

Odporúčania Európskej resuscitačnej rady pre resuscitáciu 2010

Sekcia 3. Elektrická liečba: Automatické externé defibrilátory, defibrilácia, kardioverzia a kardiostimulácia

Resuscitation 2010; 81: 1293 - 1304

Zoznam literatúry

1. Deakin CD, Nolan JP. European Resuscitation Council guidelines for resuscitation 2005. Section 3. Electrical therapies: automated external defibrillators, defibrillation, cardioversion and pacing. *Resuscitation* 2005;67(Suppl. 1):S25–37.
2. Proceedings of the 2005 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation* 2005;67:157–341.
3. Larsen MP, Eisenberg MS, Cummins RO, Hallstrom AP. Predicting survival from out-of-hospital cardiac arrest: a graphic model. *Ann Emerg Med* 1993;22:1652–8.
4. Valenzuela TD, Roe DJ, Cretin S, Spaite DW, Larsen MP. Estimating effectiveness of cardiac arrest interventions: a logistic regression survival model. *Circulation* 1997;96:3308–13.
5. Waalewijn RA, de Vos R, Tijssen JG, Koster RW. Survival models for out-of-hospital cardiopulmonary resuscitation from the perspectives of the bystander, the first responder, and the paramedic. *Resuscitation* 2001;51:113–22.
6. Weisfeldt ML, Sitlani CM, Ornato JP, et al. Survival after application of automatic external defibrillators before arrival of the emergency medical system: evaluation in the resuscitation outcomes consortium population of 21 million. *J Am Coll Cardiol* 2010;55:1713–20.
7. Myerburg RJ, Fenster J, Velez M, et al. Impact of community-wide police car deployment of automated external defibrillators on survival from out-of-hospital cardiac arrest. *Circulation* 2002;106:1058–64.
8. Capucci A, Aschieri D, Piepoli MF, Bardy GH, Iconomu E, Arvedi M. Tripling survival from sudden cardiac arrest via early defibrillation without traditional education in cardiopulmonary resuscitation. *Circulation* 2002;106:1065–70.
9. van Alem AP, Vrenken RH, de Vos R, Tijssen JG, Koster RW. Use of automated external defibrillator by first responders in out of hospital cardiac arrest: prospective controlled trial. *BMJ* 2003;327:1312.
10. Valenzuela TD, Bjerke HS, Clark LL, et al. Rapid defibrillation by nontraditional responders: the Casino Project. *Acad Emerg Med* 1998;5:414–5.
11. Spearpoint KG, Gruber PC, Brett SJ. Impact of the Immediate Life Support course on the incidence and outcome of in-hospital cardiac arrest calls: an observational study over 6 years. *Resuscitation* 2009;80:638–43.
12. Waalewijn RA, Tijssen JG, Koster RW. Bystander initiated actions in out-of-hospital cardiopulmonary resuscitation: results from the Amsterdam Resuscitation Study (ARREST). *Resuscitation* 2001;50:273–9.
13. Swor RA, Jackson RE, Cynar M, et al. Bystander CPR, ventricular fibrillation, and survival in witnessed, unmonitored out-of-hospital cardiac arrest. *Ann Emerg Med* 1995;25:780–4.
14. Holmberg M, Holmberg S, Herlitz J. Effect of bystander cardiopulmonary resuscitation in out-of-hospital cardiac arrest patients in Sweden. *Resuscitation* 2000;47:59–70.
15. Vaillancourt C, Verma A, Trickett J, et al. Evaluating the effectiveness of dispatch-assisted cardiopulmonary resuscitation instructions. *Acad Emerg Med* 2007;14:877–83.
16. O'Neill JF, Deakin CD. Evaluation of telephone CPR advice for adult cardiac arrest patients. *Resuscitation* 2007;74:63–7.
17. Yang CW, Wang HC, Chiang WC, et al. Interactive video instruction improves the quality of dispatcher-assisted chest compression-only cardiopulmonary resuscitation in simulated cardiac arrests. *Crit Care Med* 2009;37:490–5.
18. Yang CW, Wang HC, Chiang WC, et al. Impact of adding video communication to dispatch instructions on the quality of rescue breathing in simulated cardiac arrests—a randomized controlled study. *Resuscitation* 2008;78:327–32.
19. Koster RW, Baubin MA, Caballero A, et al. European Resuscitation Council Guidelines for Resuscitation 2010. Section 2. Adult basic life support and use of automated external defibrillators. *Resuscitation* 2010;81:1277–92.
20. Berdowski J, Schulten RJ, Tijssen JG, van Alem AP, Koster RW. Delaying a shock after takeover from the automated external defibrillator by paramedics is associated with decreased survival. *Resuscitation* 2010;81:287–92.

21. Zafari AM, Zarter SK, Heggen V, et al. A program encouraging early defibrillation results in improved in-hospital resuscitation efficacy. *J Am Coll Cardiol* 2004;44:846–52.
22. Destro A, Marzaloni M, Sermasi S, Rossi F. Automatic external defibrillators in the hospital as well? *Resuscitation* 1996;31:39–43.
23. Forcina MS, Farhat AY, O’Neil WW, Haines DE. Cardiac arrest survival after implementation of automated external defibrillator technology in the in-hospital setting. *Crit Care Med* 2009;37:1229–36.
24. Domanovits H, Meron G, Sterz F, et al. Successful automatic external defibrillator operation by people trained only in basic life support in a simulated cardiac arrest situation. *Resuscitation* 1998;39:47–50.
25. Cusnir H, Tongia R, Sheka KP, et al. In hospital cardiac arrest: a role for automatic defibrillation. *Resuscitation* 2004;63:183–8.
