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Comparison of Accuracy and Speed in Computer-Assisted Versus Conventional Methods for Pediatric Drug Dose Calculation: A Scenario-Based Randomized Controlled Trial

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Abstract

Pediatric emergency care is prone to medication errors in many aspects including prescriptions, administrations, and monitoring. This study was designed to assess the effects of computer-assisted calculation on reducing error rates and time to prescription of specific emergency drugs. We conducted a randomized crossover experimental study involving emergency medicine residents and paramedics in the Department of Emergency Medicine at Ramathibodi Hospital. Participants calculated and prescribed medications using both the conventional method and a computer-assisted method. Medication names, dosages, routes of administration, and time to prescription were collected and analyzed using logistic and quantile regression analysis. Of 562 prescriptions, we found significant differences between computer-assisted calculation and the conventional method in the calculation accuracy of overall medications, pediatric advanced life support (PALS) drugs, and sedative drugs (91.17% vs 67.26%, 86.54% vs 46.15%, and 89.29% vs 57.86%, respectively, $P < .001$). Moreover, there were significant differences in calculation time for overall medications, PALS drugs and sedative drugs (25 vs 47 seconds, $P < .001$), and computer-assisted calculation significantly decreased the gap in medication errors between doctors and paramedics ($P < .001$). We conclude that computer-assisted prescription calculation provides benefits over the conventional method in accuracy of all medication dosages and in time required for calculation, while enhancing the drug prescription ability of paramedics.

Keywords

pediatric emergency medicine, medication error, pediatric dosing error, drug dosage calculation, computer-assisted calculation

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Introduction

Children are especially vulnerable to medication errors, particularly dosing errors resulting from inaccurate weight measurements or incorrect weight-dependent calculations.[1-4] Moreover, the emergency department is one area of health care most prone to medication errors in prescribing, transcription, administration, and monitoring.[5-7] Studies have identified prescribing errors in 10% to 30% of the charts[8,9] and a higher rate of errors

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among residents with less experience, with an especially high rate of errors at the beginning of the academic year. The most seriously ill patients are more likely to be subjected to prescribing errors.[8,9]

A variety of methods have been established to reduce the occurrence of these medication errors in pediatric emergency medicine. The pediatric code card and Broselow Pediatric Emergency Tape (BPET) are some of these tools, and various studies have found that both enable health care personnel to provide weight-based drug doses and determine endotracheal tube sizes more accurately than did their peers without access to the cards.[10,11] However, they are inferior in terms of administration speed and accuracy compared with other calculation-free methods.[12] A study of computer-calculated dosing found that this method was the sole variable contributing to the reduced error rate (adjusted relative risk = 0.436, 95% confidence interval [CI] 0.336-0.520, $P < .001$).[13]

Our center, the emergency department at Ramathibodi Hospital, a tertiary care hospital in Bangkok, Thailand with junior doctors, nurses, paramedics, and emergency care personnel, experiences roughly 6000 pediatric visits per year. In this hospital, evaluation and treatment often depend on emergency physicians and trainees, and paramedics in charge of prehospital care management. We included paramedics in our study because although we have medical directors, the law allows prescription of emergency drugs by paramedics in some emergency situations.

Although no study of medication errors has been conducted in our center, it can be assumed that the hospital's error rate is not inferior to those found in other studies.[8,9,14-16] This study primarily aimed to assess the effects of using computer-assisted methods to more accurately calculate doses of emergency medicines in pediatric patients.

Methods

Study Design

This study was designed as a randomized crossover experimental study. Participating prescribers were 20 emergency medicine residents and 14 paramedics at the Department of Emergency Medicine in Ramathibodi Hospital, a university-affiliated super tertiary care hospital in Bangkok, Thailand. The participants were presented with paper-based written exercises (Appendix A) in which they were to respond to specific scenarios for drug dosing calculations using either conventional or computer-assisted methods. A block randomization scheme was employed to randomize both emergency residents and paramedic students into 2 groups. One group used the conventional method first, while the other group used the computer-assisted method first. Participants in each group then returned in the next 7 to 14 days to repeat the scenarios using the other method. All participants consented to participation after the methods of the study were discussed.

