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EVALUATION OF DRUG DOSES CALCULATION SKILLS OF REGISTERED NURSESWORKING IN TERTIARY CARE HOSPITAL OF RAWALPINDI: AN INTERVENTIONAL STUDY

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ABSTRACT
Medication errors due to incorrect dosage calculations are a significant concern in healthcare, potentially leading to adverse patient outcomes. This study aimed to assess the effectiveness of a structured educational intervention on improving nurses' drug dosage calculation skills in a tertiary care hospital. Enhancing these skills is crucial for patient safety and quality care, A quasi-experimental design was used with a sample of 220 nurses in a tertiary care setting.Participants completed a pre-intervention test assessing dosage calculation skills, followed by a structured training session on dosage calculations. A post-intervention test was conducted immediately after the training to evaluate the impact of the intervention. Data were analyzed using paired t-tests to compare pre- and post-intervention scores, The results showed a significant improvement in nurses' calculation accuracy and confidence following the educational intervention. The average post-intervention test scores were significantly higher compared to pre-intervention scores ($p < 0.05$), indicating the effectiveness of the training session in enhancing dosage calculation skills, The study concludes that structured educational interventions can effectively improve nurses' drug dosage calculation skills, thereby potentially reducing medication errors. Continued support, periodic refresher training, and additional decision aids are recommended to maintain competency in dosage calculations and enhance patient safety in clinical settings.
Keywords: *Medication errors, drug dosage, patient safety, quality care.*

INTRODUCTION

Medication errors are a significant issue in healthcare systems worldwide, with serious implications for patient safety, clinical outcomes, and healthcare costs. Among these errors, drug dosage calculation mistakes made by registered nurses (RNs) represent a considerable portion, often resulting in adverse effects on patient health, prolonged hospital stays, and, in some cases, fatal outcomes(Rodziewicz et al., 2018). Drug dosage calculation is a critical skill for RNs, especially in tertiary care hospitals where patients frequently present with complex health needs requiring intricateand precise medication regimens. Despite the essential role of accurate calculations in patient care, studies indicate that medication errors persist at alarming rates globally, highlighting an urgent need for targeted interventions and education to enhance dosage calculation skills among nurses(Kuriakose et al., 2020).

Globally, medication errors, particularly those related to dose miscalculations, continue to significantly affect patient safety. The World Health Organization (WHO) has estimated thatmedication errors, including dosing errors, affect 1 in 10 patients worldwide, with nearly 50% being preventable(Rodziewicz et al., 2018). In the United States, a widely cited report by the Institute of Medicine estimates that medication errors harm at least 1.5 million people each year, with drug dose miscalculations by healthcare providers being a major contributor(Vaziri et al., 2019). In Europe, studies indicate that approximately 10% of patients experience harm due to medication errors during their hospital stays, with incorrect dose calculations identified as one of the primary causes(Elonen etal., 2022). These errors are particularly concerning in high-stakes settings like intensive care units and surgical wards, where patients are critically ill and the margin for dosing inaccuracies is extremely narrow.

The impact of drug dosage miscalculations is not limited to developed nations. In low- and middleincome countries (LMICs), including Pakistan, medication errors are often underreported, butavailable data indicate a substantial prevalence. A study conducted in Iranian hospitals found a high prevalence of medical errors, with dosage miscalculations cited as a common issue affecting patientsafety(Vaziri et al., 2019). Similar findings have been reported in healthcare settings across South Asia, Africa, and Latin America, where limited resources, understaffing, and heavy workloads exacerbate the risk of medication errors. In these regions, the shortage of trained healthcare professionals and insufficient access to ongoing education and technology further complicates accurate drug dosage calculation, amplifying the likelihood of adverse patient outcomes.