26. Chan PS, Krumholz HM, Nichol G, Nallamothu BK. Delayed time to defibrillation after in-hospital cardiac arrest. *N Engl J Med* 2008;358:9–17.
27. Cummins RO, Eisenberg MS, Litwin PE, Graves JR, Hearne TR, Hallstrom AP. Automatic external defibrillators used by emergency medical technicians: a controlled clinical trial. *JAMA* 1987;257:1605–10.
28. Stults KR, Brown DD, Kerber RE. Efficacy of an automated external defibrillator in the management of out-of-hospital cardiac arrest: validation of the diagnostic algorithm and initial clinical experience in a rural environment. *Circulation* 1986;73:701–9.
29. Kramer-Johansen J, Edelson DP, Abella BS, Becker LB, Wik L, Steen PA. Pauses in chest compression and inappropriate shocks: a comparison of manual and semi-automatic defibrillation attempts. *Resuscitation* 2007;73:212–20.
30. Pytte M, Pedersen TE, Ottem J, Rokvam AS, Sunde K. Comparison of hands-off time during CPR with manual and semi-automatic defibrillation in a manikin model. *Resuscitation* 2007;73:131–6.
31. Edelson DP, Abella BS, Kramer-Johansen J, et al. Effects of compression depth and pre-shock pauses predict defibrillation failure during cardiac arrest. *Resuscitation* 2006;71:137–45.
32. Eftestol T, Sunde K, Steen PA. Effects of interrupting precordial compressions on the calculated probability of defibrillation success during out-of-hospital cardiac arrest. *Circulation* 2002;105:2270–3.
33. Yu T, Weil MH, Tang W, et al. Adverse outcomes of interrupted precordial compression during automated defibrillation. *Circulation* 2002;106:368–72.
34. Wik L, Kramer-Johansen J, Myklebust H, et al. Quality of cardiopulmonary resuscitation during out-of-hospital cardiac arrest. *JAMA* 2005;293:299–304.
35. Abella BS, Alvarado JP, Myklebust H, et al. Quality of cardiopulmonary resuscitation during in-hospital cardiac arrest. *JAMA* 2005;293:305–10.
36. Kerber RE, Becker LB, Bourland JD, et al. Automatic external defibrillators for public access defibrillation: recommendations for specifying and reporting arrhythmia analysis algorithm performance, incorporating new waveforms, and enhancing safety. A statement for health professionals from the American Heart Association Task Force on Automatic External Defibrillation, Subcommittee on AED Safety and Efficacy. *Circulation* 1997;95:1677–82.
37. Dickey W, Dalzell GW, Anderson JM, Adgey AA. The accuracy of decision-making of a semi-automatic defibrillator during cardiac arrest. *Eur Heart J* 1992;13:608–15.
38. Atkinson E, Mikysa B, Conway JA, et al. Specificity and sensitivity of automated external defibrillator rhythm analysis in infants and children. *Ann Emerg Med* 2003;42:185–96.
39. Cecchin F, Jorgenson DB, Berul CI, et al. Is arrhythmia detection by automatic external defibrillator accurate for children? Sensitivity and specificity of an automatic external defibrillator algorithm in 696 pediatric arrhythmias. *Circulation* 2001;103:2483–8.
40. van Alem AP, Sanou BT, Koster RW. Interruption of cardiopulmonary resuscitation with the use of the automated external defibrillator in out-of-hospital cardiac arrest. *Ann Emerg Med* 2003;42:449–57.
41. Rea TD, Helbock M, Perry S, et al. Increasing use of cardiopulmonary resuscitation during out-of-hospital ventricular fibrillation arrest: survival implications of guideline changes. *Circulation* 2006;114:2760–5.
42. Gundersen K, Kvaloy JT, Kramer-Johansen J, Steen PA, Eftestol T. Development of the probability of return of spontaneous circulation in intervals without chest compressions during out-of-hospital cardiac arrest: an observational study. *BMC Med* 2009;7:6.
43. Lloyd MS, Heeke B, Walter PF, Langberg JJ. Hands-on defibrillation: an analysis of electrical current flow through rescuers in direct contact with patients during biphasic external defibrillation. *Circulation* 2008;117:2510–4.
44. Miller PH. Potential fire hazard in defibrillation. *JAMA* 1972;221:192.
45. Hummel III RS, Ornato JP, Weinberg SM, Clarke AM. Spark-generating properties of electrode gels used during defibrillation. A potential fire hazard. *JAMA* 1988;260:3021–4.
46. ECRI. Defibrillation in oxygen-enriched environments [hazard]. *Health Devices* 1987;16:113–4.

47. Lefever J, Smith A. Risk of fire when using defibrillation in an oxygen enriched atmosphere. *Med Devices Agency Safety Notices* 1995;3:1–3.
48. Ward ME. Risk of fires when using defibrillators in an oxygen enriched atmosphere. *Resuscitation* 1996;31:173.
49. Theodorou AA, Gutierrez JA, Berg RA. Fire attributable to a defibrillation attempt in a neonate. *Pediatrics* 2003;112:677–9.
50. Robertshaw H, McAnulty G. Ambient oxygen concentrations during simulated cardiopulmonary resuscitation. *Anaesthesia* 1998;53:634–7.
51. Cantello E, Davy TE, Koenig KL. The question of removing a ventilation bag before defibrillation. *J Accid Emerg Med* 1998;15:286.
52. Deakin CD, Paul V, Fall E, Petley GW, Thompson F. Ambient oxygen concentrations resulting from use of the Lund University Cardiopulmonary Assist System (LUCAS) device during simulated cardiopulmonary resuscitation. *Resuscitation* 2007;74:303–9.
