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Termination of Ventricular Fibrillation and Pulseless Ventricular Tachycardia Using the Precordial Thump

Athanasios Chalkias[1,2], Anastasios Koutsovasilis[3], Athanasios Gravos[4], Konstantinos Sakellaridis[4], Alexandra Avraamidou[4], Katerina Nodarou[4], Thomas Nitsotolis[4], Spyros Vaggelis[4], Georgios Tzanoudakis[4], Konstantina Katsifa[4], Barbara Grammatikopoulou[4], Drosos Venetoulis[4], Martha Kelesi[5], Athanasios Prekates[4], Paraskevi Tselioti[4], Eugenia Vlachou[5] and Theodoros Xanthos[2,6]*

[1]University of Athens Medical School, National and Kapodistrian University of Athens, Athens, Greece

[2]Hellenic Society of Cardiopulmonary Resuscitation, Athens, Greece

[3]Department of Internal Medicine, Nikaia General Hospital, Piraeus, Greece

[4]Intensive Care Unit, Tzaneio General Hospital of Piraeus, Piraeus, Greece

[5]Technological Educational Institute of Athens, Athens, Greece

[6]European University Cyprus, School of Medicine, Nicosia, Cyprus

Abstract

Background: Although the effectiveness of precordial thump is controversial, it remains a common strategy during cardiopulmonary resuscitation. We investigated the effectiveness of precordial thump in the treatment of monitored ventricular fibrillation/pulseless ventricular tachycardia cardiac arrest.

Methods: A total of 922 patients were categorized according to their first-line treatment into the defibrillation group and the precordial thump group. In the defibrillation group, we included all monitored victims who were immediately defibrillated after cardiac arrest was recognized and underwent subsequent cardiopulmonary resuscitation, while in the precordial thump group, the victims received immediately at least one precordial thump followed by immediate cardiopulmonary resuscitation.

Results: Two hundred and nine (42.4%) defibrillation group and 10 (2.3%) precordial thump group victims restored spontaneous circulation after the first shock and first precordial thump, respectively (p=0.008). The proportion of victims achieving spontaneous circulation at any time during cardiopulmonary resuscitation was higher in the defibrillation group compared to the precordial thump group, while time to first shock was higher in the precordial thump group (p=0.038). Victims in the precordial thump group were associated with a higher proportion of suffering a re-arrest during the immediate and early post-arrest phases compared to those in the defibrillation group (p=0.035).

Conclusions: The precordial thump was ineffective in terminating most of ventricular fibrillation/pulseless ventricular tachycardia.

Keywords: Cardiac arrest; Ventricular fibrillation; Pulseless ventricular tachycardia; Precordial thump; Return of spontaneous circulation

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***Correspondence:**
Athanasios Chalkias, University of Athens Medical School, National and Kapodistrian University of Athens, Piraeus, Greece, Tel: +302104133992; Fax: +302110121758;
E-mail: thanoschalkias@yahoo.gr

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Introduction

Optimization of resuscitation interventions aims mainly at the rapid and effective rise of coronary perfusion pressure, with the main recommended treatment of Ventricular Fibrillation (VF) cardiac arrest being early electrical defibrillation [1]. The precordial thump was first described by Schott in 1920 and was included in Cardio Pulmonary Resuscitation (CPR) guidelines in 1974 by the American Heart Association (AHA) and in 1992 by the European Resuscitation Council (ERC) after its reported success in several case reports and small series [2-9]. Since then, the precordial thump has not been studied extensively and large cohorts studies or randomized controlled trials are lacking. The AHA recommends the precordial thump for patients with witnessed, monitored, unstable ventricular tachycardia, including pulseless Ventricular Tachycardia (VT), if a defibrillator is not immediately ready for use, but it should not delay CPR and shock delivery [10], while the

Table 1: Study characteristics and outcome.

