart or recommended in the manufacturers literature) to prepare a dose.
(ix) Wrong preparation technique: aseptic technique was violated, or there were deviations from hospital policies and procedures that were not justified and affected the accuracy or sterility of the final product, this included circumstances where neither hand washing nor gloves were employed.
(x) Wrong rate of administration: the administration of a dose at a rate that differed from that prescribed on the patient's chart or recommended in the manufacturer's literature or selection of an infusion device of insufficient standard to accurately deliver the drug.
(xi) Drug incompatibility error: the co-administration of 2 or more incompatible drugs.
(xii) Incomplete labelling: any syringe that was not labelled to the satisfaction of the observer; labels were only expected to be attached to syringes or infusion bags that were to be left unattended or placed on a syringe driver.

If more than 1 error occurred during the preparation of a drug, more than 1 error was counted, for example, if the nurse failed to wash his/her hands or use gloves and the drug was administered 2 hours late this would constitute 2 errors.

Protocol Development and Data Collection Procedure

Data were collected using the disguised observation technique first described by Barker and McConnell.[8] This involves observation of drug preparation and administration in order to determine whether mistakes are being made. The true nature of the study was misrepresented to the nurses so as to avoid modification of behaviour. The nurses were told that the study was an assessment of the amount of time that they spent on each aspect of parenteral drug administration. As patients were being admitted to the ward throughout the day and night a large number of drugs are administered on the authority of 'one-off' orders and it was thought that many doses would be missed if observation was limited to the times of the traditional medicine rounds, thus observation took place throughout the day. At the start of each shift the nurses trained in parenteral administration were reminded about the project and were asked to inform the observer whenever a drug was being prepared for parenteral administration. Data collection took place on the acute medical admissions ward between the hours of 8.00am and 4.30pm from Monday to Friday for a 4-week period during December 1998. Data collection outside of these times was not possible because of resource problems, but the nature of the admissions ward ensured random sampling.

Prior to data collection, the project proposal was submitted to the Acute and Elderly Medicine Clinical Management Team's (CMT) Clinical Audit Steering Group for approval. The submission was made confidentially to the group's chairman because members of the nursing staff of the CMT are members of the committee and the nursing staff were to be unaware of the true nature of the study. Permission was granted by the chairman of the audit group on condition that the Director of Nursing Services of the CMT and the Ward Manager were made aware of the true nature of the study and agreed to it being carried out. Permission was sought and obtained from these individuals. As the project was approved by Clinical Audit Steering Group, the Chairman of Local Ethics Committee confirmed it was not necessary to get approval from the Local Ethics Committee.

Ethical Issues

When it was evident that a nurse was about to commit an administration error that, in the observer's opinion, would have been detrimental to the patient the observer intervened to avert the error. In such cases the error was counted as though it had occurred, attempts were made to intervene so as to avoid alerting the nurses to the true nature of the study.

Exclusions

Drug administration during cardiac arrests and other emergencies was not studied nor was the administration of doses from pre-filled syringes.

Issues Not Addressed By the Study

No attempt was made to assess the clinical suitability of prescriptions or to assess the errors committed by medical staff when administering parenteral medication. The clinical significance of errors was not assessed.

Results

107 opportunities for error were observed, 94 (88%) of these opportunities for error involved preparation of the injection by the nurse, 13 (12%) opportunities for error were provided by ready to administer infusions. Table I shows the drugs that were administered during the study. Antibacterials were the most commonly administered class of medication; this was followed by furosemide (frusemide) and then antidotes. In 105 cases (98.1%) the medicines were given intravenously, in 1 case (0.9%) the drug was given subcutaneously and in a further 1 case (0.9%) the drug was given intramuscularly. An infusion device was used in 26 cases (24.3%).

Table I. Drugs providing the opportunities for error

Drug class	Drug	Number of opportunities for error
Antibacterials	Ampicillin	12
	Benzylpenicillin	4
	Cefotaxime	4
	Cefuroxime	37
	Erythromycin	7
	Flucloxacillin	4
	Metronidazole	4
	Trimethoprim	1
Antidotes	Acetylcysteine	9
	Naloxone	1
Diuretics	Furosemide (frusemide)	12
Others	Aminophylline	3
	Diamorphine	1
	Digoxin	1
	Nitroglycerin (glyceryl trinitrate)	1
	Heparin	2
	Insulin	1
	Metoclopramide	3
Total		**107**

27 errors were observed which equated to an error rate of 25.2% (95% CI 17.0 to 33.5%) including wrong time errors. By excluding wrong time errors, which were the most frequently occurring type of error, the error rate was reduced to 10.3% (95% CI 3.8 to 14.9%). The types of errors are shown in figure 1. Errors from the other error categories were not observed.

