



Two new chest compression methods might challenge the standard in a simulated infant model

Emilio Rodríguez-Ruiz^{1,2} · Ainhoa Martínez-Puga³ · Aida Carballo-Fazanes² · Cristian Abelairas-Gómez^{2,4} · Antonio Rodríguez-Nuñez^{2,5,6}

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Abstract

Paediatric cardiorespiratory arrest is a rare event that requires a fast, quality intervention. High-quality chest compressions are an essential prognostic factor. The aim of this prospective, randomized and crossover study in infant manikin 2-min cardiorespiratory resuscitation scenario is to quantitatively compare the quality of the currently recommended method in infants (two-thumb-encircling hand techniques) with two new methods (the new two-thumb and the knocking-fingers techniques) using a 15:2 compression-to-ventilation ratio. Ten qualified health professionals were recruited. Variables analysed were mean rate and the ratio of compressions in the recommended rate range, mean depth and the ratio of compressions within the depth range recommendations, ratio of compressions with adequate chest release and ratio of compressions performed with the fingers in the correct position. Ratios of correct compressions for depth, rate, chest release and hand position were always above 70% regardless of the technique used. Reached mean depth and mean rate were similar to the 3 techniques. No statistically significant differences were found in any of the variables analysed.

Conclusion: In an infant manikin, professionals are able to perform chest compressions with the new techniques with similar quality to that obtained with the standard method.

What is Known:

- Quality chest compressions are an essential prognostic factor in paediatric cardiorespiratory arrest.
- It has been reported poor results when studied cardiorespiratory resuscitation quality in infants applying the recommended methods.

What is New:

- In a simulated scenario, quality of chest compressions performed with two new techniques (nTTT and KF) is similar to that obtained with the currently recommended method (TTHT).

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✉ Emilio Rodríguez-Ruiz
r.ruizemilio@gmail.com

Ainhoa Martínez-Puga
ainhoamp93@hotmail.com

Aida Carballo-Fazanes
aiduska19@hotmail.com

Cristian Abelairas-Gómez
cristianabelairasgomez@gmail.com

Antonio Rodríguez-Nuñez
antonio.rodriguez.nunez@usc.es

¹ Critical Care and Intensive Care Medicine Department., Xerencia de Xestión Integrada de Santiago de Compostela, SERGAS, University of Santiago de Compostela, C/Choupana s/n, 15706 Santiago de Compostela, A Coruña, Spain

² CLINURSID research group of the University of Santiago de Compostela and Life Support and Simulation research group of the Health Research Institute of Santiago (FIDIS), Santiago de Compostela, Spain

³ School of Nursery, University of Santiago de Compostela, 15705 Santiago de Compostela, A Coruña, Spain

⁴ School of Education Sciences, University of Santiago de Compostela, 15705 Santiago de Compostela, A Coruña, Spain

⁵ Paediatric Intensive Care Unit, University Clinical Hospital of Santiago de Compostela, SERGAS, University of Santiago de Compostela, Santiago de Compostela, A Coruña, Spain

⁶ Maternal and Child Health and Development Research Network SAMID-III, Institute of Health Carlos III, Madrid, Spain

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Abbreviations

CPR	Cardiopulmonary resuscitation
IQR	Interquartile ranges
KF	Knocking-fingers technique
nTTT	New two-thumb technique
SD	Standard deviations
TFT	Two-finger technique
TTHT	Two-thumb-encircling hand techniques

Introduction

Paediatric cardiac arrest is an uncommon event that requires fast and quality intervention to achieve short-term recovery and survival free of neurological sequels of the victim [3–5, 9, 13, 21].

It has been observed that the quality of chest compressions is usually insufficient in clinical practice, even when cardiopulmonary resuscitation (CPR) is performed by professionals with experience in paediatric care [24]. Among the reasons that explain this fact, stand out the low incidence of CRP in children, the lack of training and retraining of professionals, the lack of systems for monitoring the quality of manoeuvres and even the use of CPR manoeuvres that may not be the most appropriate [14, 22, 23, 27]. As in the adult, high-quality chest compressions are an essential prognostic factor so it should be a priority objective to choose a method that achieves the best possible organic perfusion during CPR.