53. Kerber RE, Kouba C, Martins J, et al. Advance prediction of transthoracic impedance in human defibrillation and cardioversion: importance of impedance in determining the success of low-energy shocks. *Circulation* 1984;70:303–8.
54. Kerber RE, Grayzel J, Hoyt R, Marcus M, Kennedy J. Transthoracic resistance in human defibrillation. Influence of bodyweight, chest size, serial shocks, paddle size and paddle contact pressure. *Circulation* 1981;63:676–82.
55. Sado DM, Deakin CD, Petley GW, Clewlow F. Comparison of the effects of removal of chest hair with not doing so before external defibrillation on transthoracic impedance. *Am J Cardiol* 2004;93:98–100.
56. Walsh SJ, McCarty D, McClelland AJ, et al. Impedance compensated biphasic waveforms for transthoracic cardioversion of atrial fibrillation: a multi-centre comparison of antero-apical and antero-posterior pad positions. *Eur Heart J* 2005;26:1298–302.
57. Deakin CD, Sado DM, Petley GW, Clewlow F. Differential contribution of skin impedance and thoracic volume to transthoracic impedance during external defibrillation. *Resuscitation* 2004;60:171–4.
58. Deakin C, Sado D, Petley G, Clewlow F. Determining the optimal paddle force for external defibrillation. *Am J Cardiol* 2002;90:812–3.
59. Manegold JC, Israel CW, Ehrlich JR, et al. External cardioversion of atrial fibrillation in patients with implanted pacemaker or cardioverter-defibrillator systems: a randomized comparison of monophasic and biphasic shock energy application. *Eur Heart J* 2007;28:1731–8.
60. Alferness CA. Pacemaker damage due to external countershock in patients with implanted cardiac pacemakers. *Pacing Clin Electrophysiol* 1982;5:457–8.
61. Panacek EA, Munger MA, Rutherford WF, Gardner SF. Report of nitro patch explosions complicating defibrillation. *Am J Emerg Med* 1992;10:128–9.
62. Wrenn K. The hazards of defibrillation through nitroglycerin patches. *Ann Emerg Med* 1990;19:1327–8.
63. Pagan-Carlo LA, Spencer KT, Robertson CE, Dengler A, Birkett C, Kerber RE. Transthoracic defibrillation: importance of avoiding electrode placement directly on the female breast. *J Am Coll Cardiol* 1996;27:449–52.
64. Deakin CD, Sado DM, Petley GW, Clewlow F. Is the orientation of the apical defibrillation paddle of importance during manual external defibrillation? *Resuscitation* 2003;56:15–8.
65. Kirchhof P, Eckardt L, Loh P, et al. Anterior-posterior versus anterior-lateral electrode positions for external cardioversion of atrial fibrillation: a randomised trial. *Lancet* 2002;360:1275–9.
66. Botto GL, Politi A, Bonini W, Broffoni T, Bonatti R. External cardioversion of atrial fibrillation: role of paddle position on technical efficacy and energy requirements. *Heart* 1999;82:726–30.
67. Alp NJ, Rahman S, Bell JA, Shahi M. Randomised comparison of antero-lateral versus antero-posterior paddle positions for DC cardioversion of persistent atrial fibrillation. *Int J Cardiol* 2000;75:211–6.
68. Mathew TP, Moore A, McIntyre M, et al. Randomised comparison of electrode positions for cardioversion of atrial fibrillation. *Heart* 1999;81:576–9.
69. Deakin CD, McLaren RM, Petley GW, Clewlow F, Dalrymple-Hay MJ. Effects of positive end-expiratory pressure on transthoracic impedance—implications for defibrillation. *Resuscitation* 1998;37:9–12.
70. American National Standard: automatic external defibrillators and remote controlled defibrillators (DF39). Arlington, Virginia: Association for the Advancement of Medical Instrumentation; 1993.
71. Deakin CD, McLaren RM, Petley GW, Clewlow F, Dalrymple-Hay MJ. A comparison of transthoracic impedance using standard defibrillation paddles and self-adhesive defibrillation pads. *Resuscitation* 1998;39:43–6.
72. Stults KR, Brown DD, Cooley F, Kerber RE. Self-adhesive monitor/defibrillation pads improve prehospital defibrillation success. *Ann Emerg Med* 1987;16:872–7.

73. Bojar RM, Payne DD, Rastegar H, Diehl JT, Cleveland RJ. Use of self-adhesive external defibrillator pads for complex cardiac surgical procedures. *Ann Thorac Surg* 1988;46:587–8.
74. Bradbury N, Hyde D, Nolan J. Reliability of ECG monitoring with a gel pad/paddle combination after defibrillation. *Resuscitation* 2000;44:203–6.
75. Brown J, Rogers J, Soar J. Cardiac arrest during surgery and ventilation in the prone position: a case report and systematic review. *Resuscitation* 2001;50:233–8.
76. Perkins GD, Davies RP, Soar J, Thickett DR. The impact of manual defibrillation technique on no-flow time during simulated cardiopulmonary resuscitation. *Resuscitation* 2007;73:109–14.
77. Wilson RF, Sirna S, White CW, Kerber RE. Defibrillation of high-risk patients during coronary angiography using self-adhesive, preapplied electrode pads. *Am J Cardiol* 1987;60:380–2.
78. Kerber RE, Martins JB, Kelly KJ, et al. Self-adhesive preapplied electrode pads for defibrillation and cardioversion. *J Am Coll Cardiol* 1984;3:815–20.