The consequences of drug dosage miscalculations are wide-ranging and potentially severe. Incorrect doses can result in subtherapeutic effects, reducing the efficacy of treatment and delaying patient recovery, or, conversely, toxic effects, which can cause organ damage or even death(Abdulla et al., 2020). For example, an overdose of anticoagulants can lead to life-threatening bleeding, while an incorrect dose of insulin can result in hypoglycemia or hyperglycemia, both of which can be fatal(Fusco et al., 2021). In pediatric and geriatric populations, where drug doses must be carefully calculated based on body weight and other individual factors, the margin for error is even smaller, making precision essential. Additionally, dose calculation errors can also lead to secondary issues such as decreased patient trust in healthcare providers, increased litigation cases, and higherhealthcare costs due to extended hospital stays and additional treatment requirements(Kuriakose et al., 2020).

Among the various factors contributing to dosage calculation errors, time pressures, high patientto-nurse ratios, complex calculations, and inadequate mathematical skills are frequently cited. The demanding nature of nursing work in tertiary care hospitals often results in a high risk of errors, particularly in emergency situations where quick decisions are required(Stake-Nilsson et al., 2022). Research has shown that even experienced nurses may struggle with dose calculations due to these pressures, underscoring the need for comprehensive training and support systems to improvecalculation accuracy. Studies also suggest that limited exposure to standardized dosage calculation training during nursing education and insufficient emphasis on continuous learning further exacerbate this issue(Elonen et al., 2022).

In Pakistan, the scope of this problem has started to gain attention, with studies revealing that a significant percentage of nurses lack adequate dosage calculation competencies(Sultana, 2017). Interventions such as structured workshops, simulation-based training, and digital tools have shownpromising results in improving these skills, especially in high-risk healthcare settings(Komal & Hafiza Saba Javed, 2023). For example, structured training workshops for nurses in Faisalabad were found to enhance competence and confidence in drug dose calculations, suggesting that educational interventions can have a positive impact(Tabassum & Khuwaja, 2021). However, there is a need for more comprehensive research within Pakistan to better understand the specific challenges faced by nurses in tertiary care hospitals and to develop targeted strategies to address these issues effectively.

Rationale of the study:

This interventional study aims to assess and improve drug dosage calculation skills among registered nurses working in a tertiary care hospital in Rawalpindi, Pakistan. By identifying existing gaps in calculation skills and implementing a structured educational intervention, this study seeks to contribute to the reduction of medication errors and enhance patient safety. In doing so, it will provide valuable insights into the effectiveness of targeted training programs, supporting the development of evidence-based practices to improve medication safety and the quality of nursing care in Pakistan and similar settings.

Objectives

Objective of the study was;
To evaluate the nurses' competence in drug dosage calculation
To evaluate the nurses knowledge about drug dose calculation

Research Questions

What is the level of competence among nurses in accurately performing drug dosagecalculations?
How knowledgeable are nurses about the principles and practices of drug dose calculation inmedication administration?

Chapter 2 - Literature Review

Nurses play a key role in the hospitals while dealing with the drugs, their knowledge regarding metric dose calculation is significant concern to prevent errors. A cross sectional study conducted in the College of Medical Sciences-Teaching Hospital, Bharatpur, Nepal showed low level of nurses' knowledge on meter dose inhaler setting. This demands a critical need for effective education(Valarmathi & Parajulee, 2011). Work overload due to increase patient to Nurse Ratiois a major contributor in the drug dosing error. The analytical cross sectional study conducted in the Dow University Karachi showed 12.3% missed medication dose due to increase number of patients and no time to calculate the accurate dose(Kumar & Rehman, 2022). Accurate knowledge regarding drug dose calculation can decrease drug errors. An Interventional study was undertaken at Koirala Institute of Fitness Sciences to evaluate the potential of nurses regarding drug dose calculation, which reveals a statistically significant enhancement in their awareness ofthe importance of verifying their own drug dose calculations and the necessity of consulting a second individual during the dose calculation process. The heightened awareness substantially improves the accuracy of drug dose calculations and contributes to the prevention of medicationdosage-related errors(Sarraf et al., 2020). Training and effective courses can improve medicationdose calculation and decrease the dosing errors. A descriptive study was conducted in the teaching hospitals of Al-Anbar governorate showed that nurses involved in attending workshops and training have more knowledge and accurate practice related to dose calculation(Farhan, 2018).

