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SHORT REPORT

Quantifying force application to a newborn manikin during simulated cardiopulmonary resuscitation

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Abstract

Objective: To assess utility of the FingerTPS™ system in measuring chest compression (CC) rate and force.
Methods: Five minutes of CC was performed in a neonatal manikin without ($n = 29$) and with ($n = 30$) a metronome. The FingerTPS™ force (lbs.) was compared to pressure (mmHg) in a 50-mL normal-saline bag inside the manikin. FingerTPS™ CC rate and the time until a 20% decline from baseline force and pressure were calculated.
Results: The normal-saline pressure declined earlier than the FingerTPS™ force. Metronome use did not influence CC rate, force or pressure.
Conclusions: The FingerTPS™ can be used to measure CC rate and force.

Keywords

Chest compression, fatigue, neonatology, quality

History

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Introduction

Both insufficient and excessive force application during neonatal chest compressions (CCs) can negatively influence outcomes after cardiopulmonary resuscitation (CPR) [1]. The FingerTPS™ system (Pressure Profile Systems (PPS), Los Angeles, CA) was developed for analyzing the force (lbs.) exerted on an object during gripping. The system consists of 2-mm-thin force sensors that can be placed on the fingers or in the palm of the hand. It has been used in surgical research and training, and in sports sciences [2]. In this study, we aimed to test the utility of the FingerTPS™ technology in monitoring CC rate and force application over time during neonatal CC.

Audible tone guidance has been used to maintain adequate CC rate during simulated neonatal CPR [3–5]. In addition to measuring whether the FingerTPS™ could measure CC rate and catch the variations in force application during a 5-min CC experiment, we aimed to investigate whether using a metronome would improve CC performance over time. We hypothesized that the FingerTPS™ could reveal changes in CC force over time. We also hypothesized that using a metronome would alleviate the fatigue effect on CC performance.

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Methods

Environment and subjects

This study was carried out at The Royal Alexandra Hospital, Edmonton, a tertiary perinatal center admitting approximately 1500 infants to the Neonatal Intensive Care Unit annually. The Northern Alberta Neonatal Program Research Committee and Health Ethics Research Board, University of Alberta approved the study. Neonatal Resuscitation Program (NRP) healthcare professionals were included after written informed consent.

Chest compressions

A neonatal manikin (Neonatal Resuscitation Baby, Laerdal Medical, Stavanger, Norway) was placed on an adjustable resuscitation incubator (Giraffe Incubator, General Electric Healthcare, Burnaby, Canada). The NRP providers performed CC on the manikin using the two-thumb method and focusing their thumb pressure at a 2.5 cm^2 FingerTPS™ palm sensor on the chest of the manikin. Five minutes of CC were performed at a rate of 90 min^{-1}, pausing for a simulated ventilation after every third CC. The participants were randomized (http://www.randomizer.org) to performing CC without ($n = 29$) or with ($n = 30$) a metronome set at a rate of 120 (90 CC and

30 simulated ventilations)/min. The participants were blinded to force and pressure tracings during the experiments.

Data collection

We strapped the FingerTPS™ palm sensor (PPS) around the manikin's chest at the lower third of sternum. The participants also wore one FingerTPS™ thumb sensor on each thumb. The sensors were calibrated according to the manufacturer's instructions. The force (lbs.) was recorded using the Chameleon software (PPS).

Within the manikin's chest, we placed a 50-mL normal-saline bag that was connected to a pressure transducer (Edwards Lifesciences Corp., Irvine, CA) connected to an IntelliVue MP50 monitor (Philips Healthcare, Philips Electronics Ltd., Markham, ON, Canada) [6]. The pressures (mmHg) were manually recorded every 12 s. The saline bag method for assessing CC efficacy was described in one of our previous papers [6].

