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Comparing the effects of two educational methods of intravenous drug rate calculations on rapid and sustained learning of nursing students: Formula method and dimensional analysis method

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SUMMARY

Accurate calculations of flow rate of intravenous medication are crucial to safe patient care. Flow rate of these medications can be calculated using either the formula or dimensional analysis method. However, few studies have assessed the effectiveness of this teaching method or any other method of calculating drug dosages. The purpose of this study was to compare the effects of formula and dimensional analysis educational methods of intravenous drug rate calculations on nursing students' rapid and sustained learning. This was an experimental study in which 42 s year nursing students participated. They were divided randomly into two groups, control and experimental and the drug calculating skills were taught to them through formula method (control group) and dimensional analysis method (experimental group), respectively. Before the education, immediately, and three months after the teaching intervention, the students' skills were examined using a drug calculation test. The results showed that no significant difference between the two groups in pre-test and post-test 1 scores ($P > 0.05$), but did show a significant difference between the two groups in post-test 2 scores ($P < 0.05$). The mean of the scores differences of pre-test and post-test 2 were 9.8 ± 3.34 and 12.85 ± 3.07 in formula method group and dimensional analysis group, respectively, which showed significant difference between two groups. This study showed that immediate post education intervention learning was significantly better in both groups, but, in the dimensional analysis method group, the sustained learning rate was significantly better than in the formula method group.

Introduction

Medication administration is one of the most important roles and responsibilities of registered nurses (Sung et al., 2008). Effective and safe administration of medication requires knowledge of several distinct skills, such as theoretical and clinical knowledge, pharmacological knowledge and mathematical calculation of dosages. Further, information related to the patient's diagnosis, age and condition is needed (Wissman, 1996; Gee et al., 1998). Nurses need to be able to calculate accurate drug calculations in order to safely administer drugs to their patients. All nursing student must demonstrate competence in mathematical calculation skills as a prerequisite to registration (Nursing and Midwifery Council, 2007). However; a number of studies have highlighted poor drug calculation skills among nursing students and registered nurses (Wilson, 2003; Barrett, 2007; Wright, 2007; Koohestani and Baghcheghi, 2008a; Lauder et al., 2008).

Koohestani and Baghcheghi (2008a) examined medication calculation skills of nursing students in the Iran and found that only 7.89% of 76 nursing students answered correctly to all of questions. The mean and standard deviation of students' scores were 14.9 ± 6.2 (range of scores 0–20). The drug calculation skill of nurses continues to be a national concern (Wright, 2009). Researchers have found that more than 1 in 6 medication errors involve miscalculations (Lesar et al., 1997). Medication errors resulting from inaccurate medication calculations are a serious problem in health care (Grandell-Niemi et al., 2001). Medication administration errors are often used as indicators of patient safety in hospitals because of their common occurrence and potential risk to patients (Stratton et al., 2004).

Medication calculation deficiencies among nursing students have been attributed to poor basic mathematical skills, inconsistent teaching methods, inconsistent or incorrect use of mathematical formulas, and reliance on the formula method, which requires memorization of multiple formulas, to solve different types of problems (Segatore et al., 1993). Biais and Bath (1992) identified three areas of medication calculation errors: mathematical, conceptual, and measurement. They found that conceptual errors,

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defined as difficulty setting up problems, were the most common type of error. This was corroborated in a study by Segatore et al. (1993) who found that 90.9% of calculation errors were conceptual.

Intravenous (IV) administration of drugs is a complex process and errors frequently occur (Taxis and Barber, 2003) Medication, electrolyte, solution and other fluids are frequently ordered and administered a patient directly into a vein. This method is called intravenous (IV) administration. These medications may be ordered in ml/h, unit/h, μg/kg/min, μg/min, or mg/min (Boundy and Stockert, 2006).

Study's findings of Koohestani and Baghcheghi (2008b) indicated that the most prevalent cause of medication errors of nursing students in cardiac care unite was incorrect drug calculation. Accurate calculations of flow rate of intravenous medication are crucial to safe patient care. Flow rate of these medications can be calculated using either the formula or dimensional analysis method (Boundy and Stockert, 2006; Craig, 2005).

Formula method or rule method is one method for calculation medication dose. There are several standard formulas to set up flow rate of intravenous drug. In this method formulas need to be memorized (Boundy and Stockert, 2006). Examples of drug calculations formulas were shown in Fig. 1.

Dimensional analysis, also called the factor-label method, conversion factor method, unit analysis, and quantity calculus is a systematic, organized approach to setting up mathematical problems and evaluating data by recognizing the fractional nature of the problem and conversion between systems. Dimensional analysis was defined a problem-solving method that can be used to calculated medication dosage problems whenever two quantities are directly proportional to each other and one quantity must be converted to the other using conversion factor or conversion relationship. Dimensional analysis addresses the issue of conceptual errors by obviating formulas and eliminating multiple-step computations (Craig, 2005). An example of a basic dimensional analysis set-up used with drug calculation was shown in Fig. 2.

Incorrect calculations can cause drug errors and potential harm to patients (Wright, 2005). For student nurses therefore learning how to calculate drug dosages is an important skill that they need to be taught during their nurse training. Calculation of drug dosages is usually achieved through the formula method (Koohestani and Baghcheghi, 2008a). However, few studies have assessed the effectiveness of this teaching method or any other method of calculating drug dosages. Results of two studies by Craig and Sellers (1995) and Greenfield et al. (2006) indicated a significant difference in medication calculation post-test score between dimensional analysis method and formula method of drug calculation, but in those studies, the post-test only were administered immediately at the end of the course and sustained learning was not evaluated.

Most studies exploring drug calculation skills tend to focus on the method by which the teaching is delivered, for example computer-assisted learning (Weeks et al., 2001), the combination of delivery methods (Wright, 2005) revision sessions and mathematics tutorials (Hutton, 1998),and comparing the effects of lecture and work in small groups (Salimi et al., 2007). Wright (2005) conducted an action research project to explore the most effective way of teaching drug calculations to student nurses. The evaluation of this project has demonstrated that a three stage approach to drug calculation appears to be an effective teaching strategy. These stages involve addressing mathematical concepts, teaching drug

Flow rate for medicati on ordered in mcg/min

$$\frac{D \times 60}{C} = \text{rate}$$

D= dosage of medication prescribed in mcg/min
C= concentration of medication in mcg/ml
60= is the constant 60 minutes /hour
R= ml/hour

Flow rate for medication ordered in U/hour

$$\frac{D}{H} \times V = \text{rate}$$

D= dosage desired in unit/hr
H= total unit on hand
V=volume of solution in total ml
R= ml/hour

Flow rate for medication ordered in mcg/kg/ min

$$\frac{D \times 60 \times w}{C} = \text{rate}$$

D= dosage of medication prescribed in mcg/min
C= concentration of m edication in mcg/ml
60= is the constant 60 minutes /hour
W= weight in kilograms
R= ml/hour

* The most common type of pump requires that you perform calculations so that they determine the number of ml that are infused over an hour. This is called the pump rate

Fig. 1. Examples of drug calculations formulas (Pump Rates*).

Given quantity	Conversion Factor for given quantity	Conversion Factor for wanted quantity	Conversion Computation	Compute	Wanted Quantity

Fig. 2. Basic dimensional analysis set-up used with drug calculation.