Intravenous medicine preparation technique training programme for nurses in clinical areas

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ABSTRACT

Objective The key objective of this study was to highlight the weak points in the medicine use process.

Method We collected 15 videos from eight neonatal intensive care units where staff nurses showed how medicine preparation was performed. Recorded medicines were: vancomycin (6), gentamicin (5), caffeine citrate (2) and phenobarbital (2).

Results We did not review any video without errors. In 8/15 (53.3%) videos, the same syringe was used to measure the medicine and the diluent. In 8/15 (53.3%) videos, the syringes used were not the correct size for the volume being measured. In 4/15 (26.6%) videos, the volume measured into the syringes was not checked after it was measured from vials or ampoules. In just one vancomycin preparation could the reconstitution process be described as a correct process; in the other five videos, mixing after diluent addition to the vancomycin vial was almost non-existent (less than 10 s). Mixing after the medicine and diluent were in the same syringe was also non-existent in all of the videos.

Conclusions Hospitals should provide training programmes outlining the correct preparation technique.

preparations, be prepared in clinical areas. These expert recommendations related to the place for medicine preparation are not always followed in most hospitals due to a lack of resources in hospital pharmacy services. The number of medicines prepared in clinical areas is currently higher than it should be if all national and international recommendations were applied.

Providing training and supervision of healthcare professionals involved in medicine preparation is crucial to reduce errors.⁸ We have not found any international publication describing the medicine preparation process in a clinical area in detail. This lack of training documentation may lead to a higher risk of preparation errors. We believe that the risk of errors may be higher in newborn patients and the consequences may be more serious. Lack of commercial drug formulation is well known as a source of preparation errors, as well as working with small volumes. Nurses have to perform multiple steps before medicines are ready to be administered.

Many studies have been published analysing prescription, transcription, dispensing and medicine administration errors.^{9–15} However, few studies related to the preparation errors have been reported for patients of any age group. We identified four studies analysing the accuracy of the dilution process when medications designed for adults were administered to neonates. Parshuram *et al*¹⁶ analysed morphine infusions prepared for children weighing 0.7–60 kg and identified an error rate of 65%. Allegaert *et al*¹⁷ reported that in the case of amikacin, the use of paediatric vials improved dosing precision, as assessed by measurements of pharmacokinetic parameters. Popescu *et al*¹⁸ investigated the difference between the vancomycin concentration prescribed and that prepared by nurses at the bedside in a paediatric unit, and found measured drug concentrations before administration to be a mean of 7% lower than concentrations that had been prescribed by the doctor. Lastly, Aguado-Lorenzo *et al*,¹⁹ studying the accuracy of the concentration of morphine infusions, reported a mean deviation from intended concentrations of more than 20%.

In our previous research, we determined the incidence of preparation accuracy error in 10 neonatal intensive care units (NICUs).²⁰ We defined an accuracy error when the magnitude of the deviation between theoretical concentration and the concentration measured in the laboratory was over 10% of the intended concentration. We detected a lack of

INTRODUCTION

Intravenous medicine preparation in hospitals takes place in hospital pharmacy services or in clinical areas. Identifying which medicines should be prepared in each place depends on the drug characteristics, the preparation process and handler safety, among other things. The National Institute for Occupational Safety and Health (NIOSH) periodically publishes a list of antineoplastic and other hazardous drugs.¹ This group of medicines should always be handled in hospital pharmacy services. Other medicine preparations should be defined using a risk matrix—for instance, intrathecal, intracocular, epidural or central intravenous drugs should always be prepared in hospital pharmacy services, while peripheral intravenous, intramuscular or subcutaneous drug preparations will depend on other characteristics (number of different medicines in the same preparation, reconstitution and/or dilution times, double dilutions, use of special devices, narrow therapeutic index drugs, etc).²

The process of intravenous medicine preparation in hospital pharmacy services is well defined in several documents.^{3–7} Reconstitution and preparation of sterile medicines should be made in hospital pharmacy services to assure correct compliance with quality and safety standards. Only in emergency situations should sterile medicine preparations, classified as low risk

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accuracy in 234/444 samples (54.7%). This result highlighted a weak point in the medicine use process.