	All monitored (n=922)	DG* (n=493)	PTG† (n=429)	OR‡ (95% CI§)
Age, n (%)				
16-30	98 (10.6)	56 (11.3)	42 (9.8)	0.74 (0.42-1.89)
31-45	121 (13.1)	63 (12.8)	58 (13.5)	1.18 (0.52-2.96)
46-60	158 (17.1)	87 (17.6)	71 (16.5)	0.84 (0.46-2.32)
61-75	226 (24.5)	103 (20.9)	123 (28.7)	1.22 (0.69-3.58)
76-90	319 (34.6)	184 (37.3)	135 (31.5)	0.82 (0.56-1.98)
First monitored rhythm, n (%)				
Sinus rhythm	31 (3.4)	14 (2.8)	17 (4.0)	1.19 (0.48-3.18)
Sinus bradycardia	62 (6.7)	38 (7.7)	24 (5.6)	0.69 (0.44-2.85)
Sinus tachycardia	114 (12.4)	65 (13.2)	49 (11.4)	0.72 (0.49-2.36)
Supraventricular tachycardia	98 (10.6)	42 (8.5)	56 (13.0)	1.26 (0.64-3.77)
2nd degree atrioventricular block	77 (8.3)	34 (6.9)	43 (10.0)	1.31 (0.70-4.21)
3rd degree atrioventricular block	60 (6.5)	29 (5.9)	31 (7.2)	1.18 (0.81-4.12)
Atrial fibrillation	141 (15.3)	67 (13.6)	74 (17.2)	1.22 (0.86-3.95)
Atrial flutter	54 (5.8)	35 (7.0)	19 (4.4)	0.72 (0.39-2.78)
Stable ventricular tachycardia	143 (15.5)	75 (15.2)	68 (15.8)	1.09 (0.77-3.81)
Unstable ventricular tachycardia	96 (10.4)	62 (12.6)	34 (7.9)	0.80 (0.49-3.37)
Other	11 (1.2)	9 (1.8)	2 (0.5)	0.93 (0.34-2.75)
Unknown	35 (3.8)	23 (4.6)	12 (2.8)	0.82 (0.48-2.69)
Initial cardiac arrest rhythm, n (%)				
Ventricular fibrillation	639 (69.3)	342 (69.4)	297 (69.2)	0.96 (0.49-3.08)
Pulseless ventricular tachycardia	283 (30.7)	151 (30.6)	132 (30.8)	1.03 (0.67-4.52)
ROSC‖ during CPR#, n (%)	285 (30.9)	249 (50.5)	36 (8.4)	0.12 (0.08-0.46)St
Time to first shock (sec), median (IQR**)	78 (8.4)	16 (3.2)	62 (14.4)	1.28 (0.85-3.89)St
Not defibrillated	152 (16.5)	0 (0)	152 (35.4)	-
Re-arrest [median (IQR**)]				
1	411 (44.6)	261 (53.0)	150 (35.0)	0.34 (0.20-0.48)St
2	225 (24.4)	173 (35.0)	52 (12.1)	0.19 (0.12-0.45)St
3	286 (31.0)	59 (12.0)	227 (53.0)	1.26 (1.08-4.66)St
Discharged alive, n (%)	21 (2.8)	19 (3.8)	2 (0.5)	0.72 (0.46-2.09)St

* defibrillation group, †precordial thump group, ‡odds ratio, §confidence interval, ‖ return of spontaneous circulation, # cardiopulmonary resuscitation, ** interquartile range, St p<0.05

ERC has de-emphasized its role stating that it may be appropriate therapy only when used without delay whilst awaiting the arrival of a defibrillator, which is only likely to be in a critical care environment [11].

Although the effectiveness of precordial thump remains controversial, increasing evidence during the last decades indicate that it is rarely of benefit. Nevertheless, despite current guidelines and the concerns regarding the safety of the procedure, especially in inducing commotio cordis, the use of precordial thump remains a common strategy during CPR [12,13]. The aim of this study was to investigate the effectiveness of precordial thump in the treatment of monitored VF/VT.

Table 2: Effectiveness of first shock and precordial thump on rhythm conversion.

