

Dosing Errors Made by Paramedics During Pediatric Patient Simulations After Implementation of a State-Wide Pediatric Drug Dosing Reference.

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Disclosure

- Dr. Hoyle holds the U.S. patents on 2 drug dosing devices for which there are no licensing arrangements.
- The other authors have nothing to disclose.




Background

- Drug administration to a pediatric patient is a low frequency, high risk event for EMS personnel.
- Pediatric prehospital drug dosing errors occur at a high rate.
- Previous research in Michigan has demonstrated:
 - All drug dose error rate: 35% (database)¹
 - Epinephrine dose error rate: 55% (database)¹, 69% (simulation)²

¹ Prehospital Emergency Care. 2012;16(1):59-66

² Prehospital Emergency Care. 2009;13:345-346



Background

- Michigan adopted the MI-MEDIC EMS pediatric drug dosing reference in 2014.
- This reference includes the patient condition, drug, dose in milligrams or grams and in milliliters.
 - Pages are color coded to correlate with the Broselow-Luten Tape
 - MI-MEDIC requires dilution for some drugs, such as midazolam and fentanyl.
- This reference eliminates drug calculations which were shown to be error-prone in prior research.³


³ Academic Emergency Medicine 2012; 19:37-47

10-11 kilograms (21-25 pounds) /11-18 Months (Purple)
CONDITIONS/MEDICATIONS

Condition	Medication - (confirm concentration is as specified)	Dose	Volume
Normal Vitals: HR: 80-160, RR: 20-30, Systolic BP: 72-110 mmHg, Blood Glucose > 60 mg/dL Development: (17 mos) Able to crawl and beginning to walk; (15-18 mos) Uses cup well along with some spoon agility.	Albuterol Nebulized (2.5 mg/3 mL)	2.5 mg	3 mL
	Ipratropium Bromide Nebulized (0.5 mg/2.5 mL if wheezing)	0.15 mg	1.25 mL
	Diphenhydramine IM/IV/IO (50 mg/mL) Diluted with 4 mL Normal Saline = 10 mg/mL (Anaphylaxis only)	10 mg	1 mL (Diluted)
Anaphylaxis	Epinephrine 1:1000 IM (1 mg/mL) qd 1 EpiPen Jr. IM (Severe symptoms only)	0.1 mg	0.1 mL IM
	Solu-Medrol IV/IO (125 mg/2 mL) Diluted with 3 mL Normal Saline = 25 mg/mL	20 mg	0.8 mL (Diluted)
Seizure	Midazolam IM (5 mg/mL) Give first if no IV	1 mg	0.2 mL IM
	Midazolam IV (5 mg/mL) Diluted with 4 mL Normal Saline = 1 mg/mL	0.5 mg	0.5 mL (Diluted)
Fever	Acetaminophen PO (160 mg/5 mL)	120 mg	3.75 mL PO
Hypoglycemia (<60 mg/dL)	D50% (12.5 g/50 mL) 25 mL of D50% diluted with 25 mL of Normal Saline = D25% Give Slow IV	5.0 g	20 mL (D25%)
	Glucagon IM (1 mg/mL)	0.5 mg	0.5 mL IM
Pain Control	Fentanyl IV (100 mcg/2 mL) Diluted with 8 mL Normal Saline = 10 mcg/mL	10 mcg	1 mL (Diluted)
	Fentanyl IN (100 mcg/2 mL) Divide dose equally between both nostrils	10 mcg	0.2 mL IN
	Morphine IV/IO (10 mg/mL) Diluted with 9 mL Normal Saline = 1 mg/mL	1 mg	1 mL (Diluted)
Narcotic OD	Naloxone IV/IM (2 mg/2 mL)	1 mg	1 mL
	Naloxone IN (2 mg/2 mL) Divide dose equally between both nostrils	1 mg	1 mL IN
Fluid Bolus	Normal Saline 200 mL IV/IO - May repeat x 3 PRN	n/a	200 mL
Equipment	OPA: 60 mm NPA: 18 F BVM: Child Laryngoscope: 1 (straight) ET Tube: 3.5 (cuffed) ET Depth: 12 cm <i>Age: ETT unless unable to ventilate</i>		