We decided to collect videos from the participating NICUs, where a routine preparation process was demonstrated.

WEAK POINTS IN THE MEDICINE PREPARATION PROCESS

We collected 15 videos from eight NICUs. We recorded vancomycin preparation in six videos, gentamicin preparation in five videos, caffeine citrate preparation in two videos and phenobarbital preparation in two other videos. We believed that the processes recorded in those videos were the best ones because people try to do their best when they are aware of being observed. This effect is known as the Hawthorne effect. We described this effect in previous research in which we analysed prescription error in an NICU.²¹

All medicine preparations were made by staff nurses from the NICUs. We did not review any video without errors. In 8/15 (53.3%) videos, the same syringe was used to measure the medicine and the diluent (eg, a 20 mL syringe was used to measure 1 mL of the drug and later the same syringe containing 1 mL of the drug was measured to 10 mL). Drugs involved in this process were three vancomycin preparations, three gentamicin preparations, one caffeine citrate preparation and one phenobarbital preparation. In 8/15 (53.3%) videos, the syringes used were not the correct size for the volume being measured (eg, a 5 mL syringe for measuring 0.5 mL of drug). Drugs involved were three vancomycin preparations, three gentamicin preparations, one caffeine citrate preparation and one phenobarbital preparation. In 4/15 (26.6%) videos, the volume measured into syringes was not checked after it was measured from vials or ampoules. Drugs involved were one vancomycin preparation, one gentamicin preparation and two phenobarbital preparations. In just one vancomycin preparation could the reconstitution process be described as a correct process; in the other five videos, mixing after diluent addition to the vancomycin vial was almost non-existent (less than 10 s). Mixing after medicine and diluent were in the same syringe was also non-existent in all the videos.

We believe that these five actions were related to lack of preparation accuracy: (1) using the same syringe to measure medicine and diluent, (2) not using the correct syringe for the volume being measured, (3) not checking measuring volumes, (4) not shaking enough in the reconstitution process and (5) not mixing the final medicine preparation enough. Apart from these five incidents, we detected other problems related to the preparation area, aseptic technique and labelling. As a result of these findings, we decided to develop a training programme for medicine preparation technique.²²

MEDICINE PREPARATION TRAINING PROGRAMME

The programme was developed by a multidisciplinary group (pharmacists, nurses and doctors), and implementation was carried out by nurses and doctors in each NICU. This educational programme was repeated several times in each NICU to ensure all nurses attended. When new nursing personnel came to the NICU, they had to attend the educational programme before starting medicine preparations.

The training programme consisted of both a theoretical and a practical teaching session. The theoretical session consisted of two parts: (1) a discussion of preparation accuracy errors measured in NICUs and (2) the weak points of medicine preparation revealed by the video analysis. The practical teaching session consisted of watching the training video and explaining how correct medicine preparations have to be performed.

Characteristics of the preparation area, aseptic technique, syringe volumes and the measuring process, the homogenisation process, labelling and the stability of drug preparations were concepts explained during the practical teaching session.

Preparation area

A designated area should be defined only for medicine preparation. Nothing other than medicine, material needed during preparation and a safety container to throw away waste should be in the working area (no paper, no paperboard, no waste materials, no patient contaminated materials, etc). The work surface should be cleaned and disinfected daily.

There should be no interruptions during medicine preparation. Implementation of an identification system for professionals preparing medication is a useful strategy. Red cloth bracelets or aprons are some of the possible strategies to identify and hence not disturb professionals preparing medicines.

Aseptic technique

Hand hygiene before and after medicine preparation is essential. The use of gloves is recommended.