	Both rhythms (n=922)			Ventricular fibrillation (n=639)			Pulseless ventricular tachycardia (n=283)		
	DG* (n=493)	PTG† (n=429)	OR‡ (95% CI§)	DG* (n=342)	PTG† (n=297)	OR‡ (95% CI§)	DG* (n=151)	PTG† (n=132)	OR‡ (95% CI§)
Return of spontaneous circulation	209 (42.4%)	10 (2.3%)	0.04‖ (0.02-0.12)	136 (39.8%)	4 (1.3%)	0.06‖ (0.02-0.09)	73 (48.3%)	6 (4.5%)	0.08‖ (0.05-0.14)
No change	184 (37.3%)	272 (63.4%)	4.52‖ (1.98-8.42)	143 (41.8%)	199 (67.0%)	4.18‖ (2.04-7.96)	41 (27.1%)	73 (55.3%)	2.82‖ (1.82-6.48)
Rhythm change									
Ventricular fibrillation	19 (3.8%)	25 (5.8%)	1.10 (0.86-2.94)	N/A	N/A	N/A	19 (12.6%)	25 (18.9%)	1.08 (0.90-2.56)
Pulseless ventricular tachycardia	25 (5.0%)	17 (4.0%)	0.92 (0.86-1.12)	25 (7.3%)	17 (5.7%)	0.94 (0.88-1.18)	N/A	N/A	N/A
Pulseless electrical activity	28 (5.7%)	48 (11.2%)	1.52 (0.94-3.86)	16 (4.7%)	29 (9.8%)	1.41 (0.91-3.58)	12 (7.9%)	19 (14.4%)	1.35 (0.95-2.33)
Asystole	28 (5.7%)	57 (13.3%)	1.84 (0.98-2.99)	22 (6.4%)	48 (16.2%)	1.56 (0.98-3.72)	6 (4.0%)	9 (6.8%)	1.20 (0.89-2.28)

* defibrillation group; †precordial thump group; ‡odds ratio; §confidence interval; || p<0.05

Patients and Methods

Study design

We analyzed the data prospectively collected between 2005 and 2014 of all patients aged >16 years who suffered a monitored witnessed VF/VT cardiac arrest in the Emergency Department (ED). The study complies with the Declaration of Helsinki, while Ethical approval for this study was provided by the Ethical Committee of Tzaneio Hospital, Piraeus, Greece (No 15/24-01-2014) the Ethical Committee of Nikaia Hospital, Piraeus, Greece (No 23367/19-05-2014).

Study setting

The study was undertaken in two large tertiary hospitals in Athens, Greece covering an area of 50.4 km^2 with a population of 448,997 residents. In these hospitals, the patients are transferred to the ED either by the National Emergecy Medical Service or by private vehicle. Each patient is triaged by a dedicated triage team and directed depending on the severity of the disease.

In both hospitals, the ED's cardiac arrest team consists of the on-call anaesthesiologist, the ED's cardiologist, the on-site physician, and the ED's nurses. In case of cardiac arrest in the ED, the physician or the nurse calls the members of the cardiac arrest team using pre-defined numbers and rapidly informs them, while the on-site physician immediately starts CPR. When the arrest occurs outside of the ED examination rooms (other areas confined to the ED such as corridors, observational areas, waiting room), the on-site medical personnel provides CPR while the patient is transported to the ED's resuscitation room. In some cases, an ED nurse brings a manual defibrillator and Advanced Life Support (ALS) is initiated at the location of the arrest.

Population and data collection

In our study, all data were prospectively collected and analyzed retrospectively. Data analysis was based on predefined data points on a prospective data collection form. The patient records were retrieved and underwent independent screening by two members of the research team, while the patients were categorized according to their first-line treatment for the VF/VT. All monitored victims who were initially defibrillated after recognition of cardiac arrest comprised the Defibrillation Group (DG). On the other hand, all monitored individuals who have initially received 1-3 consecutive precordial thump(s) after recognition of VF/VT comprised the Precordial Thump Group (PTG). In all of them, the shock or thump was followed by immediate CPR, while all victims were defibrillated