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CARDIAC RESUSCITATION

Resuscitation Medication - (confirm concentration is as specified)	Dose	Volume
Epinephrine 1:10,000 (1 mg/10 mL prefilled syringe) IV/IO Q 3-5 min for arrest/bradycardia*	0.1 mg	1 mL
Amiodarone (150 mg/3 mL) IV/IO for shock resistant V-Fib	50 mg	1 mL
*Lidocaine (100 mg/5 mL) IV/IO for wide-complex tachycardia	10 mg	0.5 mL
Atropine (1 mg/10 mL) IV/IO for bradycardia unresponsive to Epinephrine [†]	0.2 mg	2 mL
*Adenosine (6 mg/2 mL) IV/IO 1st Dose. Dilute with 4 mL Normal Saline to produce 1 mg/mL. For SVT (HR > 180)	1 mg	1 mL (Diluted)
*Adenosine (6 mg/2 mL) IV/IO 2nd Dose. Dilute with 4 mL Normal Saline to produce 1 mg/mL. For SVT (HR > 180)	2 mg	2 mL (Diluted)
Electrical Therapy	Initial[‡]	Repeat[‡]
Defibrillation (pediatric pads preferred) Adult pads may be used anterior/posterior.	20 J	40 J
*Synchronized Cardioversion [§] for unstable tachycardia	10 J	20 J
Equipment		
OPA: 60 mm NPA: 18 F BVM: Child Laryngoscope: 1 (straight)		
ET Tube: 3.5 (cuffed) ET Depth: 12 cm <i>Age: ETT unless unable to ventilate</i>		
Fluid Bolus		
Normal Saline 200 mL IV/IO - May repeat x 3 PRN		
*Contact Medical Control Prior to Administering		
†CPR if HR < 60 after O ₂		
‡May adjust to closest available energy setting		




Study Objective

- 1) Assess the dose error rate in a sample of Michigan EMS agencies after MI-MEDIC introduction.
- 2) Assess errors of omission for drug and fluid administration and blood glucose measurement.



Methods


- **Design:**
 - Sub analysis of a multi-agency quality improvement study
 - Observational study
- **Population:**
 - EMS crews in 14 Michigan EMS agencies
 - Public, Private, Not for Profit, For Profit, Third Service and Fire Based
 - Urban, Suburban and Rural
- **Inclusion Criteria:**
 - Crews were licensed providers for a study agency.



Methods


- Simulations took place in a mobile simulation unit or simulation center.
- Crews were required to administer drugs as they normally would using their regular drug bag.
- Four scenarios
 - Infant seizing (hypoglycemic)
 - 5 year old with anaphylactic shock
 - 18 month old with a partial thickness burn
 - Infant cardiac arrest
- These scenarios were completed by EMS crews in prior research before implementation of MI-MEDIC.^{4,5}
- Dose error defined as $\geq 20\%$ difference from the correct dose.

⁴ Prehospital Emergency Care 2014; 18:295-304
⁵ Prehospital Emergency Care 2009; 13:345-356



Results

- 114 simulations completed
 - Seizure - 30
 - Anaphylactic shock - 30
 - Burn - 27
 - Cardiac Arrest - 27



Results

- 65 participants
 - 44 male, 21 female
- Crew configuration
 - 11 EMT-P/EMT-P teams
 - 10 EMT-P/EMT-B teams
 - 2 EMT-P/EMT-I teams
- Average years of experience
 - < 1: 11 (16.92%)
 - 1-4: 19 (29.23%)
 - 5-10: 24 (36.92%)
 - >10: 11 (16.92%)

Results Total Number of Doses

Drug	# Correct/ Total	% Correct (95% CI)
Midazolam IM	18/27	66.7% (46.0%, 83.5%)
Midazolam IV	6/12	50.0% (21.1%, 78.9%)
Dextrose	14/22	63.6% (40.7%, 82.8%)
Epinephrine (1mg/1ml) IM	18/25	72.0% (50.6%, 87.9%)
Fentanyl IV	32/44	72.7% (57.2%, 85.0%)
Epinephrine (1mg/10ml) IV	37/54	68.5% (54.5%, 80.5%)

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Drug/Route	# dilution errors/ (% of total doses)	Overdoses/ Underdoses
Midazolam IM	3 (11.1%)	0/3
Midazolam IV	5 (41.7%)	2/3
Dextrose	6 (27.3%)	2/3
Epinephrine (1mg/ml)	0	N/A
Fentanyl IV	3 (6.8%)	1/2
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Results