Chapter 3 - Methodology

Study Design:

A quasi experimental study was conducted among randomly selected 220 nurses who were workingin Holy Family Hospital, Rawalpindi and Rawal General and Dental Hospital.

Duration of study

This study was conducted three months after the approval of synopsis.

Target Population

The target population was 490 registered nurses male and female working in Holy Family Hospital, Rawalpindi and Rawal General and Dental Hospital.

Sampling Technique

The study will be conducted with the non-probability convenient sampling technique

Sample size

Sample size was 220 registered nurses calculated using the formula; **Sample Size = $N/(1=N*e^2)$**

Variables Independent:

Age
Gender
Qualification **Dependent:**
Orientation programs (questionnaire)

Sample Selection Inclusive criteria:

Staff nurses aged 21-60 years.
Both males and females
Nurses who were directly involved in bedside patient care were included.

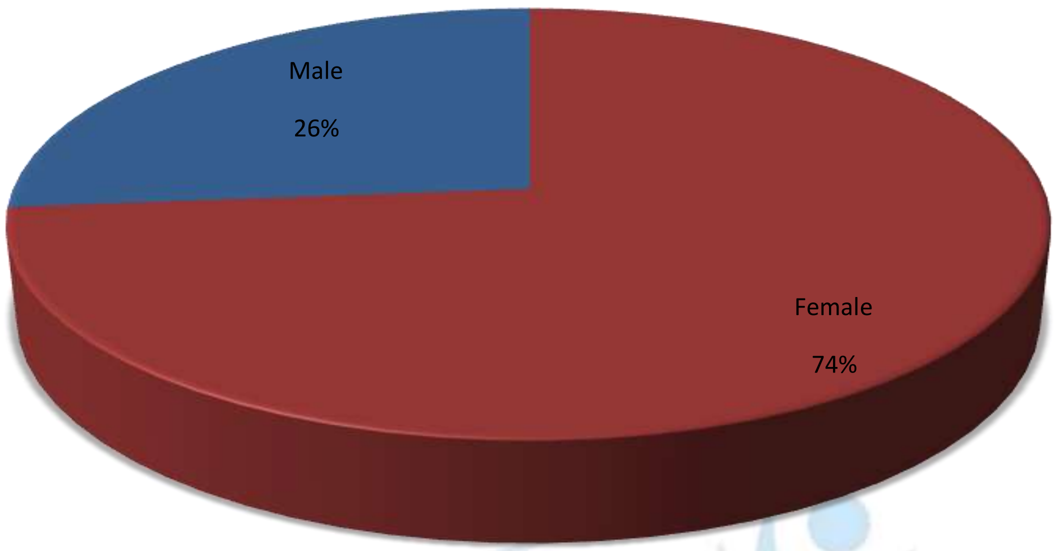
Exclusive criteria:

Head nurses, clinical instructors and student nurses not directly involved in patient care, wereexcluded.

Data collection and Data analysis

The collected data were cleaned, coded, and entered in statistical software. The statistical analysis was done using STATA version 13. Frequency distribution for selected variables was done. Data were analyzed by calculating means of pre and post test. Paired T Test was used to compare the mean score of pre and post test. P value less than 0.05 was considered statistically significant.

Figure 1- Gender



Chapter 4 - Results

In our study, out of 220 individuals, 26% of the respondents were males and 74% of therespondents were females (fig.1) in which, 118 individuals had ages between 3140 years and 102 individuals had ages between 21-30 years of age.

In our study, maximum individuals (59%) had qualification in BS Nursing (post RN), while 25% individuals had Diploma in Nursing, and 16% individuals had done BS Nursing with 41 individuals having experience less than 6 months, 128 individualhaving experience less than 5 years, 51 individuals had 5-10 years of experience.