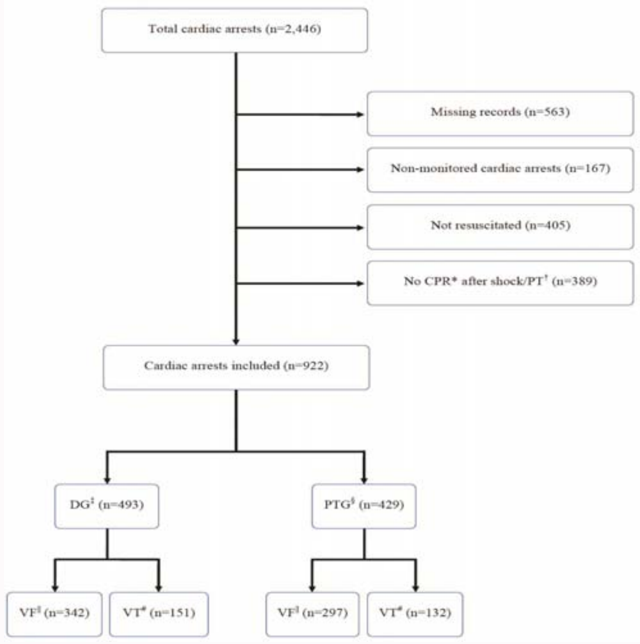

Figure 1: Utstein-style patient selection.
*Cardiopulmonary Resuscitation; †Precordial Thump; ‡Defibrillation Group; §Precordial Thump Group; ||Ventricular Fibrillation; #Pulseless Ventricular Tachycardia.

within 60 sec after the final precordial thump.

Patients with non-monitored cardiac arrest, incomplete data, or those in whom CPR was not attempted were excluded from the study. In addition, victims in whom CPR was not initiated immediately after the application of precordial thump/defibrillation were also excluded from the study. This was necessary in order to eliminate the effect of the immediate post-shock phase on the success of shock or precordial thump; even if the defibrillation attempt and possibly the precordial thump are successful in restoring a perfusing rhythm, it may take time until the post-shock circulation is established [14,15]. This may complicate the recognition of rhythm conversion and could bias our results. In our study, data were collected according to the Utstein style.

Statistical analysis

All statistical analysis were performed using SPSS version 17.0 (SPSS Inc, Chicago IL, USA). Continuous variables were expressed as mean ± SD and categorical variables as percentages. Differences between groups were assessed with x2 test Fisher's exact test and Mann-Whitney U test as appropriate. Effect size differences across groups were compared using odds ratio and 95% confidence interval. A p-value <0.05 indicated statistical significance.

Results

A total of 2,446 cardiac arrest victims were identified. Of them, 563 had missing patient care records, 167 were non-monitored cardiac arrests, 405 were not resuscitated, and 389 received no CPR subsequently to precordial thump/defibrillation. All these cases were excluded from the study, giving 922 individuals, 639 (69.3%) VF and 283 (30.7%) VT cases, eligible for further analysis (Figure 1).

In our study, 493 victims were included in DG, 342 (69.4%) with VF and 151 (30.6%) with VT, receiving a shock as first-line treatment. On the other hand, 429 victims received precordial thump as first-line treatment and were included in PTG. Of them, 297 (69.2%) suffered VF and 132 (30.8%) VT cardiac arrest. There was no difference in age, first monitored rhythm, comorbidities, or initial cardiac arrest rhythm between the DG and PTG.

The propotion of victims achieving return of spontaneous circulation (ROSC) at any time during CPR was higher in DG compared to PTG (OR 0.12, 95% CI 0.08-0.46, p=0.022), while as expected, time to first shock was higher in the PTG due to the delay for performing the precordial thump(s) (p=0.038). In PTG, the number of precordial thumps was not associated with ROSC. Victims in PTG were associated with a higher proportion of suffering a re-arrest during the immediate and early post-arrest phases compared to those in DG (OR 1.26, 95% CI 1.08-4.66, p=0.035). Only 19 (3.8%) patients from DG and 2 (0.5) patients of PTG survived to hospital discharge (Table 1).

We found a statistically significant difference between the effectiveness of first shock and first precordial thump on rhythm conversion. In our study, 209 (42.4%) DG and 10 (2.3%) PTG victims achieved ROSC after the first shock and first precordial thump, respectively (p=0.008). Specifically, of the 639 victims with VF cardiac arrest, 136 (39.8%) DG and 4 (1.3%) PTG victims achieved ROSC after the first administered shock or precordial thump, respectively (p=0.005). Of the 283 victims with VT cardiac arrest, 73 (48.3%) DG and 6 (4.5%) PTG individuals achieved ROSC after the first administered shock or precordial thump, respectively (p=0.011). Rhyhtm conversion after each shock or precordial thump into VF/VT, pulseless electrical activity, or asystole was higher in the PTG, but there was no statistically significant differecen between the two groups (Table 2).