79. Kerber RE, Martins JB, Ferguson DW, et al. Experimental evaluation and initial clinical application of new self-adhesive defibrillation electrodes. *Int J Cardiol* 1985;8:57–66.
80. Perkins GD, Roberts C, Gao F. Delays in defibrillation: influence of different monitoring techniques. *Br J Anaesth* 2002;89:405–8.
81. Chamberlain D. Gel pads should not be used for monitoring ECG after defibrillation. *Resuscitation* 2000;43:159–60.
82. Callaway CW, Sherman LD, Mosesso Jr VN, Dietrich TJ, Holt E, Clarkson MC. Scaling exponent predicts defibrillation success for out-of-hospital ventricular fibrillation cardiac arrest. *Circulation* 2001;103:1656–61.
83. Eftestol T, Sunde K, Aase SO, Husoy JH, Steen PA. Predicting outcome of defibrillation by spectral characterization and nonparametric classification of ventricular fibrillation in patients with out-of-hospital cardiac arrest. *Circulation* 2000;102:1523–9.
84. Eftestol T, Wik L, Sunde K, Steen PA. Effects of cardiopulmonary resuscitation on predictors of ventricular fibrillation defibrillation success during out-of-hospital cardiac arrest. *Circulation* 2004;110:10–5.
85. Weaver WD, Cobb LA, Dennis D, Ray R, Hallstrom AP, Copass MK. Amplitude of ventricular fibrillation waveform and outcome after cardiac arrest. *Ann Intern Med* 1985;102:53–5.
86. Brown CG, Dzwonczyk R. Signal analysis of the human electrocardiogram during ventricular fibrillation: frequency and amplitude parameters as predictors of successful countershock. *Ann Emerg Med* 1996;27:184–8.
87. Callahan M, Braun O, Valentine W, Clark DM, Zegans C. Prehospital cardiac arrest treated by urban first-responders: profile of patient response and prediction of outcome by ventricular fibrillation waveform. *Ann Emerg Med* 1993;22:1664–77.
88. Strohmenger HU, Lindner KH, Brown CG. Analysis of the ventricular fibrillation ECG signal amplitude and frequency parameters as predictors of countershock success in humans. *Chest* 1997;111:584–9.
89. Strohmenger HU, Eftestol T, Sunde K, et al. The predictive value of ventricular fibrillation electrocardiogram signal frequency and amplitude variables in patients with out-of-hospital cardiac arrest. *Anesth Analg* 2001;93:1428–33.
90. Podbregar M, Kovacic M, Podbregar-Mars A, Brezocnik M. Predicting defibrillation success by ‘genetic’ programming in patients with out-of-hospital cardiac arrest. *Resuscitation* 2003;57:153–9.
91. Menegazzi JJ, Callaway CW, Sherman LD, et al. Ventricular fibrillation scaling exponent can guide timing of defibrillation and other therapies. *Circulation* 2004;109:926–31.
92. Povoas HP, Weil MH, Tang W, Bisera J, Klouche K, Barbatsis A. Predicting the success of defibrillation by electrocardiographic analysis. *Resuscitation* 2002;53:77–82.
93. Noc M, Weil MH, Tang W, Sun S, Pernat A, Bisera J. Electrocardiographic prediction of the success of cardiac resuscitation. *Crit Care Med* 1999;27:708–14.
94. Strohmenger HU, Lindner KH, Keller A, Lindner IM, Pfenninger EG. Spectral analysis of ventricular fibrillation and closed-chest cardiopulmonary resuscitation. *Resuscitation* 1996;33:155–61.
95. Noc M, Weil MH, Gazmuri RJ, Sun S, Biscera J, Tang W. Ventricular fibrillation voltage as a monitor of the effectiveness of cardiopulmonary resuscitation. *J Lab Clin Med* 1994;124:421–6.
96. Lightfoot CB, Nrems P, Callaway CW, et al. Dynamic nature of electrocardiographic waveform predicts rescue shock outcome in porcine ventricular fibrillation. *Ann Emerg Med* 2003;42:230–41.
97. Marn-Pernat A, Weil MH, Tang W, Pernat A, Bisera J. Optimizing timing of ventricular defibrillation. *Crit Care Med* 2001;29:2360–5.
98. Hamprecht FA, Achleitner U, Krismer AC, et al. Fibrillation power, an alternative method of ECG spectral analysis for prediction of countershock success in a porcine model of ventricular fibrillation. *Resuscitation* 2001;50:287–96.

99. Amann A, Achleitner U, Antretter H, et al. Analysing ventricular fibrillation ECG-signals and predicting defibrillation success during cardiopulmonary resuscitation employing N(alpha)-histograms. *Resuscitation* 2001;50:77–85.
100. Brown CG, Griffith RF, Van Ligten P, et al. Median frequency—a new parameter for predicting defibrillation success rate. *Ann Emerg Med* 1991;20:787–9.
101. Amann A, Rheinberger K, Achleitner U, et al. The prediction of defibrillation outcome using a new combination of mean frequency and amplitude in porcine models of cardiac arrest. *Anesth Analg* 2002;95:716–22, table of contents.
102. Cobb LA, Fahrenbruch CE, Walsh TR, et al. Influence of cardiopulmonary resuscitation prior to defibrillation in patients with out-of-hospital ventricular fibrillation. *JAMA* 1999;281:1182–8.
103. Wik L, Hansen TB, Fylling F, et al. Delaying defibrillation to give basic cardiopulmonary resuscitation to patients with out-of-hospital ventricular fibrillation: a randomized trial. *JAMA* 2003;289:1389–95.