Although paediatric CPR recommendations have continued to be updated according to the evidence available in recent years, methods of chest compressions in infants have remained unchanged, either because no new evidence has been obtained or because it has not been considered a priority research topic [1, 2, 7]. Thus, current international guidelines recommend both the two-finger technique (TFT) in newborns and infants, which would be preferable in the case of CPR performed by a single rescuer, and the two-thumb-encircling hand techniques (TTHT) for two rescuers [11]. However, recent studies have shown that the TTHT could be more effective than the TFT [6, 8, 12, 26] so it is now considered the reference technique.

Aiming to find ways to improve chest compressions quality in infants, new techniques have been described lately. Studied under simulated conditions, they have not meant a decrease in the quality of resuscitation with respect to the recommended techniques [10, 17–20]. Nevertheless, no studies have been published comparing CPR quality between these new techniques and the recommended one. This fact was the rationale to perform the present study, with the hypothesis that two new

chest compression techniques, when performed by paediatric professionals in a controlled simulated scenario, are at least not inferior to the currently recommended.

Materials and methods

The study was designed as a prospective randomized cross-over trial carried out in infant manikins (SimBaby™, Laerdal Medical, Stavanger, Norway, which tries to simulate a baby of about 3 months). The study was conducted in February 2018 (Fig. 1).

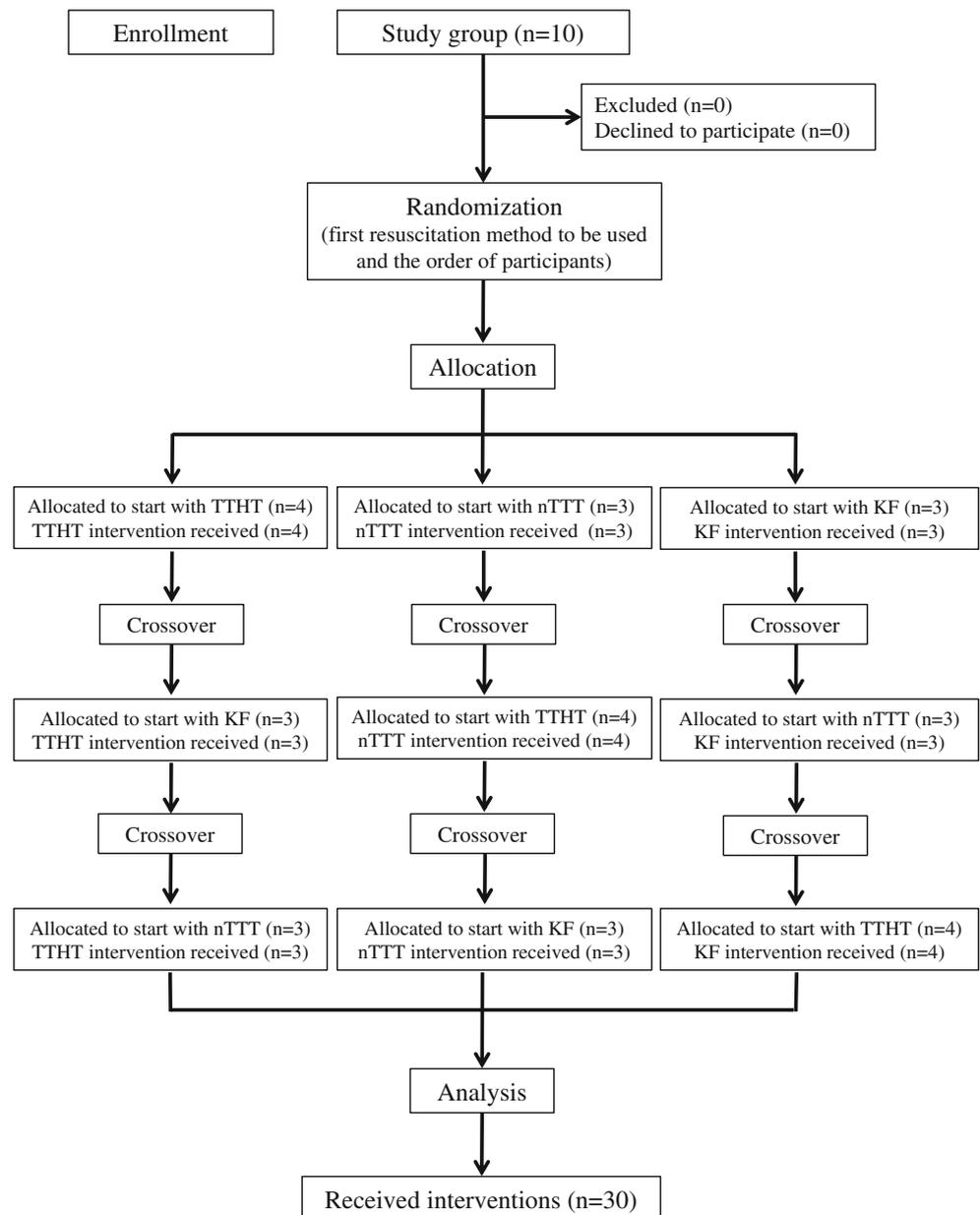
In this preliminary pilot trial, we included 10 health professionals with experience in the field of paediatrics from a university hospital. Prior to the study, all participants passed a paediatric advanced life support (EPALS) course in which they were evaluated quantitatively using the SimPad® system with SkillReporter™ (Laerdal Medical, Stavanger, Norway). Participation was voluntary, without receiving any financial compensation.