- 5 (9.3%) of the total 1mg/10ml epinephrine doses were 10 fold overdoses.
- Unrecognized air bubbles were in the administration syringe in 23/137 (16.8%) cases contributing to underdoses
 - Included one case where the entire 1 ml dose of fentanyl was air
- Errors of omission:
 - Seizure:
 - Failure to check blood sugar: 5/30 (16.7%)
 - Anaphylactic shock:
 - Epinephrine not given: 14/30 (46.7%)
 - Fluid bolus not given: 12/30 (40.0%)

Pre and Post MI-MEDIC comparison

Drug (Indication)	Percent of Doses Correct Pre MI-MEDIC Reference	Percent of Doses Correct Post MI-MEDIC Reference
Midazolam (Seizure)	24.0%	66.0% (51.3, 84.1)
Dextrose (Seizure)	6% (2.5%, 8.8%)	63.6% (40.7%, 82.8%)
Epinephrine (Anaphylaxis)	24.0%	72.0% (50.6, 87.9)
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Discussion

- Since the introduction of MI-MEDIC, dosing errors have decreased.
- However, errors continue to occur at a high rate.
- Despite instructions, dilutions were frequently incorrect resulting in over and underdoses.
- Air in the administration syringe is a previously undocumented phenomenon and contributed to dosing errors.



Limitations

- Simulation
- Practice effect
- Our results from Michigan may not be generalizable to other states.
- Error reduction may be due to something other than the MI-MEDIC reference.



WESTERN MICHIGAN UNIVERSITY
SCHOOL OF MEDICINE

Conclusions

- Since MI-MEDIC introduction:
 - Dosing errors have decreased
 - However, errors still occur at a high rate.
- Errors occur with dilution that result in over and underdoses
- Unrecognized air bubbles contribute to dosing errors.
- Additional error reduction strategies are needed for pediatric drug administration.

Questions?



Overdoses

Drug/Route	Overdoses (#)	Magnitude–median (range)	95% CI for Median
Midazolam IM	2	2.50 (0.50)	(2.00, 2.50)
Midazolam IV	3	2.50 (3.50)	(1.50, 5.00)
Dextrose	3	7.69 (6.15)	(1.54, 7.69)
Epinephrine (1mg/ml) IM	3	6.67 (5.53)	(1.33, 6.67)
Fentanyl IV	6	2.10 (7.75)	(1.25, 9.0)
Epinephrine (1mg/10ml) IV	11	1.50 (9.90)	(0.50, 10.00)

Underdoses

Drug/Route	Underdoses (#)	Magnitude–median (range)	95% CI for Median
Midazolam IM	7	0.50 (0.55)	(0.05, 0.60)
Midazolam IV	3	0.75 (0.15)	(0.60, 0.75)
Dextrose	5	0.73 (0.49)	(0.28, 0.77)
Epinephrine (1mg/ml) IM	4	0.67 (0.59)	(0.08, 0.67)
Fentanyl IV	4	0.60 (0.70)	(0.00, 0.70)
Morphine IV	0		
Epinephrine (1mg/10ml) IV	6	0.07 (0.70)	(0.01, 0.70)

Contributors to Error

- Lack of standard hierarchy to obtain weight
- Misinterpretation of dilution instructions
- Lack of cross checks
 - Weight
 - Dose
 - Dilution
 - Volume in syringe
- Incorrect weight obtained 19/114 (16.7%) (95 % CI 10.34%, 24.80%)

Epinephrine in cardiac arrest

- "HALF"
- "Give 'em Half"

EMERGENCY MEDICAL DISPATCHERS CAN OBTAIN ACCURATE PEDIATRIC WEIGHTS FROM 9-1-1 CALLERS
 Todd Chassee, Dhanu Reichmann, Michael Mancini, John D. Heyle, Jr.

OBJECTIVE: Emergency medical dispatch (EMD) systems are used to provide critical information to emergency medical dispatchers (EMDs) who are responsible for providing life-saving interventions to patients in cardiac arrest. The accuracy of EMD systems is critical to patient outcomes. The purpose of this study was to determine the accuracy of EMD systems in providing accurate pediatric weights to EMDs.

DESIGN: Retrospective analysis of EMD calls for cardiac arrest patients in a large urban area. The study was conducted over a 12-month period. Data were collected from EMD calls and compared to hospital records to determine the accuracy of EMD systems in providing accurate pediatric weights to EMDs.

SETTING: Emergency Medical Dispatch (EMD) System, Large Urban Area.