104. Berg RA, Hilwig RW, Kern KB, Ewy GA. Precountershock cardiopulmonary resuscitation improves ventricular fibrillation median frequency and myocardial readiness for successful defibrillation from prolonged ventricular fibrillation: a randomized, controlled swine study. *Ann Emerg Med* 2002;40:563–70.
105. Berg RA, Hilwig RW, Ewy GA, Kern KB. Precountershock cardiopulmonary resuscitation improves initial response to defibrillation from prolonged ventricular fibrillation: a randomized, controlled swine study. *Crit Care Med* 2004;32:1352–7.
106. Kolarova J, Ayoub IM, Yi Z, Gazmuri RJ. Optimal timing for electrical defibrillation after prolonged untreated ventricular fibrillation. *Crit Care Med* 2003;31:2022–8.
107. Indik JH, Hilwig RW, Zuercher M, Kern KB, Berg MD, Berg RA. Preshock cardiopulmonary resuscitation worsens outcome from circulatory phase ventricular fibrillation with acute coronary artery obstruction in swine. *Circ Arrhythm Electrophysiol* 2009;2:179–84.
108. Baker PW, Conway J, Cotton C, et al. Defibrillation or cardiopulmonary resuscitation first for patients with out-of-hospital cardiac arrests found by paramedics to be in ventricular fibrillation? A randomised control trial. *Resuscitation* 2008;79:424–31.
109. Jacobs IG, Finn JC, Ozer HF, Jelinek GA. CPR before defibrillation in out-of-hospital cardiac arrest: a randomized trial. *Emerg Med Aust* 2005;17:39–45.
110. Hayakawa M, Gando S, Okamoto H, Asai Y, Uegaki S, Makise H. Shortening of cardiopulmonary resuscitation time before the defibrillation worsens the outcome in out-of-hospital VF patients. *Am J Emerg Med* 2009;27:470–4.
111. Bradley SM, Gabriel EE, Aufderheide TP, et al. Survival Increases with CPR by Emergency Medical Services before defibrillation of out-of-hospital ventricular fibrillation or ventricular tachycardia: observations from the Resuscitation Outcomes Consortium. *Resuscitation* 2010;81:155–62.
112. Christenson J, Andrusiek D, Everson-Stewart S, et al. Chest compression fraction determines survival in patients with out-of-hospital ventricular fibrillation. *Circulation* 2009;120:1241–7.
113. Deakin CD, Nolan JP, Soar J, et al. European Resuscitation Council Guidelines for Resuscitation 2010. Section 4. Adult advanced life support. *Resuscitation* 2010;81:1305–52.
114. Berg RA, Sanders AB, Kern KB, et al. Adverse hemodynamic effects of interrupting chest compressions for rescue breathing during cardiopulmonary resuscitation for ventricular fibrillation cardiac arrest. *Circulation* 2001;104:2465–70.
115. Kern KB, Hilwig RW, Berg RA, Sanders AB, Ewy GA. Importance of continuous chest compressions during cardiopulmonary resuscitation: improved outcome during a simulated single lay-rescuer scenario. *Circulation* 2002;105:645–9.
116. Valenzuela TD, Kern KB, Clark LL, et al. Interruptions of chest compressions during emergency medical systems resuscitation. *Circulation* 2005;112:1259–65.
117. Bain AC, Swerdlow CD, Love CJ, et al. Multicenter study of principles-based waveforms for external defibrillation. *Ann Emerg Med* 2001;37:5–12.
118. Poole JE, White RD, Kanz KG, et al. Low-energy impedance-compensating biphasic waveforms terminate ventricular fibrillation at high rates in victims of out-of-hospital cardiac arrest. *LIFE Investigators. J Cardiovasc Electrophysiol* 1997;8:1373–85.
119. Schneider T, Martens PR, Paschen H, et al. Multicenter, randomized, controlled trial of 150-J biphasic shocks compared with 200- to 360-J monophasic shocks in the resuscitation of out-of-hospital cardiac arrest victims. *Optimized Response to Cardiac Arrest (ORCA) Investigators. Circulation* 2000;102:1780–7.
120. 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;46:132–41.
121. Olasveengen TM, Vik E, Kuzovlev A, Sunde K. Effect of implementation of new resuscitation guidelines on quality of cardiopulmonary resuscitation and survival. *Resuscitation* 2009;80:407–11.

122. Bobrow BJ, Clark LL, Ewy GA, et al. Minimally interrupted cardiac resuscitation by emerge 123. Steinmetz J, Barnung S, Nielsen SL, Risom M, Rasmussen LS. Improved survival after an out-of-hospital cardiac arrest using new guidelines. *Acta Anaesthesiol Scand* 2008;52:908–13.
124. Jost D, Degrange H, Verret C, et al. DEFI 2005: a randomized controlled trial of the effect of automated external defibrillator cardiopulmonary resuscitation protocol on outcome from out-of-hospital cardiac arrest. *Circulation* 2010;121:1614–22.
125. Soar J, Perkins GD, Abbas G, et al. European Resuscitation Council Guidelines for Resuscitation 2010. Section 8. Cardiac arrest in special circumstances: electrolyte abnormalities, poisoning, drowning, accidental hypothermia, hyperthermia, asthma, anaphylaxis, cardiac surgery, trauma, pregnancy, electrocution. *Resuscitation* 2010;81:1400–33.
126. Didon JP, Fontaine G, White RD, Jekova I, Schmid JJ, Cansell A. Clinical experience with a low-energy pulsed biphasic waveform in out-of-hospital cardiac arrest. *Resuscitation* 2008;76:350–3.