Figure 2- Age Range

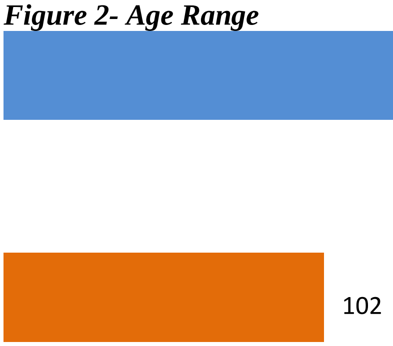


Figure 3- Qualification

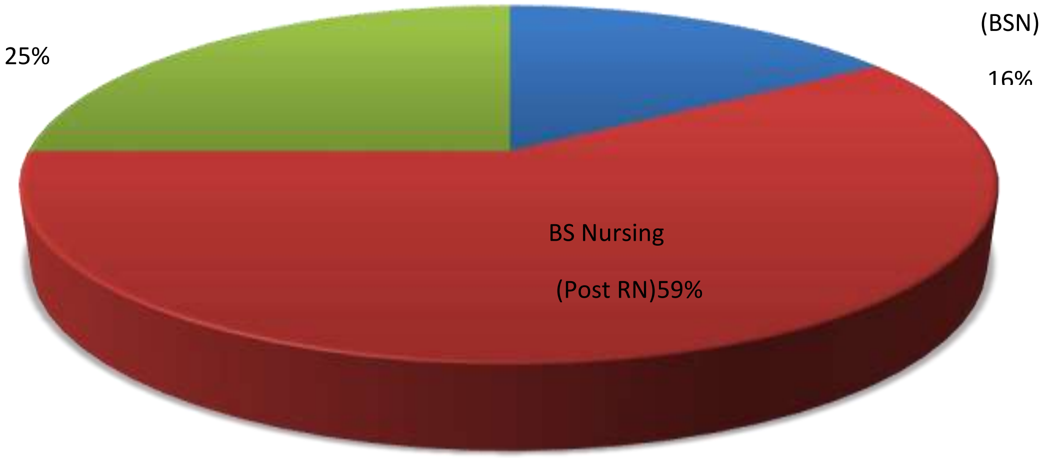


Figure 4- Experience

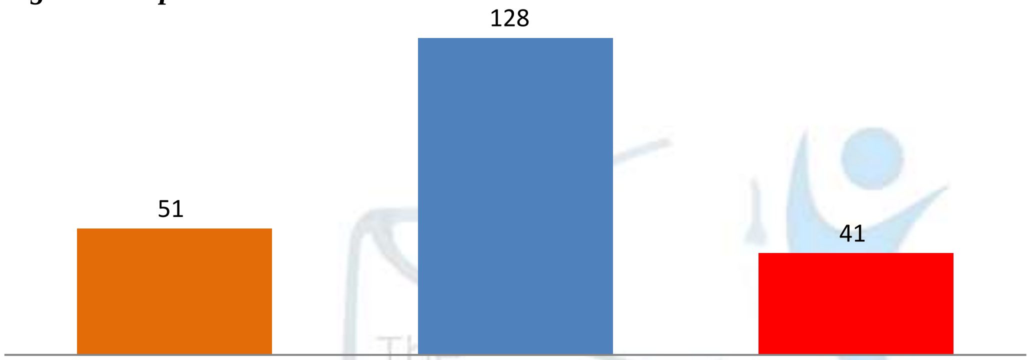


Table 1 presents the results of a drug dosage calculation skills assessment administered to participants, showing pre-test and post-test responses to various questions. Each question evaluates the participants' knowledge of correct dosage calculations for different medications and scenarios, such as calculating lignocaine dosage, determining safe volumes for adrenaline and bupivacaine, and preparing drugs for pediatric patients. The correct answers for each question are indicated, and the number of participants who selected each option in both the pre-test and post-test is shown. Thedata demonstrates a general increase in correct responses from pre-test to post-test, suggesting an improvement in participants' drug calculation skills following an intervention. This increase highlights the effectiveness of the educational interventionin enhancing participants' competence in safe medication administration.

