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Clinical paper

Hands at work: A randomised cross-over mannequin-based trial exploring the impact of hand preference of health care professionals on effectiveness of chest compressions

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Abstract

Aim and background: There are various theories regarding the ideal hand to be in contact with chest during chest compressions when healthcare professionals and medical students perform cardiopulmonary resuscitation (CPR). Our study aimed to compare the impact of preferred versus non-preferred hand placement on chest on the CPR quality.

Methodology: The volunteers were randomised to place their preferred (P)/non-preferred (NP) hand over sternum for the first session and switch hands for the second. Participants performed 2 min of uninterrupted chest compressions, followed by a 2-minute break and another 2 min of chest compressions on Laerdel QCPR Little Anne® mannequin with auditory feedback. The CPR parameters were analysed using QCPR mobile application. Comfort was assessed using 5-point Likert scale.

Results: Among the 82 volunteers, 51 participants (62.2%) preferred their dominant hand to be in contact with the chest. Comparable results were seen with mean QCPR score, rate of compression, mean depth and good recoil percentage. The NP set had higher adequate depth percentage (94.8 +/- 13.7) than the P set (92.3 +/- 19.9) ($p = 0.042$), but participants were more comfortable using their preferred hand over chest ($p = 0.0001$).

Conclusion: Rescuer performance during chest compressions may not be impacted by whether the preferred hand or non-preferred hand of the provider is in contact with sternum.

Keywords: Cardiopulmonary resuscitation, Handedness, Mannequin, Cardiac arrest, Fatigue, Simulation

Introduction

Despite the remarkable strides in resuscitation science, high-quality cardiopulmonary resuscitation (CPR) remains the cornerstone of achieving good outcomes in cardiac arrest victims. Hence, guidelines across the globe emphasize the need for improving the quality of chest compressions with recommendations such as using feedback devices, using CPR-coach in the team, targeting high chest compression fractions. However, a study by Hoybye, et al demonstrated the 1-year survival rates of in-hospital (IHCA) and out-of-hospital cardiac arrest (OHCA) was found to be 18% and 13% respectively.[1] In a systematic review of global OHCA reports, the pooled 1-month survival rate was 10.7%.[2] These statistics highlight the need for improving the chest compression quality.

The use of correct technique is as important as the awareness of the skill itself. Prolonged resuscitation can lead to rescuer fatigue and discomfort and may lead to decline in CPR effectiveness.

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Hence, adopting sound and optimal technique will help us overcome this and allow us to provide consistent high-standard CPR. Good technique includes correct hand position, appropriate rate and depth and adequate chest recoil, which can be practised on mannequins with feedback mechanisms. Simulation and mannequin-based research offers several advantages by providing a controlled, reproducible, and safe environment for testing and training.

Literature is divided regarding whether dominant hand/non-dominant hand or left/right hand should be placed in contact with the chest while delivering compressions.[3] Hence many health-care providers have developed their own preferences for the same. Recent neurophysiological studies have shed light on how the brain chooses hand preferences in gross motor tasks irrespective of right/left dominance.[4] Our study aimed to compare the impact of preferred versus non-preferred hand placement on chest on the CPR quality.

Methodology

This randomised crossover study was conducted in between June to September 2024 in a tertiary care academic institution in India after institutional ethics committee approval (IEC1-428/2023).

Participants: The study participants were students pursuing medicine, medical doctors who were under residency, and health care workers. All of them had either completed institutional/ American Heart Association training in Cardiopulmonary Resuscitation. Exclusion criteria included participants with arm/back/wrist pain prior to the start of the study. Participants who did not attend the second session with the opposite hand were excluded from the analysis as this was a cross over trial. Resident doctors or healthcare workers who were routinely involved in care of critically ill patients including cardiac arrest victims (in departments who deal with cardiac arrestscenarios and are part of rapid response teams) for at least one year were categorised as experts. Novices were defined as participants who were health care professionals who had less than one year of experience in real life cardiac arrest scenarios or were medical students. A flyer was circulated across social media platforms and college groups requesting for volunteers to participate in the study. Interested volunteers were enrolled in the study after taking informed consent.