Data processing and statistical analyses

The FingerTPS™ force data are distributed as peaks representing the force exerted with CC, and troughs representing the force applied to the sensor between CC. The trough values may provide information regarding residual leaning force during CPR. However, this was not a focus of the current study. A curve of best fit was estimated for the peak and trough values using the polyfit function of the MatLab software (The MathWorks, Inc., Natick, MA). We estimated the net force applied to the chest by subtracting the quadratic equation for the curve of best fit, $y = ax^2 + bx + c$, for the troughs from that of the peaks; ''c'' being the y-intercept of the line of best fit and ''x'' being a specific point of time (displayed on the x-axis). The median (interquartile range, IQR) of the mean CC rate, net force and pressure in each experiment was calculated.

As a measure of the fatiguing effect of performing CC, we calculated the median (IQR) time point where the force and pressure had declined by 20% from baseline. Experiments without and with a metronome, and the two measurement methods were compared with the Mann–Whitney U test.

Statistical analyses were performed in IBM SPSS Statistics 22 (IBM Corporation, Armonk, NY) and the MatLab software.

Results

From a simulated neonatal CPR study including 53 NRP providers, 29 FingerTPS™ recordings without and 30 with a metronome were selected for analysis. The thumb sensors generally recorded forces $\ll$10 lbs. Therefore, we used the palm sensor recordings for comparison to the normal-saline bag pressures. Three of the FingerTPS™ recordings without a metronome and six of the recordings with a metronome were excluded due to consistent measurements either >100 or $\ll$10 lbs. Thus, good quality force data from the FingerTPS™ palm sensor were available for 26 of 29 (90%) and 24 of 30 (80%) experiments, respectively.

CC rate

The median (IQR) FingerTPS™ CC rates without and with a metronome were 95 (86–105)/min and 92 (90–94)/min, respectively ($p = 0.13$).

Amount of force applied

The median (IQR) force and pressure without and with a metronome are presented in Table 1. There was neither a difference in the median force, nor in the median pressure in the full 5 min CC experiments without or with a metronome.

Consistence of CC force and pressure during 5 min of CC

There was no difference in the duration of CC before a 20% decline in force or pressure occurred without or with a metronome (Table 1). However, the 20% normal-saline pressure decline happened earlier than the 20% decline in the FingerTPS™ force ($p < 0.001$ and $p = 0.01$ without and with a metronome, respectively).

Discussion

In this study, we instructed NRP providers to perform CC to 1/3 of the anterior–posterior diameter of a newborn manikin's chest according to guidelines [7]. In the manikin we used, this equals about 35 mm, and a force of 14.3 lbs. is necessary to achieve a 40 mm deep CC (Laerdal Medical, personal communication). Our results indicate that the FingerTPS™ force measurements are within a reasonable to high range (Table 1) and that the FingerTPS™ detects significant force

Table 1. Group characteristics of the FingerTPS™ chest compression force and pressure measured within a normal-saline bag placed inside a neonatal manikin.

	Chest compression force (lbs.)			Chest compression pressure (mmHg)		
	Without metronome ($n = 29$)	With metronome ($n = 30$)	Difference*	Without metronome ($n = 29$)	With metronome ($n = 30$)	Difference*
Median (IQR) of each participant's mean	22 (11–25)	22 (14–52)	$p = 0.12$	26 (20–34)	27 (21–37)	$p = 0.61$
Median (IQR) time until a 20% decline from baseline (s)	241 (189–274)[a]	250 (182–300)[b]	$p = 0.40$	84 (54–102)[a]	144 (60–192)[b]	$p = 0.15$

IQR, interquartile range.
*p value indicates the comparison of median (IQR) without and with metronome.
[a]$p < 0.001$ for the comparison of the respective median (IQR) time of force and pressure decline.
[b]$p = 0.01$ for the comparison of the respective median (IQR) time of force and pressure decline.

changes later compared to the normal-saline system. However, we do not know which system displays a CC profile most close to the reality.