The conventional method involved calculating dosages using a calculator, books/Internet search, or chart for dosages and prescriptions. The computer-assisted method for dosing calculation involved a spreadsheet program pre-loaded with dosage formulas and a blank block for individual body weight to instantly calculate dosage. All participants were trained on use of the spreadsheet.

The data record form included names of medication, dosages, and routes of treatment as prescribed in real-world hospital settings. Prescriptions that were clearly incorrect by clinical indication were excluded.

Study Size Estimation

We used STATA Version 16.0 analysis software to calculate the sample size with 2 independent proportion formulas. The assumptions follow: alpha = 0.05 (2-sided test), power of sample size = 0.8, and the ratio of sample size = 1:1. A sample size of 113 in each group was obtained.[13]

Statistical Analysis

Data from the data record form were recorded in Numbers for MacOS program version 5.1 and analyzed using STATA Version 16.0. The comparison of corrected doses was done using logistic regression analysis and presented as numbers and percentages. The comparison of calculated time was done using quantile regression analysis and presented as medians with interquartile ratios.

Ethical Approval and Informed Consent

This study was approved by the Office of The Committee for Research, Faculty of Medicine Ramathibodi Hospital Mahidol University (COA. MURA2019/528). Informed consent was obtained from all participants.

Results

Between October and November 2018, participating prescribers responded to 4 paper-based case scenarios that resulted in 562 prescriptions. These included 336

Table 1. Participant Characteristics.

	Computer-assisted method first	Conventional method first
Age, years		
Emergency medicine residents	28	27.6
Paramedics	22.5	24.29
Experience in emergency department (0-3 years/more than 3 years)		
Emergency medicine residents	6/4	5/5
Paramedics (0-3 years/more than 3 years)	6/0	8/0
Roles/prescriptions		
Emergency medicine residents	10 (29.4%)	10 (29.4%)
Paramedics	6 (17.6%)	8 (23.5%)

Abbreviation: PALS, pediatric advanced life support.

Table 2. Calculation Accuracy Rate by Conventional and Computer-Assisted Methods.

Drug type	Accuracy rate using conventional method (N = 280)	Accuracy rate using computer method (N = 280)	*P*-value
PALS drugs	67.26% (113/168)	91.17% (153/168)	<.001
Sedative drugs	46.15% (48/104)	86.54% (90/104)	<.001
Paralytic drugs	12.5% (1/8)	87.5% (7/8)	.003
All drugs	57.86% (162/280)	89.29% (250/280)	<.001

Abbreviation: PALS, pediatric advanced life support.

Table 3. Calculation Time Using the Conventional Method and the Computer-Assisted Method.

Drug type	Calculation time, conventional method (seconds), median (IQR)	Calculation time, computer method (seconds), median (IQR)	*P*-value
PALS drug	47 (31, 80)	25 (19, 33)	<.001
Sedative drugs	47.5 (30.5, 91.5)	25 (16.5, 35)	<.001
Paralytic drugs	46 (36, 63)	15 (12, 22.5)	.012
All drugs	47 (31, 82.5)	25 (18, 33)	<.001

prescriptions (59.79%) from 20 emergency medicine residents (58.8%), and 224 prescriptions (39.86%) from 14 paramedics (41.10%). Two prescriptions (0.36%) were excluded from the analysis because they displayed the wrong indications, which left an analysis set of 560 prescriptions. Table 1 shows the characteristics of the participants in the dosing scenarios, participants ages, roles, and experiences in both groups were no statistical differences ($P < .001$).

Table 2 shows the accuracy of dosage calculation using conventional and computer-assisted methods. All medications were more accurately calculated with the computer-assisted method than with the conventional method, at 89.29% and 57.86%, respectively ($P < .001$).

Table 3 shows the time elapsed from drug identification to the prescription using both methods. The computer-assisted method showed shorter time elapsed than did the conventional method for both PALS drugs and sedative drugs.

We likewise compared paramedics and emergency residents in terms of dosage accuracy and time spent on the prescriptions. Paramedics prescribed accurately 38.89% of the time with the conventional methods versus 85.71% of the time with the computer-assisted method ($P < .001$), while residents did so accurately 70.83% of the time with the conventional methods versus 91.67% of the time with the computer-assisted method ($P < .001$). In addition, the median speed of calculation with the computer-assisted method was shorter than with the conventional method for both paramedics and residents (81 vs 31 seconds and 38 vs 20 seconds, respectively). These results reveal that both participant groups made faster and more accurate prescriptions using computer-assisted means than conventional methods ($P < .001$).