127. Li Y, Wang H, Cho JH, et al. Comparison of efficacy of pulsed biphasic waveform and rectilinear biphasic waveform in a short ventricular fibrillation pig model. *Resuscitation* 2009;80:1047–51.
128. van Alem AP, Chapman FW, Lank P, Hart AA, Koster RW. A prospective, randomised and blinded comparison of first shock success of monophasic and biphasic waveforms in out-of-hospital cardiac arrest. *Resuscitation* 2003;58:17–24.
129. Carpenter J, Rea TD, Murray JA, Kudenchuk PJ, Eisenberg MS. Defibrillation waveform and post-shock rhythm in out-of-hospital ventricular fibrillation cardiac arrest. *Resuscitation* 2003;59:189–96.
130. Morrison LJ, Dorian P, Long J, et al. Out-of-hospital cardiac arrest rectilinear biphasic to monophasic damped sine defibrillation waveforms with advanced life support intervention trial (ORBIT). *Resuscitation* 2005;66:149–57.
131. Gliner BE, White RD. Electrocardiographic evaluation of defibrillation shocks delivered to out-of-hospital sudden cardiac arrest patients. *Resuscitation* 1999;41:133–44.
132. Freeman K, Hendey GW, Shalit M, Stroh G. Biphasic defibrillation does not improve outcomes compared to monophasic defibrillation in out-of-hospital cardiac arrest. *Prehosp Emerg Care* 2008;12:152–6.
133. Hess EP, Atkinson EJ, White RD. Increased prevalence of sustained return of spontaneous circulation following transition to biphasic waveform defibrillation. *Resuscitation* 2008;77:39–45.
134. Kudenchuk PJ, Cobb LA, Copass MK, Olsufka M, Maynard C, Nichol G. Transthoracic incremental monophasic versus biphasic defibrillation by emergency responders (TIMBER): a randomized comparison of monophasic with biphasic waveform ascending energy defibrillation for the resuscitation of out-of-hospital cardiac arrest due to ventricular fibrillation. *Circulation* 2006;114:2010–8.
135. Mittal S, Ayati S, Stein KM, et al. Transthoracic cardioversion of atrial fibrillation: comparison of rectilinear biphasic versus damped sinewave monophasic shocks. *Circulation* 2000;101:1282–7.
136. Page RL, Kerber RE, Russell JK, et al. Biphasic versus monophasic shock waveform for conversion of atrial fibrillation: the results of an international randomized, double-blind multicenter trial. *J Am Coll Cardiol* 2002;39:1956–63.
137. Koster RW, Dorian P, Chapman FW, Schmitt PW, O’Grady SG, Walker RG. A randomized trial comparing monophasic and biphasic waveform shocks for external cardioversion of atrial fibrillation. *Am Heart J* 2004;147:e20.
138. Ambler JJ, Deakin CD. A randomized controlled trial of efficacy and ST change following use of the Welch-Allyn MRL PIC biphasic waveform versus damped sine monophasic waveform for external DC cardioversion. *Resuscitation* 2006;71:146–51.
139. Pagan-Carlo LA, Allan JJ, Spencer KT, Birkett CL, Myers R, Kerber RE. Encircling overlapping multipulse shock waveforms for transthoracic defibrillation. *J Am Coll Cardiol* 1998;32:2065–71.
140. Zhang Y, Ramabadran RS, Boddicker KA, et al. Triphasic waveforms are superior to biphasic waveforms for transthoracic defibrillation: experimental studies. *J Am Coll Cardiol* 2003;42:568–75.
141. Zhang Y, Rhee B, Davies LR, et al. Quadriphasic waveforms are superior to triphasic waveforms for transthoracic defibrillation in a cardiac arrest swine model with high impedance. *Resuscitation* 2006;68:251–8.
142. Kerber RE. External defibrillation: new technologies. *Ann Emerg Med* 1984;13:794–7.
143. Joglar JA, Kessler DJ, Welch PJ, et al. Effects of repeated electrical defibrillations on cardiac troponin I levels. *Am J Cardiol* 1999;83:270–2. A6.
144. Kerber RE, Martins JB, Kienzle MG, et al. Energy, current, and success in defibrillation and cardioversion: clinical studies using an automated impedance-based method of energy adjustment. *Circulation* 1988;77:1038–46.
145. Martens PR, Russell JK, Wolcke B, et al. Optimal Response to Cardiac Arrest study: defibrillation waveform effects. *Resuscitation* 2001;49:233–43.

146. Weaver WD, Cobb LA, Copass MK, Hallstrom AP. Ventricular defibrillation: a comparative trial using 175-J and 320-J shocks. *N Engl J Med* 1982;307:1101–6.
147. Tang W, Weil MH, Sun S, et al. The effects of biphasic and conventional monophasic defibrillation on postresuscitation myocardial function. *J Am Coll Cardiol* 1999;34:815–22.
148. Gliner BE, Jorgenson DB, Poole JE, et al. Treatment of out-of-hospital cardiac arrest with a low-energy impedance-compensating biphasic waveform automatic external defibrillator. The LIFE Investigators. *Biomed Instrum Technol* 1998;32:631–44.
149. White RD, Blackwell TH, Russell JK, Snyder DE, Jorgenson DB. Transthoracic impedance does not affect defibrillation, resuscitation or survival in patients with out-of-hospital cardiac arrest treated with a non-escalating biphasic waveform defibrillator. *Resuscitation* 2005;64:63–9.
150. Stiell IG, Walker RG, Nesbitt LP, et al. BIPHASIC Trial: a randomized comparison of fixed lower versus escalating higher energy levels for defibrillation in out-of-hospital cardiac arrest. *Circulation* 2007;115:1511–7.