Randomisation: Since this is a cross-over trial, study participants were considered as a control for themselves to account for confounding factors including strength, weight and height. Using an online randomisation allocator (https://www.randomizer.org/) a sequence was generated assigning participants to preferred or non-preferred hand based on enrolment serial number. As per this randomisation sequence the participants performed chest compressions with either preferred or non-preferred on chest on the first attempt. This was followed by a cross-over on a different date when the participants performed chest compressions with the opposite hand in contact with the chest. The demographic details along with hand dominance and preferred hand for chest compression were noted. All participants had CPR training more than one month prior to the first session and none in between the two sessions. Participants performed 2 min of uninterrupted chest compressions, followed by a 2-minute break and another 2 min of chest compressions on Laerdel QCPR Little Anne® mannequins (which have auditory feedback in the form of a click indicating adequate depth). The mannequin was placed on the floor on a mat for all participants. However, arrangements were kept for a table and a step stool for participants who requested for it. But none of the participants required a table or a stepstool. No report of the performance was provided to the participants after the first session. If requested, they were provided with the QCPR reports of both sessions after second session.

Outcomes: Using the Laerdel's QCPR mobile application (Version 7.0.1) various parameters of chest compression were obtained. The primary objective was to compare mean depths (average of the two sets for each hand) between preferred and non-preferred hand in contact with the chest of the mannequin. The recommended value is 5–6 cm according to the latest AHA guidelines. Secondary objectives parameters noted were mean QCPR scores, mean adequate depth %, average rate (100–120 compressions per minute), good chest recoil % and pause time. The CPR score is a composite metric developed by Laerdal Medical, generated through an algorithm that takes multiple parameters into account, such chest compression fraction, depth, rate, recoil.[5] Correct hand placement and completion of two minutes of uninterrupted chest compressions were noted. Fatigue was assessed subjectively by asking the participant to indicate when they start feeling fatigued. At completion participants were asked to rate the comfort of performing chest compressions on a 5-point Likert scale. In the next session, as per participant's convenience, the same process was repeated with the opposite hand (cross-over) in contact with the sternum and same parameters were noted.

Sample size: Since no studies were found that directly compared CPR quality between the preferred and non-preferred hand, a relevant study was used that demonstrated the effect of handedness on CPR quality for our sample size calculation. In this study, the researchers found that the mean chest compression depth was slightly higher when using the dominant hand.[6] Sample size of 81 study participants was calculated by taking the mean depth of compression in standard (dominant) arm as 54.4 +/- 4 mm and in alternate arm (non-dominant) as 53.4 +/- 5.1 mm. The margin of non-inferiority was taken as 3 mm of depth. The power was 80% with a confidence interval of 95% for the calculation.

Statistical analysis: Microsoft Excel (Office 365) was used to organise and enter data and analysed using Statistical Package for Social Sciences (SPSS) version 26.0 (IBM Corporation, Chicago, Illinois, USA). The data are presented as means ± standard deviation (SD), along with numbers and percentages. These data were an average of the two attempts of 2-minute chest compressions for each session. T-tests were used for comparing two means. Chi-squared tests or Fisher's exact tests were used to compare multiple percentages, depending on appropriateness. Levene's test was used to assess the homogeneity of variances in the variable distributions. McNemar test was used to compare fatigue and various sets of dominant or preferred hand placement and expertise. All p-values were two-tailed, with values less than 0.05 considered statistically significant.

Results

A total of 109 volunteers agreed to participate in our study. Out of them, 82 completed sessions with both hands, and hence were included in our analysis (Fig. 1). Among them 51 participants (62.2%) preferred their dominant hand to be in contact with the chest. Out of these, 48 were right-handed and three were left-handed individuals. Demographic details along with handedness and hand preference are outlined in Table 1.