Table 1- Pretest and Posttest Results

Questions	Pre Test	Post Test
Lignocaine is available in 20ml vials of 1%. How much lignocaine, inmilligrams (mg) i in the vial?		
150mg	21	23
200 mg (correct)	135	157
200ml	17	28
230mg	47	12

Your doctor plan to suture an 80kg patient. Given the maximum safe doseof lignocaine is 3mg/kg, what is the maximum safe volume in ml of 2% lignocaine solution that can be given?		
12mcg	23	21
12mg	22	19
12ml (correct)	129	158
21ml	46	22
A 20ml ampule containing 0.25% bupivacaine contains how many milligrams per milliliter (mg/ml) of bupivacaine?		

2.5mcg/ml	27	21
2.5mg/ml (correct)	132	155
25mg/ml	40	19
5.2mg/ml	21	25
A 25kg girl is being treated with the femoral fracture requiring a femoral nerve block. The maximum safe dose of bupivacaine is 2mg/kg. what is themaximum safe volume of 0.25% of bupivacaine, in ml?		
10ml	29	30
15ml	48	27
20ml (correct)	120	142
5ml	23	21
How many ml of 1:10000 solutions would you need to obtain 1mg ofadrenaline?		
1000ml	18	12
100ml	40	25
10ml (correct)	140	162
None of Above	22	21
How many micrograms (mcg) of adrenaline are there in a 10ml ampoule of0.25% bupivacaine with adrenaline 1:400000 solution?		
2.5mcg (correct)	149	160
25mcg	30	15
25mg	23	24
25ml	18	21
You are attending the cardiac arrest of a 60-year-old male. How many ml of1:1000 adrenalines do you need to give a dose of 1 mg of adrenaline?		
0.1ml	33	39

0.9ml	22	8
100ml	29	12
1ml (correct)	136	161
A 4-year –old on your ward is in cardiac arrest. He weighs 16kg. The dose of intravenou adrenaline in pediatric arrest is 10mcg/kg. How many ml of		
1:10000 adrenaline will you need to draw up for a single dose?		
0.6ml	27	23
1.6ml (correct)	143	152
16ml	26	28
60ml	24	17
Atropine "Mini-Jets" are found on emergency trolleys in your hospital. Each10ml Mini jet contains 1mg of atropine. What is the concentration, in mg/ml,of this solution?		
0.01mg/ml	21	33
0.1mg/ml (correct)	126	152
1.2mg/ml	28	21
2.5mg/ml	45	14
A 45 kg female patient develops symptomatic bradycardia. Your doctor electsto trea this with atropine, 20mcg/kg, given intravenously. How many ml of an atropine "Mini Jet" (1mg in 10ml) will be required?		
50ml	28	21
70ml	24	37
90ml	42	32
9ml (correct)	126	130
Your doctor is doing an emergency intubation on a 15kg child using suxamethonium The dose of suxamethonium in children is 2 mg/kg. Suxamethonium is supplied in vial of 100 mg in 2ml. To prepare this drug for use, one vial of suxamethonium is dilute with normal saline to 10 ml totalvolume. How many ml of this solution are required fo a single dose? (3ml)		
13ml	57	26
30ml	21	23
35ml	24	36
3ml (correct)	118	135
You plan to sedate a 25 kg child with midazolam. A vial of midazolam has 15mg in 3ml. the intravenous sedation dose of midazolam for children is		
0.1mg/kg. How many ml will you need to draw up? (0.5)		

0.5ml (correct)	143	150
1.5ml	32	39
500ml	26	10
50ml	19	21

Table 2 provides statistical results from a paired t-test comparing pre-test and post-test scores on a drug dosage calculation skills assessment among 220 participants. The pre-test had a mean score of 7.25 (±1.569) with scores ranging from 4 to 11, while the post-test mean increased to 8.327 (±1.556), with scores ranging from 4 to 12. The mean difference between the pre-test and post-test scores was -1.077, indicating an improvement in performance. The standard error of the difference was 0.152, and the calculated t-value was -7.1 with a highly significant p-value of 0.000, suggesting that the observed improvement in scores from pre-test to post-test is statistically significant. This result implies that the intervention or training likely had a positive effect on participants' drug calculation skills.

