

OPIS PRZYPADKU/CASE REPORT

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Cardiac arrest following electrocution using unconventional CPR: a case study**Przemysław Wołoszyn, Ignacy Baumberg**

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**Abstract**

Background. Prehospital resuscitation of a healthy male aged 36, who developed ventricular fibrillation, following electrocution with unconventional CPR management. **Material and methods.** During CPR, ECG, End-tidal CO₂ and SpO₂ were monitored in relation to the chest compression technique as well as the mode of ventilation. The CPR data recorded by the Zoll X-Series defibrillator was analyzed in relation to the CPR technique applied. **Results.** The following observations were found: - EtCO₂ readings in the endotracheal tube (19 mmHg) appeared even before ventilation was introduced; - the high impact, push hard, push fast and hands off technique appeared to provide higher EtCO₂ values (up to 42 mmHg) and changes in the morphology of chest compression waveform on the ECG screen (higher and narrow - up to 0,06 sec) in comparison to the standard, widely taught and used, chest compression technique (EtCO₂ up to 36 mmHg, the waveform width up to 0.10 sec); - introduction of asynchronous ventilation with the use of a portable ventilator during constant chest compressions was associated with a decrease in EtCO₂ readings (24 mmHg) in comparison with the standard 30:2 pattern with ventilation provided by a bag; - the first sign of ROSC was the sudden increase of the EtCO₂ level up to 72 mmHg. Following ROSC chest compressions were discontinued before completing a 2 minute cycle of CPR. **Conclusions.** 1. Opening the airway, before intubation, was performed by head tilt and pulling the jaw and keeping the mouth open. This action decreased the risk of obturated nasal ducts during the breathing assessment. 2. Ultimate shortening of the breaks in chest compressions was obtained by finishing the resuscitation cycle with chest compression and not 2 breaths as recommended by the ERC ALS protocols. 3. Sudden and rapid, push hard, push fast, hands off chest compressions facilitated the immediate, fast, physiological full chest recoil extending the time of blood flow into the chest, probably improving cardiac output during CPR which was indicated by ET CO₂ level. 4. A synchronous, 30:2 pattern of compression/ventilation after intubation provided appropriate levels of Et CO₂. 4. Achieving ROSC led to early discontinuation of chest compressions without performing 2 minutes of CPR after defibrillation. *Anestezjologia i Ratownictwo 2015; 9: 381-386.*

Keywords: CPR technique, hands off, high impact, push hard and fast, EtCO₂ monitoring, ROSC

Introduction

The International Liaison Committee on Resuscitation (ILCOR) issues standardized guidelines for cardio-pulmonary resuscitation following cardiac arrest based upon an evaluation of the published clinical evidence base. We report a case of a successful resuscitation following electrocution monitored with capnography where there were significant departures

from the standard ILCOR CPR procedures.

Material and methods

During CPR, ECG, End-tidal CO₂ and SpO₂ were monitored in relation to the chest compression technique as well as the mode of ventilation. The CPR data recorded by the Zoll X-Series defibrillator was analyzed in relation to the CPR technique applied.

Case study - results

A healthy, 36 year old male, suffered a cardiac arrest caused by electrocution due to the contact of his fishing rod with the high voltage line. Responding crew on arrival 10 minutes after the emergency call, found an unconscious, not breathing male in recovery position with no signs of circulation, with no bystander resuscitation in progress. The sequence of actions was as follows:

08:07

The casualty was turned to supine position, the airway opened by head tilt and jaw thrust with the mouth kept open. Chest compressions were started according to the ILCOR guidelines.

8:10

ECG assessment: VF - defibrillation was carried

out with a delivered energy of 150J.

Constant chest compression was continued and an endotracheal tube (9 mm at the depth of 23 cm) with an EtCO₂ probe attached, was introduced. The position of the tube was verified by EtCO₂ measurement - 19 mmHg just after inserting the distal end of endotracheal tube below epiglottis. After starting ventilation the EtCO₂ level rose to 23 mmHg. Until the next rhythm assessment the EtCO₂ varied between 23 and 36 mmHg. An 18 G intravenous cannula was inserted and *i.v.* infusion of normal saline at maximum flow was commenced.