Discussion

Although in both the 2010 AHA and 2015 ERC guidelines, the precordial thump is not considered as a first-line treatment in VF/VT cardiac arrest [10,11], it is still practiced, despite the limited evidence for or against its use. Indeed, although the coupling between electrical and mechanical events in the heart is an active area of research, little information on arrhythmia termination with mechanical impact exist [16,17]. In our study, there was a statistically significant difference between the effectiveness of first shock and first precordial thump in DG and PTG, respectively. Specifically, although about half of the participants in DG achieved ROSC after a single shock, only 2.3% of PTG victims restored spontaneous circulation after a single thump. This is consistent with the results of Haman et al. [18] who investigated the precordial thump in 485 consecutive patients with ventricular arrhythmias (21 with VF) who underwent electrophysiological study. The authors reported that the efficacy of precordial thump in termination of arrhythmias was very low even with early application after VF onset. In a prospective electrophysiological study, a total of nine patients received precordial thumps for 11 separate episodes of electrically induced sustained VT. The thumps failed on all 11 attempts, while the patients were successfully treated with subsequent shock or overdrive pacing [6]. Moreover, Amir et al. [19] investigated the precordial thump as first treatment option in 28 victims with VF and reported that it was unsuccessful in all of them. In another prospective study, Pellis et al. [13] used a very strict protocol in order to study the utility of precordial thump for the treatment of out-of-hospital cardiac arrest. In this study in which the thump needed to be the very first measure without notable delay in other procedures, none of the 47 victims with VF/VT achieved ROSC. Similarly, Nehme et al. [20] studied the value of the precordial thump as first-line treatment of monitored out-of-hospital VF/VT cardiac arrest and reported that the precordial thump rarely results in ROSC.

In addition, the evidence from animal studies investigating the success of precordial thump in the treatment of VF/VT is also scarce. Gertsch et al. [21] investigated the efficacy of serial chest thumps in five pigs with VT after experimental myocardial infarction and reported that six VTs were converted by a single chest thump, seven VTs were converted by the first serial chest thumps, and six VTs were converted by the last of multiple (two to seven) serial chest thumps, concluding that serial chest thumps should be practiced only very cautiously. Madias et al. [22] assessed the relationship between left ventricular pressures generated by thumps and their effectiveness in defibrillation of VF or resuscitation of asystole after defibrillation. They reported that despite generating high left ventricular pressures, precordial thump for VF in cardiac arrest victims cannot be recommended but for asystolic victims might be beneficial. However, the precordial thump itself may result in asystole [13,23]. Further more, asystole is usually associated with more severe pathophysiological disturbaces and ensues after several minutes of untreated VF/VT [24-28], i.e., during the metabolic phase of cardiac arrest during which the success of precordial thump is highly unlikely [11,17].

Another critical issue is whether the application of precordial thump may decrease the efficacy of subsequent shocks and CPR. In a series of 50 patients who developed monitored VF/VT, 23 patients were thumped without effect. Subsequently, 12 of these 23 patients were successfully resuscitated with electrical shock [23]. In three other studies, the authors reported that all victims with VF/VT were succesfully resuscitated with subsequent defibrillation [6,18,19]. However, in the study by Pellis et al. [13], post-thump ROSC was not achieved by other interventions in 36 VF/VT victims. In our study, only 26 PTG victims achieved ROSC during subsequent CPR, although time to first shock was significantly higher in this group. Also, PTG victims had a higher proportion of suffering multiple arrests, while only two of them survived to hospital discharge. Our results indicate that the application of precordial thump resulted in significant delays in initiating high quality CPR. The prolongation of cardiac arrest interval aggravates myocardial perfusion and survivability, decreasing the efficacy of subsequent shocks and diminishing survival rates [11,24,29]. Of note, targeted temperature management is not widely applied in our country despite the existing Guidelines, which together with the lack of resuscitation skills of both lay persons and healthcare personnel contribute to the poor survival rates in our study [30,31].