Table 2- Outcome Comparison T-Test (Statistics)

Variable	Obs	Mean	Std. Dev.	Min	Max
Pretest	220	7.25	1.569	4	11
Posttest	220	8.327	1.556	4	12

	Obs	Mean1	Mean2	dif	St Err	t value	p value
pretest - posttest~	220	7.25	8.328	-1.077	.152	-7.1	0

Discussion

The findings of this study highlight the critical impact of educational interventions on enhancing drug dosage calculation skills among registered nurses in tertiary care hospitals. Our pre- and posttest analysis demonstrated a marked improvement in participants' accuracy and confidence in performing calculations after undergoing structured training. This reinforces the premise that targeted educational programs can significantly enhance competency, as evidenced by the statistically significant increase in correct answers across multiple test items.

One of the major findings is the notable gap in baseline knowledge of drug dosage calculations, especially with complex medications requiring specific conversions and precise dosing. Initially, a substantial portion of participants struggled with calculating safe doses of common drugs like lignocaine and adrenaline. This aligns with previous studies that emphasize a lack of confidence and competence in drug calculations among nurses, often attributed to insufficient training and reliance on memory rather than structured protocols(Weeks et al., 2019) (Iqbal et al., 2020). Our findings further underscore the necessity of continuous, hands-on training, as improvements were observed after the intervention, with a significant increase in correct responses related to these calculations.

The discrepancy in knowledge levels pre-intervention may also be attributed to varying educational backgrounds among participants. Nurses holding a BS in Nursing (post-RN) performed better than those with only a diploma, suggesting that higher qualifications may provide better foundational knowledge in pharmacology and clinical mathematics. Similar observations were reported in a studyby (Aggar et al., 2018), where nurses with additional training and workshop exposure showed superior calculation skills compared to their peers without such training.

The study also highlights critical areas requiring improvement, particularly in emergency medication administration. High-stakes situations like cardiac arrest require rapid yet accurate drug calculations. Before the intervention, several participants had difficulty with pediatric dose calculations and emergency medications like adrenaline, which carry a high risk of adverse effects if miscalculated. Post-intervention results showed improvement, indicating that structured training can boost competence in these crucial areas, an outcome that supports prior findings by(Zyoud et al., 2019), who noted a marked reduction in dosage errors after similar training interventions.

However, some areas showed only marginal improvement post-intervention, especially with intricatedosage problems requiring advanced math skills. Factors such as time pressure, high patient loads, and fatigue likely impact nurses' calculation abilities, as highlighted by(Malik et al., 2020). This suggests that while educational interventions are essential, they must be accompanied by support systems within hospitals, such as access to digital dosage calculators and supportive peer-review protocols, to mitigate errors in high-stress scenarios.

In the Pakistani context, our study contributes valuable insights into the prevalent gaps in nursing education regarding drug dosage calculations. With nursing roles evolving and responsibilities increasing, there is a need for a nationwide push to enhance the mathematical and pharmacological competencies of nursing staff. Given the positive impact of our intervention, implementing similar training programs across healthcare institutions in Pakistan may help reduce medication errors and promote patient safety.

Ultimately, our study reinforces the critical role of continuing education and structured interventionsin addressing skill gaps in dosage calculation. Further research could focus on implementing real-time decision-support tools and evaluating long-term retention of skills posttraining. Addressingthese issues is paramount, especially in resource-constrained settings, to optimize patient safety andbuild a stronger, more competent nursing workforce.

Conclusion

This study demonstrates that structured educational interventions significantly enhance nurses'proficiency in drug dosage calculations, thus supporting safer medication administration in tertiary care settings. Improvements in calculation accuracy and confidence following training underscore the value of continuous, targeted education. However, further support systems, such as decision aids andperiodic refreshers, are essential to sustain competency, particularly in high-stakes clinical situations.

Limitations of the Study

Limited sample size may affect generalizability to other healthcare settings.

Short duration of follow-up may not capture long-term retention of skills.

Variability in participants' prior education and experience levels could influence results.

Lack of control group limits comparison to other potential training methods.

Study conducted in a single tertiary care hospital; findings may not apply to different healthcare environments.