151. Walsh SJ, McClelland AJ, Owens CG, et al. Efficacy of distinct energy delivery protocols comparing two biphasic defibrillators for cardiac arrest. *Am J Cardiol* 2004;94:378–80.
152. Higgins SL, Herre JM, Epstein AE, et al. A comparison of biphasic and monophasic shocks for external defibrillation. *Physio-Control Biphasic Investigators. Prehosp Emerg Care* 2000;4:305–13.
153. Berg RA, Samson RA, Berg MD, et al. Better outcome after pediatric defibrillation dosage than adult dosage in a swine model of pediatric ventricular fibrillation. *J Am Coll Cardiol* 2005;45:786–9.
154. Killingsworth CR, Melnick SB, Chapman FW, et al. Defibrillation threshold and cardiac responses using an external biphasic defibrillator with pediatric and adult adhesive patches in pediatric-sized piglets. *Resuscitation* 2002;55:177–85.
155. Tang W, Weil MH, Sun S, et al. The effects of biphasic waveform design on post-resuscitation myocardial function. *J Am Coll Cardiol* 2004;43:1228–35.
156. Xie J, Weil MH, Sun S, et al. High-energy defibrillation increases the severity of postresuscitation myocardial dysfunction. *Circulation* 1997;96:683–8.
157. Koster RW, Walker RG, Chapman FW. Recurrent ventricular fibrillation during advanced life support care of patients with prehospital cardiac arrest. *Resuscitation* 2008;78:252–7.
158. Walker RG, Koster RW, Sun C, et al. Defibrillation probability and impedance change between shocks during resuscitation from out-of-hospital cardiac arrest. *Resuscitation* 2009;80:773–7.
159. Hess EP, Russell JK, Liu PY, White RD. A high peak current 150-J fixed-energy defibrillation protocol treats recurrent ventricular fibrillation (VF) as effectively as initial VF. *Resuscitation* 2008;79:28–33.
160. Deakin CD, Ambler JJ. Post-shock myocardial stunning: a prospective randomised double-blind comparison of monophasic and biphasic waveforms. *Resuscitation* 2006;68:329–33.
161. Khaykin Y, Newman D, Kowalewski M, Korley V, Dorian P. Biphasic versus monophasic cardioversion in shock-resistant atrial fibrillation. *J Cardiovasc Electrophysiol* 2003;14:868–72.
162. Kmec J. Comparison the effectiveness of damped sine wave monophasic and rectilinear biphasic shocks in patients with persistent atrial fibrillation. *Kardiologia* 2006;15:265–78.
163. Kosior DA, Szulec M, Torbicki A, Opolski G, Rabczenko D. A decrease of enlarged left atrium following cardioversion of atrial fibrillation predicts the long-term maintenance of sinus rhythm. *Kardiologia Pol* 2005;62:428–37.
164. Kuisma M, Suominen P, Korpela R. Paediatric out-of-hospital cardiac arrests: epidemiology and outcome. *Resuscitation* 1995;30:141–50.
165. Sirbaugh PE, Pepe PE, Shook JE, et al. A prospective, population-based study of the demographics, epidemiology, management, and outcome of out-of-hospital pediatric cardiopulmonary arrest. *Ann Emerg Med* 1999;33:174–84.
166. Hickey RW, Cohen DM, Strausbaugh S, Dietrich AM. Pediatric patients requiring CPR in the prehospital setting. *Ann Emerg Med* 1995;25:495–501.
167. Atkins DL, Everson-Stewart S, Sears GK, et al. Epidemiology and outcomes from out-of-hospital cardiac arrest in children: the Resuscitation Outcomes Consortium Epistry-Cardiac Arrest. *Circulation* 2009;119:1484–91.
168. Appleton GO, Cummins RO, Larson MP, Graves JR. CPR and the single rescuer: at what age should you “call first” rather than “call fast”? *Ann Emerg Med* 1995;25:492–4.
169. Ronco R, King W, Donley DK, Tilden SJ, Outcome. cost at a children’s hospital following resuscitation for out-of-hospital cardiopulmonary arrest. *Arch Pediatr Adolesc Med* 1995;149:210–4.
170. Losek JD, Hennes H, Glaeser P, Hendley G, Nelson DB. Prehospital care of the pulseless, nonbreathing pediatric patient. *Am J Emerg Med* 1987;5:370–4.

171. Mogayzel C, Quan L, Graves JR, Tiedeman D, Fahrenbruch C, Herndon P. Out-of-hospital ventricular fibrillation in children and adolescents: causes and outcomes. *Ann Emerg Med* 1995;25:484–91.
172. Safranek DJ, Eisenberg MS, Larsen MP. The epidemiology of cardiac arrest in young adults. *Ann Emerg Med* 1992;21:1102–6.
173. Berg RA, Chapman FW, Berg MD, et al. Attenuated adult biphasic shocks compared with weight-based monophasic shocks in a swine model of prolonged pediatric ventricular fibrillation. *Resuscitation* 2004;61:189–97.
174. Tang W, Weil MH, Jorgenson D, et al. Fixed-energy biphasic waveform defibrillation in a pediatric model of cardiac arrest and resuscitation. *Crit Care Med* 2002;30:2736–41.
175. Clark CB, Zhang Y, Davies LR, Karlsson G, Kerber RE. Pediatric transthoracic defibrillation: biphasic versus monophasic waveforms in an experimental model. *Resuscitation* 2001;51:159–63.
176. Gurnett CA, Atkins DL. Successful use of a biphasic waveform automated external defibrillator in a high-risk child. *Am J Cardiol* 2000;86:1051–3.
