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Assessing Pediatric Intensive Care Unit Mattress Compressibility with a Standard Backboard and Real-time Feedback: A simulation-based study

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Backgrounds

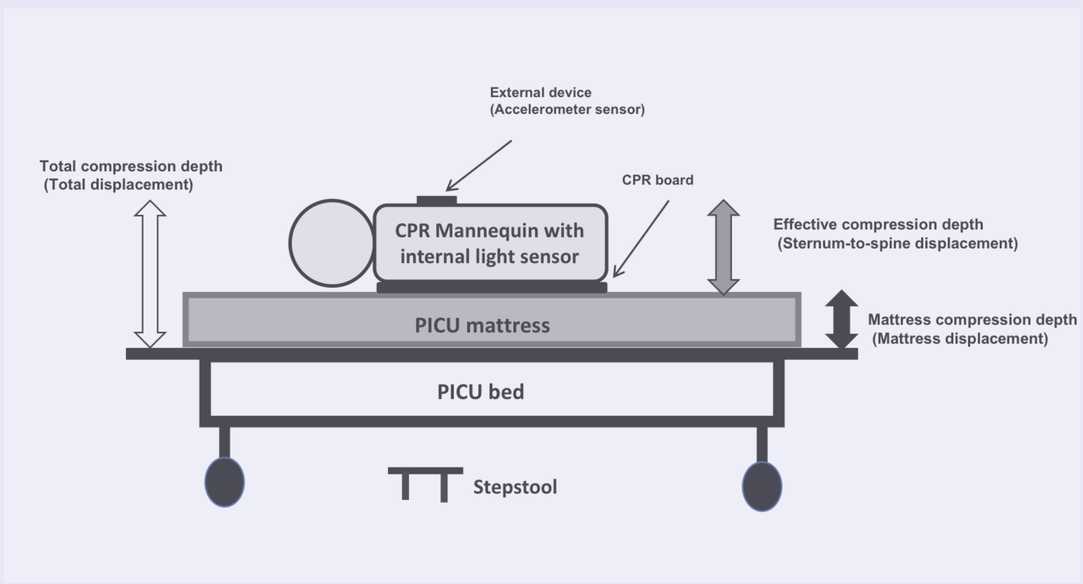
- The depth of chest compressions (CC) during cardiac arrest is associated with patient survival and neurological outcomes. [1-3]
- Mattress compression can reduce the proportion of CCs given with adequate depth due to increased vertical hand movement and fatigue. [4,5]
- The use of CPR backboard and mattress firming technology partially attenuate the mattress compressibility. [6,7]
- Real-time feedback using single force and deflection sensor fails to adjust mattress compressibility and may overestimate compression depth when CPR is performed on a mattress. [5]

Objectives

1. Quantify the amount of depletion when cardiopulmonary resuscitation (CPR) is performed on 2 different PICU mattresses, with or without use of backboard;
2. Explore factors (i.e. mattress type, use of backboard) associated with mattress compression depth;
3. Explore the effect of feedback sources on effective compression depth by PICU healthcare providers.