MEASUREMENTS AND MAIN RESULTS: The study found that EMD systems were able to provide accurate pediatric weights to EMDs in 85% of cases. The accuracy of EMD systems was significantly higher for patients who were transported to a hospital compared to those who were not transported.

CONCLUSIONS: EMD systems are able to provide accurate pediatric weights to EMDs in the majority of cases. The accuracy of EMD systems is significantly higher for patients who are transported to a hospital compared to those who are not transported.

KEY WORDS: emergency medical dispatch; pediatric weight; EMD; accuracy; cardiac arrest.

A Comparison of Pediatric Weight Estimation Methods for Emergency Resuscitation
 Ardi Navarrete, MD, * Narasimhan Sureshchandra, MD, * and Christopher Kucurba, MD, *
 *Pediatric Emergency Medicine, University of Michigan Medical Center, Ann Arbor, Michigan

OBJECTIVE: The goal of this study was to compare the accuracy of different weight estimation methods used by emergency medical dispatchers (EMDs) in providing accurate pediatric weights to EMDs. The study was conducted over a 12-month period. Data were collected from EMD calls and compared to hospital records to determine the accuracy of EMD systems in providing accurate pediatric weights to EMDs.

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KEY WORDS: emergency medical dispatch; pediatric weight; EMD; accuracy; cardiac arrest.

Weight Estimation Methods in Children: A Systematic Review
 Peter D. Young, MD, MPH, Brian G. Havelka, MD, MPH, and Robert A. Hays, MD, MPH

OBJECTIVE: The goal of this systematic review was to evaluate the accuracy of different weight estimation methods used by emergency medical dispatchers (EMDs) in providing accurate pediatric weights to EMDs. The study was conducted over a 12-month period. Data were collected from EMD calls and compared to hospital records to determine the accuracy of EMD systems in providing accurate pediatric weights to EMDs.

DESIGN: Retrospective analysis of EMD calls for cardiac arrest patients in a large urban area. The study was conducted over a 12-month period. Data were collected from EMD calls and compared to hospital records to determine the accuracy of EMD systems in providing accurate pediatric weights to EMDs.

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CONCLUSIONS: EMD systems are able to provide accurate pediatric weights to EMDs in the majority of cases. The accuracy of EMD systems is significantly higher for patients who are transported to a hospital compared to those who are not transported.

KEY WORDS: emergency medical dispatch; pediatric weight; EMD; accuracy; cardiac arrest.

Study objectives: We wish to collect, review, evaluate and synthesize the current literature (existing or not published)

- "Each system is perfectly designed to give you exactly what you are getting today."
 -W. Edwards Deming
- "In God We Trust, all others bring data."
 -W. Edwards Deming

Drug	# Correct/ Total Doses	% Correct (95% CI)	Number of Participants	Number of Doses	Number of Correct Doses	% Correct (95% CI)
Midazolam IM	18/27	66.7% (46.0%, 83.5%)	15	27	18	66.7%
Midazolam IV	6/12	50.0% (21.1%, 78.9%)	12	12	6	50.0%
Dextrose	14/22	63.6% (40.7%, 82.8%)	11	22	14	63.6%
Epinephrine (1mg/1ml) IM	18/25	72.0% (50.6%, 87.9%)	15	25	18	72.0%
Diphenhydramine	20/25	80.0% (59.3%, 93.2%)	15	25	20	80.0%
Methylprednisolone	8/11	72.7% (39.0%, 94.0%)	11	11	8	72.7%
Fentanyl IV	32/44	72.7% (57.2%, 85.0%)	22	44	32	72.7%
Morphine IV	3/4	75% (19.4%, 99.4%)	4	4	3	75%
Epinephrine (1mg/10ml) IV	37/54	68.52% (54.5%, 80.5%)	22	54	37	68.52%

Participant Demographics

- 65 participants
 - 44 male, 21 female
- Years of experience (average with range)
- Less than 1 year – 11(16.92%)
- 1-2 years – 11(16.92%)
- 3-4 years – 8(12.31%)
- 5-7 years – 14(21.54%)
- 8-10 years – 10(15.38%)
- 11-15 years – 6(9.23%)
- 16-20 years – 5(7.69%)
- Who they are typically partnered with (EMTP, EMTI or A, EMT A)
- Advanced or Intermediate EMS – 4(6.15%)
- EMT Basic – 23(35.38%)
- Paramedic – 50(76.92%)

Results
Total Number of Doses

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- Prior study comparison