Details of the Errors

Details of the errors observed are as follows.

(i) Deteriorated drug error: a syringe containing benzylpenicillin that was prepared 1 hour 40 minutes prior to administration, the delay in administration occurred as the patient did not have an indwelling intravenous cannula.

(ii) Wrong time errors: could be explained on 5 occasions; 3 patients lacked indwelling intravenous cannulae, 1 patient was off of the ward at the time that drug administration was scheduled, and on 1 occasion the drug was not available on the ward at the required time.

(iii) Wrong base solution: on 3 occasions water for injections was selected as the diluent for a furosemide infusion, the diluents recommended in the British National Formulary are sodium chloride 0.9% or Ringer's lactate solution.[9] On each of the 3 occasions an intervention was made by the observer and the doses were diluted with sodium chloride 0.9% in each instance.

(iv) Incompatibility error: metoclopramide was injected into the side port of a giving set that had been delivering an acetylcysteine infusion, the infusion was stopped but the line was not flushed either prior to or after the metoclopramide bolus. A review of the information provided in the Summary of Product Characteristics for metoclopramide and acetylcysteine, and that provided in the textbook by Trissel[10] revealed no data to suggest that these drugs are compatible.

(v) Wrong preparation technique: on 3 occasions (aminophylline, acetylcysteine, ampicillin) the nurse neither washed his/her hands nor donned gloves prior to preparation of the drug. On another occasion (cefuroxime) an intravenous cannula was accessed

without the nurse changing his/her gloves between patients. Finally, 0.5ml of insulin was added to sodium chloride 0.9% and the mixture was not agitated prior to administration.

(vi) Incomplete labelling error: this was assigned to the dose that also contributed the deteriorated drug error, the syringe containing benzylpenicillin was left unattended and unlabelled for 1 hour and 40 minutes.

Discussion

One of the criticisms of the data collection method used in this study is that the presence of the observer may affect the process that is being observed. It was difficult to judge the effect of the observer on the observed in this study. Some of the nurses appeared to be more influenced by the pharmacist's presence than others; one remarked, 'I don't like it when you watch me, it makes me nervous' and another said, 'I'll have to do this properly because you are watching me'. Other staff appeared to consider the observation to be a learning opportunity for the pharmacist and offered information such as 'I'm using a filter straw to remove any glass, [introduced into the product when the ampoule was opened], I'm doing this so that I don't inject particles into the patient which would get lodged in their lungs'. On the whole, however, the nurses did not comment on the pharmacist's presence. However, as noted earlier, when an intervention was made by the observer the nurses modified their behaviour the next time they were called to perform the same task, thus the error rate recorded may be falsely low.

The total error rate in the current study was 25.2% including wrong time errors and 10.3% excluding wrong time errors. Although these figures are lower than those found by previous studies it is not possible to make direct comparisons because of differing error classifications.

Case reports of errors involving the incorrect programming of infusion pumps are frequent.[11,12] No wrong rate of administration errors were observed during this study; the definition of this error was such that it included the incorrect programming of pumps or the selection of an insufficiently accurate pump. In this study, the hospital has put a risk management policy into place such that all infusion pumps and controllers are clearly labelled as being 'Suitable for High Risk Infusions' or 'Suitable for Low Risk Infusions'. These classifications have been devised using criteria published by the UK Department of Health.[13] The Biomedical Engineering Department at the hospital identified all of the pumps in the hospital that met 'High Risk' criteria, gave them a unique identification number to enable at service history for each individual pump to be maintained, and attached a 'Suitable for High Risk Infusions' sticker to each pump. The system is supported by a poster that classifies infusions into the low or high risk categories and is prominently displayed on all wards. The failure of our study to reveal any wrong rate of administration error suggests that our risk management program is working effectively; however, as an infusion device was only employed in 26 of the 107 opportunities for error, the study sample may have been too small to detect such an error.