Methods

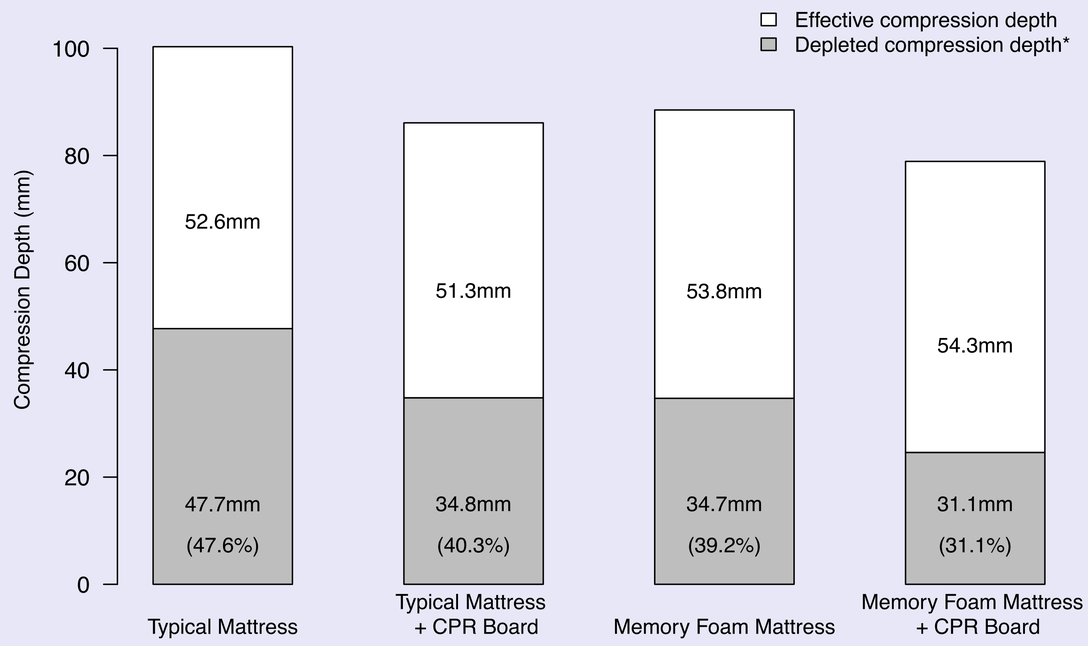
- Simulation used as method of investigation
- Participants: CPR certified Pediatric Intensive Care Unit (PICU) providers
- Simulation Settings
  - Bed height (Hill-Rom 1000™ Medical Surgical Bed, 75cm)



- Outcome Measures
  - Total compression depth: external accelerometer sensor (Laerdal CPR Meter™)
  - Effective compression depth: Internal light sensor (Laerdal Resusci Anne QCPR™ + SIMPad SkillReporter)
  - Mattress compression depth = Total compression depth – Effective compression depth
- Procedures
  - Participants perform 1 min chest compression in following scenarios in random order
    - Typical PICU mattress (Advance 1000™ foam)
    - Typical PICU mattress + CPR board
    - Memory foam PICU mattress (Hill-Rom Accumax Quantum™ VPC)
    - Memory foam PICU mattress + CPR board
  - Repeat each scenario with 2 different sources of feedback
    - Accelerometer sensor
    - Internal light sensor
- Sample size estimation: n = 16
- Statistical analysis: multi-level linear regression model

Results

- Amount of chest compression depletion



*Percentage represents proportion of depleted compression depth over total compression depth

- Effect of foam mattress and use of backboard on depleted depth

	Mean (95% confidence interval), mm			
Depleted depth	No backboard	Backboard	Backboard benefit	Backboard mean benefit main effect
Typical PICU mattress	47.9 (40.5, 55.3)	34.6 (28.6, 40.7)	13.3 (10.6, 15.9)	11.6 (9.0, 14.3)
Typical PICU memory foam mattress	34.6 (28.6, 40.7)	24.6 (22.5, 26.7)	10.0 (7.4, 12.7)	
New mattress benefit	13.3 (6.4, 20.2)	10.0 (3.2, 16.9)	NA	NA
New mattress mean benefit main effect	11.7 (4.8, 18.5)		NA	NA

- Effect of feedback source on effective compression depth

Effective compression depth	Mean (95% confidence interval), mm Source of Feedback		
	Anterior sensor	Internal measure	Difference
Typical PICU mattress only	37.8 (34.1, 41.5)	52.1 (50.1, 54.1)	14.3 (12.0, 16.5)
Typical PICU mattress + backboard	42.9 (39.5, 46.3)	51.7 (49.8, 53.5)	8.7 (6.5, 11.0)
PICU memory foam mattress only	41.2 (37.9, 44.4)	54.2 (52.3, 56.1)	13.0 (10.7, 15.3)
PICU memory foam mattress + backboard	46.3 (43.2, 49.3)	53.7 (52.0, 55.5)	7.5 (5.2, 9.8)

Conclusions

- Chest compression depth is significantly depleted when CPR is performed on a PICU mattress.
- Mattress firming technology should be considered for patient with high risk of cardiac arrest.
- A CPR board should always be used when managing patient with cardiac arrest.
- When real-time feedback is used, healthcare providers should consider devices that measure sternum-to-spine displacement to improve effective compression depth.
- CPR training should allow healthcare providers to practice chest compressions with real-time feedback on the mattress that patients are typically placed on in their relevant clinical unit.

References

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