By subtracting the residual leaning force due to incomplete release of the chest between CC from the additional force applied with CC, the FingerTPS™ gives a more reliable measure of CC effect than methods that only measure the force or pressure peaks. The magnitude of the normal-saline bag pressures could therefore not be compared to the FingerTPS™ force. Also, the FingerTPS™ measures the focal force transmitted to a sensor pad, whereas the normal-saline bag system measures the diffuse pressure transmitted to 50 mL of fluid. Further, the normal-saline bag measures pressure transmission to the interior of the manikin, whereas the FingerTPS™ measures the force applied to the chest surface. We therefore focused our utility assessment on the force and pressure profiles.

The FingerTPS™ offers the opportunity for force-targeted rather than depth-targeted CC, a concept that has been investigated in adult CPR [8]. However, it is difficult to measure force application without interfering with CC performance. In addition to displaying the exact force including residual leaning, advantages of the FingerTPS™ therefore include the small size of the sensor, which can be applied to the chest of neonates of various gestations. To our knowledge, the smallest feedback device used in a published study is the CPRcard [9] measuring 55 mm × 85 mm × 1 mm, whereas the largest sensor pad in the FingerTPS™ system is 25 mm × 2 mm.

Although there was no difference in CC force without or with the use of a metronome, using a metronome helped deliver a rate slightly closer to target as per NRP guidelines. This is in agreement with Milander et al. [10].

Limitations of the study include that out of a larger CPR study, only a selection of recordings were suitable for performing the force analyses. Despite the theoretical possibility of converting force to pressure in different units, the normal-saline bag pressure could not be compared to the FingerTPS™ force in absolute numbers.

In conclusion, the FingerTPS™ gave reliable information about applied CC rate and force. The force profiles were somewhat displaced compared to the pressure profiles measured within the manikin. However, we do not know which profile most closely reflects the reality. The FingerTPS™ is potentially useful in teaching and training, as well as in clinical CPR by giving real-time feedback on CC rate and force. However, more research is needed.

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Declaration of interest

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References

1. Christman C, Hemway RJ, Wyckoff MH, et al. The two-thumb is superior to the two-finger method for administering chest compressions in a manikin model of neonatal resuscitation. Arch Dis Child Fetal Neonatal Ed 2011;96:F99–101.
2. Pressure Profile Systems. FingerTPS advanced hand and finger pressure sensor system. Available from: http://www.pressureprofile.com/fingertps [last accessed Apr 2015].
3. Cocucci C, Madorno M, Aguilar A, et al. A metronome for pacing manual ventilation in a neonatal resuscitation simulation. Arch Dis Child Fetal Neonatal Ed 2015;100:F47–9.
4. Roehr CC, Schmolzer GM, Thio M, et al. How ABBA may help improve neonatal resuscitation training: auditory prompts to enable coordination of manual inflations and chest compressions. J Paediatr Child Health 2014;50:444–8.
5. Dold SK, Schmolzer GM, Kelm M, et al. Training neonatal cardiopulmonary resuscitation: can it be improved by playing a musical prompt? A pilot study. Am J Perinatol 2014; 31:245–8.
6. Li ES, Cheung PY, O'Reilly M, et al. Rescuer fatigue during simulated neonatal cardiopulmonary resuscitation. J Perinatol 2015; 35:142–5.
7. Kattwinkel J, Perlman JM, Aziz K, et al. Part 15: neonatal resuscitation: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation 2010;122:S909–19.
8. Dellimore KH, Scheffer C. A modeling approach to the effects of force guided versus depth guided compression during cardiopulmonary resuscitation on different chests and back support surfaces. Resuscitation 2013;84:837–42.
9. Cheng A, Overly F, Kessler D, et al. Perception of CPR quality: influence of CPR feedback, just-in-time CPR training and provider role. Resuscitation 2015;87:44–50.
10. Milander MM, Hiscok PS, Sanders AB, et al. Chest compression and ventilation rates during cardiopulmonary resuscitation: the effects of audible tone guidance. Acad Emerg Med 1995;2: 708–13.