In all cases the correct dose was administered to the patient. This is in contrast to the evidence from

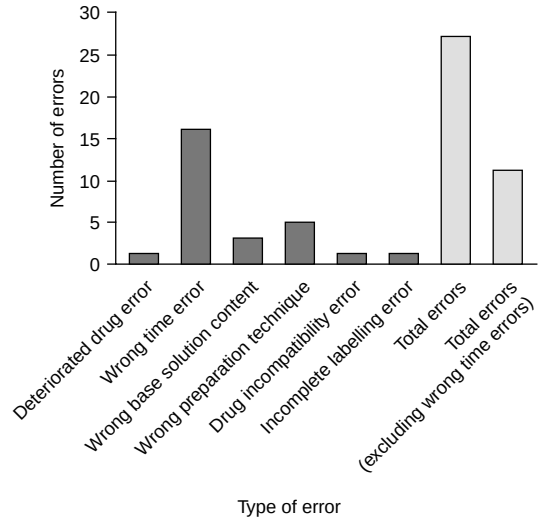

Fig. 1. Errors observed during the study

a large number of case reports and the results of previously published studies. When Gladstone[14] showed that over 50% of incident reports filed at her hospital were associated with the administration of an incorrect dose to the patient she also uncovered startling information regarding the mathematics qualifications of the nurses involved in drug administration at her hospital. In the current study, the hospital only allows accredited nurses to administer parenteral medicines; the nurses must first complete the open learning course and undergo an assessment of their mathematical abilities. Such procedures may have reduced the risk of dose miscalculation by the nurses.

More than half of the errors recorded were as a result of the drug being administered ± 60 minutes from the time that it was prescribed. All of the first doses were excluded, thus the errors cannot be attributed to failure of the doctor to inform the nurse of a new prescription. In this study, the wrong time errors could be explained on 5 of the 16 occasions on which they occurred. Three of the patients lacked indwelling cannulae; however, the ward has a junior doctors' support worker available at most times throughout the day. The duties of this support worker include the placement of indwelling intravenous cannulae. Thus, it should have been possible for the nurses to co-ordinate the care such that a catheter could have been placed and the drug administered without too much delay. The reasons that this did not occur on these occasions are unclear.

Three nurses were found to use water for injection as a diluent for furosemide. Consequently, an intervention was made by the observer as this is not the diluent recommended in the British National Formulary.[9] In each case the final volume of 15ml was infused over a 20 minute period. The clinical significance of this error is uncertain. However, there appears to be a need for further education regarding the administration of this drug.

The circumstances surrounding the incompatibility error showed that the nurse had given some thought to whether the drugs should be administered together. This was displayed in the way that the acetylcysteine infusion was stopped prior to the administration of the metoclopramide. The failure to flush the line enabled the 2 drugs to mix and theoretically may have led to treatment failure (via inactivation of either agent) or cannula failure [via precipitation of the drug(s)]. The patient did not appear to experience any ill-effects from this incident but an incompatibility error was assigned.

Hand Washing and the Use of Gloves

Good hand washing is the single most important procedure for the prevention of nosocomial infections; hands have been shown to be an important route of transmission of infection.[15] Therefore, our hospital has developed it's own glove policy and has also adopted the Royal Marsden's Manual of Clinical Nursing Procedures for hand washing. None of the nurses observed fully complied with these policies.[16] However, in assigning wrong preparation technique errors it was necessary to consider whether the use of nonsterile gloves, with or without hand washing, would provide a similar, or smaller bioburden to the injection preparation procedure compared with hand washing alone. There is evidence to show that the use of an antiseptic hand wash without wearing gloves or the use of nonsterile latex gloves over unwashed hands produces a similar bioburden,[17] therefore wrong preparation technique errors were only assigned in circumstances where neither hand washing nor gloves were employed. The differing policies for hand washing and glove use adopted by different hospitals may explain the variances in the incidence of this type of error between hospitals.

Limitations of the Study

As with other UK studies our study is single sited and of small sample size. This reflects a problem with this study method. As an observer is required it is financially and logistically impossible for this observer to be available 24 hours a day, 7 days a week to observe the errors. Hartley and Dhillon[5] also highlighted this problem. While Hartley and Dhillon[5] chose to observe drug administration during the drug round, we chose to observe administration between 8.00am to 4.30pm.