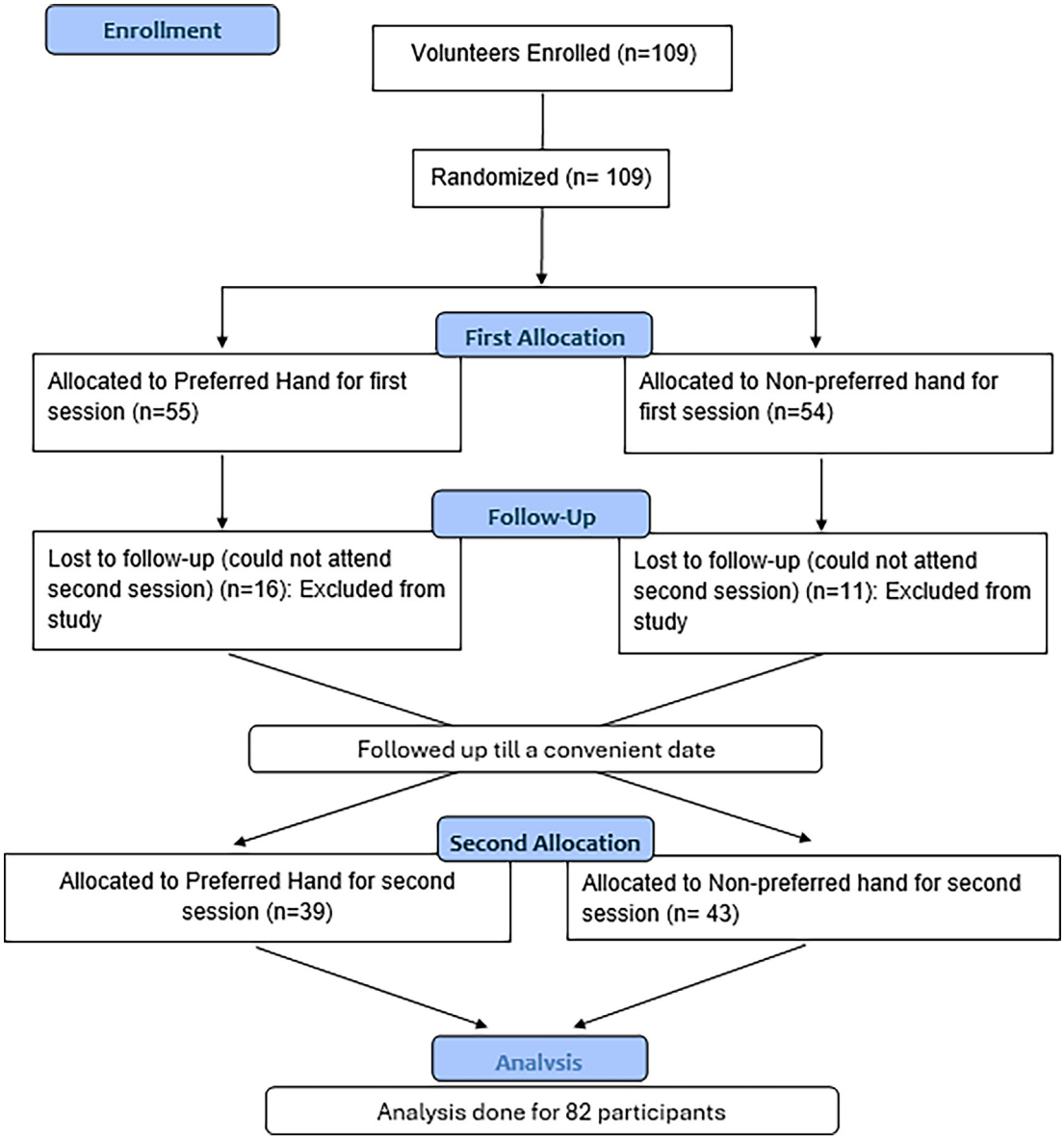

Fig. 1 – CONSORT flow diagram.

Table 1 – Demographic details, handedness and hand preference of the participants (N = 82).

Serial no.	Variable	Number (%); Mean (SD)
1.	Mean Age (year)	23.9 (3.8)
2.	Gender (n)	Female: 48 (58.5) Male: 34 (41.5)
3.	Experience (n)	Expert: 38 (46.3) Novice: 44 (53.7)
4.	Preferred hand for CPR (n)	Dominant: 51 (62.2); Non-dominant: 31 (37.8) Left: 33 (40.2); Right: 49 (59.8)
5.	Dominant Hand (n)	Left: 4 (4.9) Right: 78 (95.1)
6.	Mean Height (m)	1.67 (0.09)
7.	Mean Body Mass Index	23.6 (4.15)

[#]Categorical data are represented as number and percentages; continuous data are represented as mean and standard deviation (SD).
[$]CPR: Cardiopulmonary resuscitation

Quality of chest compressions based on hand preference

The mean depth of compression was comparable in preferred (P) and in non-preferred (NP) sets (70.9 +/- 10.4 mm vs 69.89 +/- 9.93 mm). Similar comparable results were seen with mean QCPR score, rate of compression, and good recoil percentage (Table 2). However, the NP set had higher adequate depth percentage (94.8 +/- 13.7) than the P set (92.3 +/- 19.9) (p = 0.042). The P set was significantly more comfortable to perform chest compression (4.1 +/- 0.8) as per Likert scale than NP set (3.5 +/- 0.8). Subgroup analysis comparing the findings between expert and novice showed no significant differences between the 2 groups. (Supplementary tables). Among the study participants perceived fatigue was seen in 21 participants in both P and NP sets. Participants paused for an average mean of 1.8 (+/-4.0) seconds during P set and 1.3 (+/- 3.5) seconds during NP set (p = 0.368).