Of note, the post-thump deterioration of VF/VT into a non-shockable rhythm may have contributed to the poor outcomes in PTG. In this group, post-thump or post-shock conversion of initial VF/VT to pulseless electrical activity or asystole was more frequent compared to DG, although there was no statistically significant difference between the two groups. Our findings indicate that current recommendation on precordial thump may have to be abandoned. In case of a witnessed, monitored VF/VT cardiac arrest, high quality chest compressions should be started immediately and continue until a defibrillator is available. The precordial thump may be considered only in settings in which shock delivery is not feasible, i.e., when a defibrillator is not available, or when prolonged time to shock is expected.

One limitation in our study is its design, as errors due to confounding and bias are more common in retrospective studies than in prospective studies. However, a prospective study would be highly unethical in this case. Moreover, the data analyzed in this study were prospectively collected. Also, the risk of under-reporting precordial thump use in patient care records may have resulted in smaller sample size [20]. However, 922 individuals were included in our study which, to our knowledge, makes it the largest retrospective observational study until now. Another limitation is that we cannot ascertain the consistent application of precordial thump across the study population. Also, it is impossible to assess the level of training among the medical personnel. We sought to avoid such biases by carefully designing our study and excluding victims in whom CPR was not initiated immediately. The success of precordial thump in these patients was hard to be assessed as any delay in initiating chest compressions could result in the concealing of a successful thump and subsequent re-arrest.

Conclusion

The precordial thump was ineffective in terminating most of VF/VT and was associated with delayed onset of CPR and shock delivery, a higher proportion of suffering a re-arrest during the immediate and early post-arrest phases, and poorer outcome compared to defibrillation. Of note, the application of precordial thump was associated with decreased efficacy of subsequent shocks and CPR in thumped victims, advocating the need for high quality CPR until a defibrillator is available.