Although one may speculate that at different times of the day staff levels and degree of fatigue will affect the error rates, we have been unable to identify any systematic study to confirm or refute this speculation. Indeed, one study of 1371 errors showed no association between workload volume and the number of dispensing errors.[18] Furthermore, Ho et al.[19] failed to demonstrate any statistical differences between the medication administration error rate on weekdays compared with the weekend. However, Rose and Booker[20] found that medication errors are associated with some nursing staff workload factors such as number of shifts worked by temporary staff and the number of patient days per month. The hypothesis that staffing level and time of day affects the error rate is interesting and warrants future research; however, at the present time, there is no conclusive evidence to show the relationship between these factors and drug administration errors.

Since the disguised observation method is very labour intensive and there was a low volume of intravenous drug use on the ward, the sample size was inevitably small. Therefore, a few studies have chosen to exclude intravenous medication error completely. In the 2 other UK studies that investigated intravenous medication errors, only 320 and 168 observations were reported by Hartley and Dhillon[5] and O'Hare et al.,[4] respectively. Consequently, our study and previous UK studies have very limited statistical power to detect infrequent and serious errors. In this respect, only spontaneous reporting systems can afford to detect such infrequent and serious errors. Such a system is in operation in our hospital. Currently the UK Department of Health is establishing the National Patient Safety Agency to organise a national reporting scheme,[21] and this will provide the missing piece in the jigsaw of medication error monitoring.

Based on our small study, and 2 previous small studies, we can conclude that parenteral medication administration errors are common in the UK; however, these studies are too small-scale to detect rare and serious errors.

Proposed Strategies to Reduce Error Rate During Parenteral Administration

Wrong Time Errors

Currently the hospital's drug charts contain blank spaces in which the doctor is required to write the times that a drug should be administered. While this approach allows flexibility with drug administration, it also leads to drug administration being spread out throughout the day; middle of the day doses of parenteral medications may be prescribed at 12.00pm, 2.00pm or 4.00pm, for example. This system can make it especially difficult for a busy nurse to remember all of the times of administration of his or her patients' drugs. It may be preferable to produce drug charts that have a limited number of administration time options printed on them. This would encourage the doctors to prescribe drugs to be administered at standardised times, thereby enabling the nurses to remember more easily when drugs should be administered.

Wrong Preparation Technique Errors

Wrong preparation technique errors were most frequently assigned because of a breakdown in the hand washing procedure. Motivation to undertake adequate hand washing is notoriously difficult to maintain;[22] therefore, it may be more realistic to update the hospital's glove policy and encourage the nurses to use nonsterile latex gloves. This approach would have the added benefit of protecting the nurses from blood-borne infections.

Wrong Base Solution Content

As all of these errors occurred as a result of the inappropriate dilution of furosemide this problem would be overcome by producing a bulletin reminding the nursing staff of the correct way to dilute and administer furosemide. Furthermore, all nurses should be reminded to check the appropriate references prior to reconstitution of intravenous medication rather than rely on 'experience'.

Incompatibility Error

It may be possible to prevent incompatibility errors by running a campaign to highlight the difficulties that can occur when medicines are mixed together.

Course for Nursing Staff

In the study hospital there is currently an open learning training course that nurses must complete before they are deemed to be competent to administer parenteral treatments. This is supported by tutorials run by the pharmacy department and a mathematics exam. From this study it could be recommended that more attention should be given in the course to the importance of employing and maintaining aseptic techniques and more emphasis should be placed upon the need to administer medication promptly.

Opportunities for Further Study

A further study that assessed the errors that occur when medical staff administer parenteral medications would provide an useful comparison with this work especially as medical staff, in contrast with the nursing staff, do not receive any formal training from our hospital in the administration of parenteral medications.

The ward used in the current study is a particularly busy ward and parenteral medications are frequently administered to patients. A comparison of the error rates found in this study with those found on other wards would be valuable. This aspect of parenteral administration was not included in the current study because of the excessive time commitment that would be required to collect data using the direct observation technique on wards that do not frequently use parenteral medications.

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