All the participants were familiar with the two-thumb-encircling hand techniques (TTHT) (Fig. 2) recommended by current paediatric CPR guidelines [15]. The new studied methods, the ‘new two-thumb technique’ (nTTT) (Fig. 3) and the ‘knocking-fingers’ (KF) technique (Fig. 4), were explained to each participant in a 20-min training session (10 min per protocol) allowing them to practice in a manikin with quality monitoring device for chest compressions.

Each participant performed three paediatric CPR tests with chest compression to ventilation ratio of 15:2. Each test lasted 2 min with a 30-min inter-test break to recovery. Chest compressions were performed using three different techniques in a randomized sequence as follows:

- Two-thumb-encircling hand techniques (TTHT) (Fig. 2): In this technique, both thumbs are placed over the lower third of the sternum, with the rest of the fingers encircling the rib cage and supporting the back.
- ‘New two-thumb technique’ (nTTT) (Fig. 3): This method consists in using both thumbs directed at an angle of 90° to the chest while closing the fingers of both hands in a fist [20–23].
- ‘Knocking-fingers technique’ (KF) (Fig. 4): It consists in stretching the metacarpophalangeal joint 180° from the dorsum of the hand, bending the proximal and distal interphalangeal joints 90°, placing the tip of the thumb against the palmar side of the middle phalanx of the index finger and performing the technique with the dorsal side of the middle phalanx of the index finger [24].

Fig. 1 Flowchart



Participants were exclusively in charge of chest compressions; ventilations were carried out by trained personnel foreign to the study to avoid bias with a self-inflating bag and mask of the appropriate size to the manikin.

Data on compressions were recorded with a SimBaby™ manikin with the SimPad® system with SkillReporter™ (Laerdal Medical, Stavanger, Norway). For each CPR sequence, mean compression rate, percentage of compressions with adequate rate, mean compression depth, percentage of compressions deep enough, percentage of full chest recoil and compressions with correct hands position were recorded. Moreover, we asked the participants their subjective perception about which of the techniques was easier and less

exhausting, evaluating the average difficulty perceived by a subjective scale of 1 (less difficulty) to 10 (greater difficulty).