Quality of chest compressions based on hand dominance

The mean depth of compressions was comparable between non-dominant set (ND) and dominant hand set (D). The ND set fared better with respect to chest compression rate and mean QCPR scores and was statistically significant as well (Table 2). Percentages of adequate depth and of adequate recoil were similar between the two sets. Subgroup analysis comparing the findings between expert and novice showed no significant differences between the 2 groups (Supplementary table 2). The perceived comfort using Likert scale was also similar in both the sets. Perceived fatigue was seen in 20 in D set and 22 in ND set. Only one participant failed to complete 2 min of chest compressions (stopped after 92.5 s) with their non-dominant hand which was her non-preferred hand (see Table 3).

Discussion

Current AHA and ERC guidelines do not specify which hand should be placed over the sternum[7,8] allowing for rescuer hand preference. Ours is probably the first study aimed to identify any objective improvement in quality of uninterrupted chest compressions when using the preferred hand over the sternum as compared to the non-preferred hand. We found the quality of chest compressions similar in both preferred and non-preferred hand except for percentage of chest compressions with adequate depth, which was better when using the non-preferred hand. The higher adequate depth percentage seen with the NP set (94.8 vs 92.3, p = 0.04) could be because while using the non-preferred hand, participants would have deliberately tried to focus on performing optimal compressions than relying on their muscle memory. Even though it was not statistically significant, the mean QCPR score was better in NP set than P set. This may be attributed to the fact that overall QCPR scores are non-binary values representing how closely the provider is approaching success. These scores are calculated based on Laerdal's proprietary QCPR algorithm, which evaluates performance across all CPR sub-skills.[5] Even when novice rescuers were analysed separately, no benefit was identified with using preferred hand over non-preferred hand. This demonstrates that good quality chest compressions can be performed equally well with either hand,[9] and in prolonged periods of resuscitation the provider can choose to switch to their non-preferred hand without compromising the quality of CPR.

In our study. the mean chest compression depth was comparable between ND set and D set. The ND set had a better mean QCPR score (as close to 100 as possible), and rate of compressions were closer to the recommendations (100 – 120 per minute). Previous studies have tried to assess the quality of chest compression using dominant hand vs non-dominant hand. While some studies have shown benefits by placing the dominant hand over the sternum,[6,10,11] others have not shown any significant advantage of using the dominant hand.[12–14] A systematic review also failed to identify any benefit of using the dominant hand over the non-dominant hand. Advances in neurobiology can shed light on this inconclusion. Earlier understanding was that of hemispheric specialisation, where the dominant hand was described to be specialised in rapid and precise movements, and the non-dominant hand specialised in postural stabilisation.[9] This was hypothesised as the reason for poor performance with the non-dominant hand, which was said to be less effective in directing compressive forces over the sternum leading to dissipation of forces and poor quality chest compressions.[11] Current studies demonstrate cerebral flexibility in assigning control to arms depending on the goal of the presented task without specialisation.[15,16] Similarly, kinematic studies looking into finding the optimal posture for good quality CPR, have identified placing the arm at 90 degree to the chest wall,[17] placing the centre of the rescuer's body over the point of sternal compression point and generating power from the hips along with knee flexion as part of optimal posture.[18] The role of the upper limb is mainly to redirect the force generated by the hips to the chest wall of patients. So, the handedness of the provider should not objectively affect the quality of chest compressions.

Placing the dominant hand over the sternum was preferred in 62% of the participants. The remaining 38% preferred placing their

Table 2 – Comparison of chest compression parameters in preferred and non-preferred hand set.

Serial No.	Variable	Preferred hand (Mean +/- SD) N = 82	Non-Preferred hand (Mean +/- SD) N = 82	P value
1	QCPR score	69.2 +/- 28.4	72.9 +/- 26.3	0.143
2	Rate of Compressions (per min)	125.6 +/- 14.6	123.8 +/- 16.2	0.167
3	Mean Depth (mm)	70.9 +/- 10.4	69.9 +/- 9.9	0.237
4	Adequate Depth %	92.3 +/- 19.9	94.8 +/- 13.7	0.042
5	Good Recoil %	69.9 +/- 35.3	72.0 +/- 33.6	0.568
6	Likert scale for perceived comfort	4.1 +/- 0.8	3.5 +/- 0.8	0.0001

*Paired T tests used to determine significance.