Discussion

Our study presents the results of medication dosing errors calculated with a computer-assist method compared to conventional methods. We found that the accuracy of dosing and time to prescription were significantly better using the computer-assisted method, for both emergency medicine trainees (with a reduction in error rate was from 29.17% to 8.33%) and paramedics (reduction from 61.61% to 14.29%). These results are compatible with the findings of previous studies. Murray et al[17] studied 46 372 pediatric patients' visits and found that the number of medication errors decreased significantly after introduction of calculator-based methods. In addition, Kirk et al[13] found that the computer-calculated dose error rate was 12.6% compared with the traditional prescription error rate of 28.2%, and logistical regression analysis showed that a computer-calculated dose was an important and independent variable influencing the error rate (adjusted relative risk = 0.436, 95% CI 0.336-0.520, $P < .001$). Because a large number of previous studies have showed deficiencies of Boslow tape as weight estimation and medication dosing tools,[12] the computer-assisted method has been proposed as a better option to increase patient safety via medication accuracy.[18,19]

In addition, our results showed that the computer-assisted method improves the prescribing speed and accuracy of paramedics, which should offer justification for Thai practice guidelines to advance our offline protocol and add computer-assisted drug calculation method for paramedics in prehospital emergent care. In 2018, the Health & Care Professions Council recommended legislation allowing paramedics who had undertaken prescribing program training to be able to prescribe supplementary medications. Additionally, Edwards et al[20] proposed best practices for allowing paramedics to independently prescribe medications, and the countries that have insufficient health care personnel should consider using this strategy.

Limitations

Our study employed paper-based scenarios rather than real patients in emergency situations. This might not have captured the effects of stress and emotion in decision-making as would a real situation with actual patients in an emergency department. This design was chosen because our center handles on average 2 pediatric critical cases per day, meaning that the long period of time (over 1 year) required to compile sufficient prescriptions for analysis would have made it impossible to maintain the randomization method. We minimized this limitation by preparing scenarios based on the most common cases found in Thai emergency departments.

Conclusion

In conclusion, the computer-assisted method for calculating dosages provides advantages over the conventional method in reducing prescription errors and calculation time, regardless of whether it is used by emergency medicine residents or paramedics.

Appendix A. Paper-based Scenarios

Scenario 1. A 3-year-old boy presented with drowsiness. At arrival in the ED, the child had no pulse. The EKG showed asystole, and high-quality CPR was initiated. Answer the following questions.

- Which medication will you choose? Specify dose and route.
- If the patient had persistent VT (more than 3 times), which medication would you use? Specify dose and route.
- After ROSC, the child had capillary blood sugar at 34 mg/dL. What medication will you give him? Specify dose and route.

Scenario 2. A 6-year-old girl presented with progressive dyspnea that had persisted for 3 days. She had been coughing with plaque. Upon arrival at the ED, she had a respiratory rate of 32/minutes with 88% oxygen saturation. Examination of the lungs showed wheezing bilaterally. Nebulizer medicine was given without improvement.

- What medication will you use for induction and paralysis of this patient? Specify medications, doses, and routes.
- After intubation, the patient had EKG showing bradycardia with hypotension. What medication will you give her? Specify dose and route.

Scenario 3. A 7-year-old boy presented with palpitations lasting 3 hours. The EKG showed SVT.

- What medication will you give him for tachycardia? Specify the dose and route.

After his heart rate returned to normal, he started to become agitated. What medication will you give him? Specify the dose and route.

Author Contributions

NC Contributed to interdrafted manuscript; critically revised; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.
PP Contributed to conception and design; acquisition; analysis; interpretation; interdrafted manuscript; critically revised; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.
CK Contributed to conception and design; acquisition; analysis; interpretation; interdrafted manuscript; agrees to be accountable for all aspects of work ensuring integrity and accuracy.
CY Contributed to conception and design; agrees to be accountable for all aspects of work ensuring integrity and accuracy.
YS Contributed to conception and design; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.
CA Contributed to gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.
PA Contributed to conception and design; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

Declaration of Conflicting Interests

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