Once the test was completed, demographic characteristics of the participants were also recorded.

All analyses were performed using SPSS Statistics version 21 software (SPSS Inc., Chicago, IL). Variables have been expressed through measures of central tendency and dispersion. Means and standard deviations (SD) were used for the demographic variables and medians and interquartile ranges (IQR) for the variables related to chest compressions. The Friedman test was used for the intra-group analysis, and for the pairwise comparison, the Wilcoxon signed-rank test. In all the analyses, a significance level $p < 0.05$ was used.

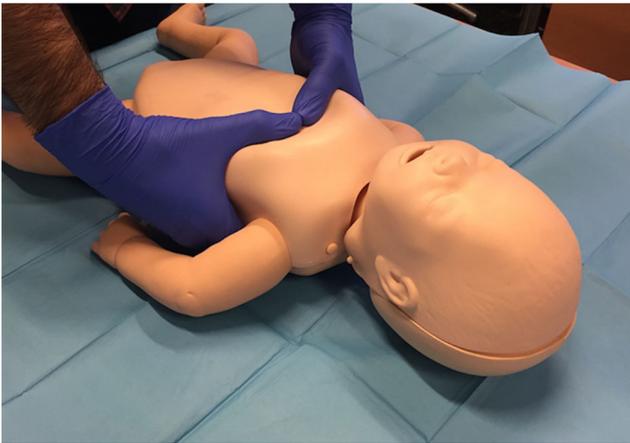


Fig. 2 Two-thumb-encircling hand techniques

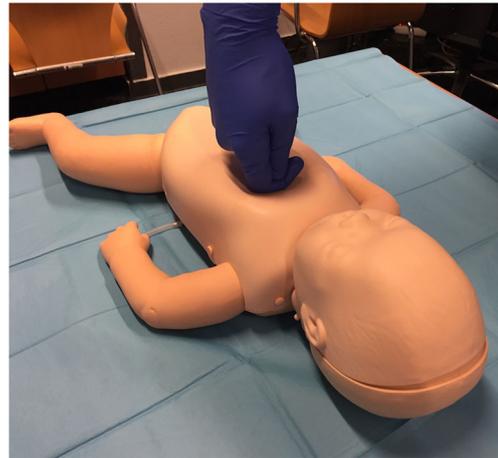


Fig. 4 Knocking-fingers technique

Results

Ten paediatric health professionals (7 females) participated in this study, 8 doctors and 2 nurses. Mean age was 26.6 ± 2.7 years. Participants mean weight was 62.6 ± 8.7 kg, and mean body mass index was 21.6 ± 2.2 kg m⁻².

Percentages of correct compressions for depth, rate, chest recoil and hand position were always above 70% regardless of the technique used. No statistically significant differences were found in any of the variables analysed (Table 1).

The KF technique was the one with the lowest percentage of correct chest compressions depth (89.5%), although, in all three techniques, median depth compressions were reached according to the recommended standards. TTHT achieved the highest percentage of correct chest compressions rate (87.0%). nTTT and KF methods achieved the fastest chest compression rate but with percentages of correct chest compressions rate below 80% in both cases (Fig. 5).

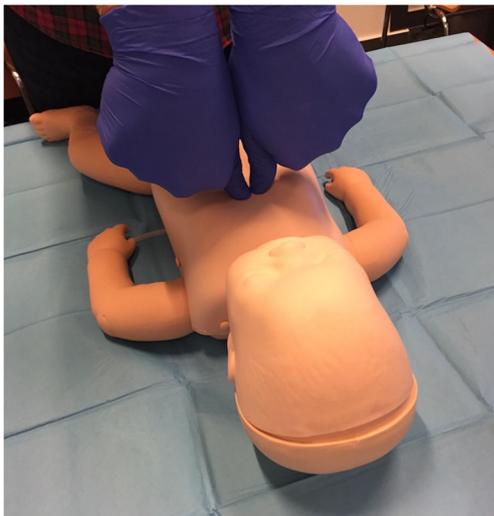


Fig. 3 New two-thumb technique

When asked, 50% of all participants preferred the nTTT, and the other 50% preferred TTHT, as they considered it the least difficult. On the other hand, all participants perceived the KF technique as the most difficult.