Before the medicine preparation starts, a visual inspection of the ampoule and vial is needed. Lack of particles on the surface should be assured. The next step should be surface disinfection with 70% alcohol. Cleaning should be done in one direction to assure all particles are eliminated. Alcohol must have evaporated before starting medicine preparation. High risk contamination areas should never have been touched (syringe tip, ampoule neck and vial elastomeric area) after disinfection. A plug or other type of cover is recommended to cover the needle before removing air contained in the syringe.

Syringe volumes and the measuring process

Selection of an appropriate volume of syringe is a relevant issue in medicine preparation. An inappropriate syringe size will affect the accuracy of the process. Large volume syringes tend to be less accurate than small volume syringes for measuring small volumes. Measuring 1 mL would be more accurate using a 1 mL syringe than using a 20 mL syringe. As medicine preparation consists of mixing two components, drug and diluent, and the volumes of these two components may be different, each component should be measured with the appropriate sized syringe. Volume transfer devices should be used to transfer volume from one syringe to another. Transferring volume by introducing the needle of the syringe one through the tip of syringe two is a practice that should be avoided.

Syringe providers have to comply with current legislation (UNE-EN-ISO 7886-1:1998). Among all their technical features, the tolerance on graduated capacity and dead space of syringes must be highlighted because these parameters affect accuracy. Tolerance on graduated capacity is $\pm 5\%$ of the expelled volume for syringes with volumes up to 5 mL and $\pm 4\%$ of the expelled volume for larger volume syringes. Dead space can vary from 0.07 to 0.20 mL depending on syringe volume.²³ Therefore, all syringes available on the market may not have the same accuracy, and these aspects should be taken into account by those responsible for procurement.

The preparation process should finish with visual checking of the measured volume in the syringe. Never assume that the volume contained in vials or ampoules is that indicated on the label. There may be differences. This discrepancy between the theoretical volume indicated on the label and the possible measuring volume is a legal discrepancy. Manufacturers have to

fill vials or ampoules ensuring that the volume expelled by a syringe after measuring the full vial or ampoule is at least the volume stated on the label.²⁴

Homogenisation process

Preparation from lyophilised medicine (powder) involves two homogenisation processes: medicine reconstitution and medicine dilution. Mixing time should be approximately 30–60 s; less time may not assure a good homogenisation process. As this step is essential for proper distribution of the medicine in the solution, we decided to make nurses visualise the process. We introduced colourant to a vancomycin vial so that the time required to achieve the correct colour homogenisation was easily distinguished. This simple experiment helps nurses to be aware of the importance of spending time mixing the components of the medicine preparation.

Labelling

The medicine preparation process finishes with correct labelling. The only situation in which not labelling is permitted is when medicine is prepared at the bedside and immediately administered (intravenous push injection) to the patient without any break in the process.

Labels should contain the following information: medicine name, dosage (amount of drug and drug concentration in solution), administration route, speed and duration of administration (if applicable), final volume (if applicable), date and time of preparation, expiration, and name or initial of preparer. In addition, each preparation must be identified with the patient's label (full name, number of clinical note, bed and location).²

Stability

The stability of medicines prepared in clinical areas lasts for 1–2 hours due to the risk of microbiological contamination. Therefore, administration should take place within 1–2 hours after preparation.²

Medicine remaining in ampoules should be thrown away after its use because medicine is easily contaminated once ampoules are opened. Vials should be protected with adhesive sealants to reduce the risk of contamination during its period of stability. A label should indicate opening and discarding dates. Never leave needles inserted in the vial. The stability of drugs in vials should always be checked with the hospital pharmacy service.

CONCLUSIONS

The sterile medicine preparation process should ideally take place in hospital pharmacy services. Nevertheless, this is difficult to fulfil due to a lack of resources in pharmacy services and emergency situations in which medicine administration must be immediate. We should provide nurses with training programmes in the preparation technique. Nurses should know which method to use to prepare each medicine and the risks associated with poor preparation technique. Hospitals should provide training programmes outlining the correct preparation technique.

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