References

1. Dragoumanos V, Iacovidou N, Chalkias A, Lelovas P, Koutsovasilis A, Papalois A, et al. Passive leg raising during cardiopulmonary resuscitation results in improved neurological outcome in a swine model of prolonged ventricular fibrillation. Am J Emerg Med. 2012;30(9):1935-42.
2. Bierfeld JL, Rodriguez-Viera V, Aranda JM, Castellanos A Jr, Lazzara R, Befeler BL. Terminating ventricular fibrillation by chest thump. Angiology. 1979;30(10):703-7.
3. Patros RJ, Goren CC. The precordial thump: an adjunct to emergency medicine. Heart Lung. 1983;12(1):61-4.
4. Caldwell G, Millar G, Quinn E, Vincent R, Chamberlain DA. Simple mechanical methods for cardioversion: defence of the precordial thump and cough version. Br Med J (Clin Res Ed). 1985;291(6496):627-30.
5. Befeler B. Mechanical stimulation of the heart: its therapeutic value in tachyarrhythmias. Chest. 1978;73(6):832-8.
6. Miller J, Addas A, Akhtar M. Electrophysiology studies: precordial thumping patients paced into ventricular tachycardia. J Emerg Med. 1985;3(3):175-9.
7. Morgera T, Baldi N, Chersevani D, Medugno G, Camerini F. Chest thump and ventricular tachycardia. Pacing Clin Electrophysiol. 1979;2(1):69-75.
8. Volkmann H, Klumbies A, Kuhnert H, Paliege R, Dannberg G, Siegert K. Terminating ventricular tachycardias by mechanical heart stimulation with precordial thump. Z Kardiol. 1990;79(10):717-24.
9. Sclarovsky S, Kracoff OH, Agmon J. Acceleration of ventricular tachycardia induced by a chest thump. Chest. 1981;80(5):596-9.
10. Neumar RW, Otto CW, Link MS, Kronick SL, Shuster M, Callaway CW, et al. Part 8: adult advanced cardiovascular life support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2010;122:S729-67.
11. Soar J, Nolan JP, Böttiger BW, Perkins GD, Lott C, Carli P, et al; Adult advanced life support section Collaborators. European Resuscitation Council Guidelines for Resuscitation 2015: Section 3. Adult advanced life support. Resuscitation. 2015;95:100-47.
12. Krijne R. Rate acceleration of ventricular tachycardia after a precordial chest thump. Am J Cardiol. 1984;53(7):964-5.
13. Pellis T, Kette F, Lovisa D, Franceschino E, Magagnin L, Mercante WP, et al. Utility of pre-cordial thump for treatment of out of hospital cardiac arrest: a prospective study. Resuscitation. 2009;80(1):17-23.
14. Sunde K, Eftestøl T, Askenberg C, Steen PA. Quality assessment of defribrillation and advanced life support using data from the medical control module of the defibrillator. Resuscitation. 1999;41(3):237-47.
15. Rea TD, Shah S, Kudenchuk PJ, Copass MK, Cobb LA. Automated external defibrillators: to what extent does the algorithm delay CPR? Ann Emerg Med. 2005;46(2):132-41.
16. Trayanova NA, Constantino J, Gurev V. Models of stretch-activated ventricular arrhythmias. J Electrocardiol. 2010;43(6):479-85.
17. Li W, Kohl P, Trayanova N. Myocardial ischemia lowers precordial thump efficacy: an inquiry into mechanisms using three-dimensional simulations. Heart Rhythm. 2006;3(2):179-86.
18. Haman L, Parizek P, Vojacek J. Precordial thump efficacy in termination of induced ventricular arrhythmias. Resuscitation. 2009;80(1):14-6.
19. Amir O, Schliamser JE, Nemer S, Arie M. Ineffectiveness of precordial thump for cardioversion of malignant ventricular tachyarrhythmias. Pacing Clin Electrophysiol. 2007;30(2):153-6.
20. Nehme Z, Andrew E, Bernard SA, Smith K. Treatment of monitored out-of-hospital ventricular fibrillation and pulseless ventricular tachycardia utilising the precordial thump. Resuscitation. 2013;84(12):1691-6.
21. Gertsch M, Hottinger S, Mettler D, Leupi F, Gurtner HP. Conversion of induced ventricular tachycardia by single and serial chest thumps: a study in domestic pigs 1 week after experimental myocardial infarction. Am Heart J. 1989;118(2):248-55.
22. Madias C, Maron BJ, Alsheikh-Ali AA, Rajab M, Estes NA 3rd, Link MS. Precordial thump for cardiac arrest is effective for asystole but not for ventricular fibrillation. Heart Rhythm. 2009;6(10):1495-500.
23. Miller J, Tresch D, Horwitz L, Thompson BM, Aprahamian C, Darin JC. The precordial thump. Ann Emerg Med. 1984;13(9):791-4.
24. Chalkias A, Xanthos T. Pathophysiology and pathogenesis of post-resuscitation myocardial stunning. Heart Fail Rev. 2012;17(1):117-28.
25. Chalkias A, Xanthos T. Post-cardiac arrest syndrome: Mechanisms and evaluation of adrenal insufficiency. World J Crit Care Med. 2012;1(1):4-9.
26. Chalkias A, Fanos V, Noto A, Castrén M, Gulati A, Svavarsdóttir H, et al. H NMR-metabolomics: can they be a useful tool in our understanding of cardiac arrest? Resuscitation. 2014;85(5):595-601.

27. Chalkias A, Xanthos T. Post-cardiac arrest brain injury: pathophysiology and treatment. J Neurol Sci. 2012;315(1-2):1-8.

28. Chalkias A, Xanthos T. Redox-mediated programed death of myocardial cells after cardiac arrest and cardiopulmonary resuscitation. Redox Rep.2012;17(2):80-3.

29. Leventis C, Chalkias A, Sampanis MA, Foulidou X, Xanthos T. Emergency airway management by paramedics: comparison between standard endotracheal intubation, laryngeal mask airway, and I-gel. Eur J Emerg Med. 2014;21(5):371-3.

30. Chalkias A, Koutsovasilis A, Mystrioti D, Dragoumanos V, Xanthos T. Outcomes of cardiopulmonary resuscitation efforts in a Greek tertiary hospital. Acute Card Care. 2013;15(2):34-7.

31. Pantazopoulos I, Aggelina A, Barouxis D, Papapanagiotou P, Troupis G, Kotsiomitis E, et al. Cardiologists' knowledge of the 2005 American Heart Association Resuscitation Guidelines: The Athens Study. Heart Lung. 2011;40(4):278-84.