Discussion

Quality of the CPR is one of the fundamental factors that affect the survival of the victim in a cardiac arrest, either out or in hospital.

In infants, during the last decades, two techniques have been recommended, the TFT and the TTHT [11], being the latter the most recommended at present [6, 8, 12, 26]; but, we do not truly know if we are actually recommending the best technique, having in mind the poor results observed when CPR quality in infants has been studied, even in the hands of ‘experts’ [24].

To solve the problem of poor chest compressions quality, current CPR recommendations are aimed at reinforcing the training of health professionals and the use of monitoring and feedback devices in real time; since, although high-quality chest compressions are a crucial part for the recovery of spontaneous circulation, it has been observed that even professionals perform this manoeuvre in a suboptimal way [24].

In the case of infants, in addition to the insufficient training of professionals, it remains the possibility that the chest compression technique, itself, is not the most effective. For this reason, two new techniques have recently been tested in simulated conditions, with the aim of improving the results of traditional techniques, especially in relation to the maintenance of chest compressions quality. This is the first study that compares the TTHT with two novel techniques developed in recent years. In a previous study, our group compared TTHT with the nTTT [15] without finding significant differences in the quality of chest compressions.

Table 1 Chest compressions parameters

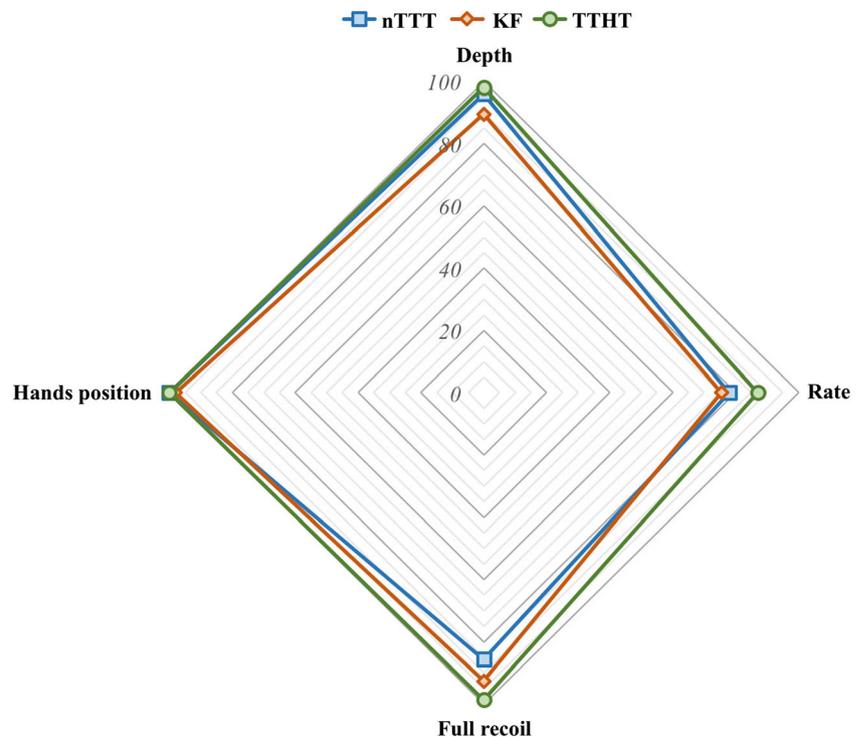
	nTTT (<i>n</i> = 10)	KF (<i>n</i> = 10)	Standard TTHT (<i>n</i> = 10)	<i>p</i>
Depth (mm)	40 (40–42)	40 (37–41)	40 (40–42.5)	0.122
% CCC for depth	96 (89.7–100)	89.5 (57–99)	98 (77.5–100)	0.378
Rate (compr/min)	115 (111–121)	116 (111–122)	111 (106–118)	0.607
% CCC for rate	78 (42.3–90.5)	75.5 (40–87.8)	87 (28.3–98.3)	0.924
% CCC for chest recoil	85.5 (47.8–99.3)	92.5 (65–99)	98.5 (88.8–99.3)	0.255
% CCC for hand position	100 (81.3–100)	98 (81–99.3)	100 (94.3–100)	0.163