#Categorical data are represented as number and percentages; continuous data are represented as mean and standard deviation (SD).

$CPR: Cardiopulmonary resuscitation

Table 3 – Comparison of chest compression parameters in dominant and non-dominant hand set.

Serial No.	Variable	Dominant hand (Mean +/- SD) N = 82	Non dominant hand (Mean +/- SD) N = 82	P value
1	QCPR score	67.5+/- 27.06	74.5 +/- 27.4	0.005
2	Rate of Compressions (per min)	127.6 +/- 15.3	121.8+/- 15.0	0.0001
3	Mean Depth (mm)	70.9 +/- 10.7	69.9 +/- 9.6	0.286
4	Adequate Depth %	92.45 +/- 19.7	94.65 +/- 13.85	0.506
5	Good Recoil %	69.5 +/- 35.02	72.3 +/- 34.0	0.446
6	Likert scale for perceived comfort	3.8 +/- 0.86	3.79 +/- 0.9	0.86

*Paired T tests used to determine significance.

[#]Categorical data are represented as number and percentages; continuous data are represented as mean and standard deviation (SD).

[$]CPR: Cardiopulmonary resuscitation

non-dominant hand over the sternum. Marcori et al while assessing lateralization preferences demonstrated that motor tasks requiring larger muscle groups (i.e., gross skills) such as chest compressions, display a less lateralized behaviour as compared to fine motor skills.[4] They also noticed that when performing tasks under stress or pressure, there is a slightly higher preference for using the dominant hand. This could help explain the 62:38 split in the preference for using the dominant hand. Even other studies by Jo et al and Nikandish et al found the preference for dominant hand for chest compression (58% and 53% respectively).[12,14]

During prolonged resuscitation providers sometimes experience hand fatigue.[19] As quality of chest compressions remains similar between preferred and non-preferred hands, further studies may help to determine if switching to non-preferred hand would help alleviate or reduce fatigue. The findings of this study show that the overall QCPR scores are affected by the average time adequate depth and good recoil are achieved during the cycle. Even though simulation-based study has its advantages, in real life scenarios replicating the parameters may have different outcomes, which may include rib fractures and other harmful effects.[20].

Limitations

The sample size was calculated based on a previous study on dominance, as there is no study available on hand preference. Even though we used a feedback simulation mannequin, the motivation in a real-life scenario was missing as this study did not assess chest compressions on patients. Participants showed higher than recommended mean depth and rate of compressions, which could be partly attributed to Hawthorne bias. The participants in this study performed two minutes of chest compressions two times with preferred and nonpreferred hand. This is not properly representative of prolonged CPR duration and the effects of prolonged CPR remains unknown. However, there are studies which have shown that during real life CPR scenarios with audiovisual feedback, depth of compression decayed after 90 s of CPR.[19] Lastly, the proprietary algorithm of QCPR score is restricted to the company Laerdel and prevented us from further analysing the cause of differences in the QCPR scores. The Laerdel website,[21] detailing QCPR app parameters, has mentioned that all compression with more than 50 mm depth is considered as 'Ok' compressions. Hence, even compression > 60 mm were considered as 'Ok' compression.

Conclusion

Rescuer performance during chest compressions may not be impacted by whether the preferred hand or the non-preferred hand of the provider is in contact with sternum. During cardiopulmonary resuscitation, both novice and expert rescuers, may approach patient with preferred or non-preferred hand on the sternum to achieve effective chest compressions.

Ethical approval statement

This study had been approved by the institutional ethics committee prior to recruitment of participants.

CRediT authorship contribution statement

Shivam Thaker: Writing – original draft, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation. **Savan Kumar Nagesh:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation. **Prithvishree Ravindra:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **Eesha Vilas Kharade:** Validation, Resources, Project administration, Investigation. **Nitish Reddy Lingala:** Resources, Project administration, Investigation. **Shambhavi Vivek Joshi:** Resources, Investigation. **Sumanth Mallikarjuna Majgi:** Validation, Software. **Shreya Das Adhikari:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2024.100849.

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