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Rawal College of Nursing
Title of Research Study: Evaluation of drug dose calculation ability of Registered nursesworking in tertiary care hospital Rawalpindi : An interventional study
Demographics
Name of Participant (Optional):

1. How old are you?

A) 21-30	B) 31-40

2. What is your nursing qu lification?

A).Diploma in Nursing	B). BS Nursing (Post RN)	C. BS Nursing (BSN)

3. What is your gender?

A). Male	B). Female

4. Your work experience?

A) <6 months	B) < 5 years	C) 5 -10 years	C) >10 years

Questionnaire

1. Lignocaine is available in 20ml vials of 1%. How much lignocaine, in milligrams (mg) is inthe vial?

a) 150mg	b) 200mg (CORRECT ANSWER)	c) 230mg	d) 200ml

2. Your doctor plan to suture an 80kg patient. Given the maximum safe dose of lignocaine is 3mg/kg, what is the maximum safe volume in ml of 2% lignocaine solution that can be given?

a) 12ml (CORRECT ANSWER)	b) 21ml	c) 12mg	d) 12mcg

A 20ml ampule containing 0.25% bupivacaine contains how many milligrams per milliliter(mg/ml) of bupivacaine?

a) 25mg/ml	b) 2.5mg/ml (CORRECT ANSWER)	c) 5.2mg/ml	d) 2.5mcg/ml

3. A 25kg girl is being treated with the femoral fracture requiring a femoral nerve block. The maximum safe dose of bupivacaine is 2mg/kg. what is the maximum safe volume of 0.25%of bupivacaine, in ml?

a) 5ml	b) 10ml	c) 15ml	d) 20ml (CORRECT ANSWER)

4. How many ml of 1:10000 solutions would you need to obtain 1mg of adrenaline?

a) 10ml (CORRECT ANSWER)	b) 100ml	c) 1000ml	d) None of above

5. How many micrograms (mcg) of adrenaline are there in a 10ml ampoule of 0.25% bupivacaine with adrenaline 1:400000 solution?

a) 25mg	b) 25ml	c) 25mcg	d) 2.5mcg (CORRECTANSWER)

6. You are attending the cardiac arrest of a 60-year-old male. How many ml of 1:1000 adrenalines do you need to give a dose of 1 mg of adrenaline?

a) 0.1ml	b) 100ml	c) 0.9ml	d) 1ml (CORRECTANSWER)

7. A 4-year –old on your ward is in cardiac arrest. He weighs 16kg. The dose of intravenous adrenaline in pediatric arrest is 10mcg/kg. How many ml of 1:10000 adrenaline will you need to draw up for a single dose?

a) 0.6ml	b) 60ml	c) 1.6ml (CORRECTANSWER)	d) 16ml

Atropine “Mini-Jets” are found on emergency trolleys in your hospital. Each 10ml Mini-jetcontains 1mg of atropine. What is the concentration, in mg/ml, of this solution?

a) 0.1mg/ml (CORRECTANSWER	b) 0.01mg/ml	c) 1.2mg/ml	d) 2.5mg/ml

10.A 45 kg female patient develops symptomatic bradycardia. Your doctor elects to treat this with atropine, 20mcg/kg, given intravenously. How many ml of an atropine “Mini-Jet” (1mg in10ml) will be required?

a) 90ml	b) 9ml (CORRECTANSWER	c) 50ml	d) 70ml

11. Your doctor is doing an emergency intubation on a 15kg child using suxamethonium. The dose of suxamethonium in children is 2 mg/kg. Suxamethonium is supplied in vials of 100mg in 2ml. To prepare this drug for use, one vial of suxamethonium is diluted with normalsaline to 10 ml total volume. How many ml of this solution are required for a single dose?(3ml)

a) 13ml	b) 35 ml	c) 30 ml	d) 3 ml (CORRECT ANSWER)

12. You plan to sedate a 25 kg child with midazolam. A vial of midazolam has 15mg in 3ml. theintravenous sedation dose of midazolam for children is 0.1mg/kg. How many ml will you need to draw up? (0.5)

a) 0.5ml (CORRECTANSWER)	b) 50ml	c) 1.5ml	d) 500ml