Data are presented as median and interquartile range (IQR). *nTTT*, ‘new two-thumb technique’; *KF*, ‘knocking-fingers technique’; *TTHT*, two-thumb-encircling hand techniques, recommended technique; *CCC*, correct chest compressions

Our results are consistent with those of the authors who described these techniques [10, 17], in the sense that the nTTT and the KF have been shown at least not inferior to the TTHT when health professionals apply it in infant manikins. These professionals, who had trained and had previously demonstrated their ability to apply TTHT, both in manikins and in real infants, practically did not know the new techniques (they received only 10 min of explanation and they were allowed another 10 min of practice). We speculate that if the participants had also received training for enough time with the new techniques (nTTT and KF), their results could probably have been better than those obtained with the TTHT. In the view of our results, it could be interesting to compare the three methods, applied by well-trained professionals also in the new techniques and should be considered the implementation of a randomized and controlled study in real patients.

In both the nTTT and the KF technique, the position of the hands would allow the rescuer to apply pressure with the entire arm and body weight, so that compressions depth would tend to be greater and the exhaustion of the rescuer less in comparison with the TTHT, in which the force is exerted only with the thumbs. This possible advantage was not appreciated in our case since the subjective perception of the difficulty in performing chest compressions by professionals in the KF technique was higher with respect to the other two techniques, having a similar subjective difficulty among them. In addition, the performance success with these new techniques, as Smereka et al. [17] and Jung et al. [10] demonstrated, is neither directly influenced by the size of the rescuer’s hands nor by the diameter of the patient’s chest, as it happens with the TTHT. This might be an advantage if the infant is large and/or the rescuer’s hands (in many cases women) are relatively

Fig. 5 Evaluation of the cardiorespiratory resuscitation quality parameters for the three techniques. Variables are expressed in percentage (median) of correct chest compressions by depth, by rate, by hand position and by chest recoil



small. The angle of the fingers is especially important when performing these techniques; Ruetzler et al. [16, 25] compared the performance of the nTTT with the two thumbs at an angle of 45° instead of 90°, the latter achieving better results.

Our study has some limitations that must be taken into account. Firstly, the use of a manikin model in a simulated scenario may not directly translate results to real infants. Nonetheless, our data would support the performance of a future trial in which the potential impact of the nTTT and KF techniques in real-life cardiac arrest could be evaluated. Secondly, the number of subjects included in our study is scarce, but we consider it sufficient to study the hypothesis of non-inferiority of the new techniques compared with the THT, which was our main objective. It is clear that for the demonstration of superiority of any of the new techniques, it will be necessary to recruit a higher number of well-trained subjects, which we intend to do in a future investigation, including realistic mental distressors to also study if in such conditions the new techniques are poor or comparable with the standard one.

In conclusion, in a simulated infant scenario, the quality of chest compressions performed with two new techniques ('new two-thumb technique' and 'knocking-fingers technique'), when done by professionals who usually assist children at the hospital level, is similar to that obtained with the standard method. More studies must be carried out in manikins, animal models and in real patients in order to assess the real potential of these new techniques of CPR in infants.

Author's contributions ER-R participated in the design of the study, reviewed the data and drafted the final manuscript. AM-P and AC-F carried out the fieldwork and the control of the quality of the data. CA-G participated in the design of the study and performed the statistical analysis and figures. AR-N participated in the design of the study, supervised the fieldwork and the elaboration of the results and reviewed the final manuscript.

Compliance with ethical statements

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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