177. Atkins DL, Jorgenson DB. Attenuated pediatric electrode pads for automated external defibrillator use in children. *Resuscitation* 2005;66:31–7.
178. Gutgesell HP, Tacker WA, Geddes LA, Davis S, Lie JT, McNamara DG. Energy dose for ventricular defibrillation of children. *Pediatrics* 1976;58:898–901.
179. Bar-Cohen Y, Walsh EP, Love BA, Cecchin F. First appropriate use of automated external defibrillator in an infant. *Resuscitation* 2005;67:135–7.
180. Divekar A, Soni R. Successful parental use of an automated external defibrillator for an infant with long-QT syndrome. *Pediatrics* 2006;118:e526–9.
181. Rodriguez-Nunez A, Lopez-Herce J, Garcia C, Dominguez P, Carrillo A, Bellon JM. Pediatric defibrillation after cardiac arrest: initial response and outcome. *Crit Care* 2006;10:R113.
182. Samson RA, Nadkarni VM, Meaney PA, Carey SM, Berg MD, Berg RA. Outcomes of in-hospital ventricular fibrillation in children. *N Engl J Med* 2006;354:2328–39.
183. Lown B. Electrical reversion of cardiac arrhythmias. *Br Heart J* 1967;29:469–89.
184. Ambler JJ, Deakin CD. A randomised controlled trial of the effect of biphasic or monophasic waveform on the incidence and severity of cutaneous burns following external direct current cardioversion. *Resuscitation* 2006;71:293–300.
185. Joglar JA, Hamdan MH, Ramaswamy K, et al. Initial energy for elective external cardioversion of persistent atrial fibrillation. *Am J Cardiol* 2000;86:348–50.
186. Boodhoo L, Mitchell AR, Bordoli G, Lloyd G, Patel N, Sulke N. DC cardioversion of persistent atrial fibrillation: a comparison of two protocols. *Int J Cardiol* 2007;114:16–21.
187. Boos C, Thomas MD, Jones A, Clarke E, Wilbourne G, More RS. Higher energy monophasic DC cardioversion for persistent atrial fibrillation: is it time to start at 360 joules? *Ann Noninvasive Electrocardiol* 2003;8:121–6.
188. Glover BM, Walsh SJ, McCann CJ, et al. Biphasic energy selection for transthoracic cardioversion of atrial fibrillation. The BEST AF Trial. *Heart* 2008;94:884–7.
189. Rashba EJ, Gold MR, Crawford FA, Leman RB, Peters RW, Shorofsky SR. Efficacy of transthoracic cardioversion of atrial fibrillation using a biphasic, truncated exponential shock waveform at variable initial shock energies. *Am J Cardiol* 2004;94:1572–4.
190. Pinski SL, Sgarbossa EB, Ching E, Trohman RG. A comparison of 50-J versus 100-J shocks for direct-current cardioversion of atrial flutter. *Am Heart J* 1999;137:439–42.
191. Alatawi F, Gurevitz O, White R. Prospective, randomized comparison of two biphasic waveforms for the efficacy and safety of transthoracic biphasic cardioversion of atrial fibrillation. *Heart Rhythm* 2005;2:382–7.
192. Kerber RE, Kienzle MG, Olshansky B, et al. Ventricular tachycardia rate and morphology determine energy and current requirements for transthoracic cardioversion. *Circulation* 1992;85:158–63.
193. Hedges JR, Syverud SA, Dalsey WC, Feero S, Easter R, Shultz B. Prehospital trial of emergency transcutaneous cardiac pacing. *Circulation* 1987;76:1337–43.
194. Barthell E, Troiano P, Olson D, Stueven HA, Hendley G. Prehospital external cardiac pacing: a prospective, controlled clinical trial. *Ann Emerg Med* 1988;17:1221–6.
195. Cummins RO, Graves JR, Larsen MP, et al. Out-of-hospital transcutaneous pacing by emergency medical technicians in patients with asystolic cardiac arrest. *N Engl J Med* 1993;328:1377–82.
196. Ornato JP, Peberdy MA. The mystery of bradyasystole during cardiac arrest. *Ann Emerg Med* 1996;27:576–87.
197. Niemann JT, Adomian GE, Garner D, Rosborough JP. Endocardial and transcutaneous cardiac pacing, calcium chloride, and epinephrine in postcountershock asystole and bradycardias. *Crit Care Med* 1985;13:699–704.

198. Quan L, Graves JR, Kinder DR, Horan S, Cummins RO. Transcutaneous cardiac pacing in the treatment of out-of-hospital pediatric cardiac arrests. *Ann Emerg Med* 1992;21:905–9.
199. Dalsey WC, Syverud SA, Hedges JR. Emergency department use of transcutaneous pacing for cardiac arrests. *Crit Care Med* 1985;13:399–401.
200. Knowlton AA, Falk RH. External cardiac pacing during in-hospital cardiac arrest. *Am J Cardiol* 1986;57:1295–8.
201. Ornato JP, Carveth WL, Windle JR. Pacemaker insertion for prehospital bradyasystolic cardiac arrest. *Ann Emerg Med* 1984;13:101–3.
202. Stockwell B, Bellis G, Morton G, et al. Electrical injury during “hands on” defibrillation-A potential risk of internal cardioverter defibrillators? *Resuscitation* 2009;80:832–4.
203. Monsieurs KG, Conraads VM, Goethals MP, Snoeck JP, Bossaert LL. Semiautomatic external defibrillation and implanted cardiac pacemakers: understanding the interactions during resuscitation. *Resuscitation* 1995;30:127–31.