CPR was continued according to 30:2 pattern with use of bag valve with reservoir fed with oxygen at the flow of 15 l/min. In order to minimize the breaks in chest compressions, the CPR cycles, before rhythm assessment and defibrillations, were finished after the 5-th series of compressions. Pulse oximetry measured on the left thumb showed no reading.

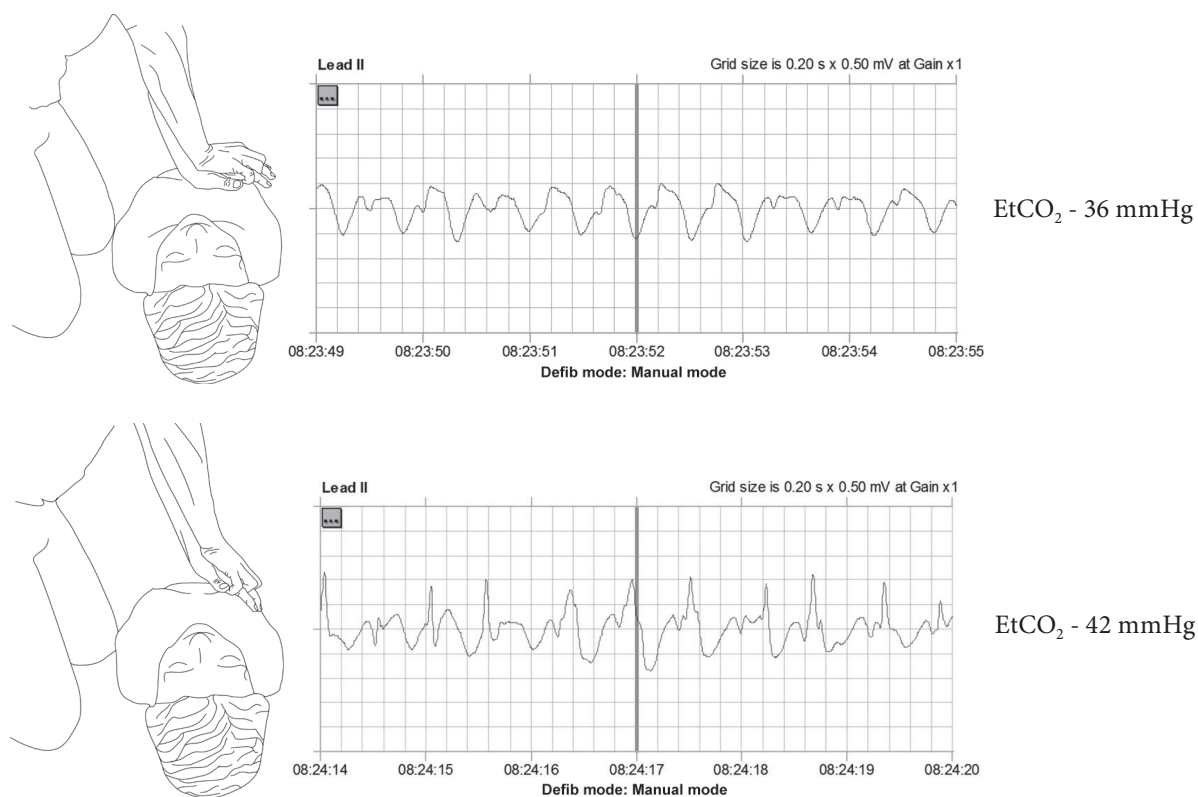


Figure 1. Comparison of two techniques of CPR - standard and hands off (immediate separation of palm from chest wall at the end of compression phase) presented as schematic pictures with relevant waveforms readings seen on ECG screen and EtCO₂ values

- **8:14**
ECG assessment: VF - defibrillation with 151 J.
EtCO₂ oscillating between 32 - 36 mmHg, no SpO₂ readings.
- **8:15**
1 mg of epinephrine was administered, the infusion of normal saline was maintained, CPR 30:2. The first reading of SpO₂ showed 55%.
- **8:18**
ECG assessment: VF - defibrillation with 188 J.
A second dose of epinephrine 1 mg was given and an infusion of 300 mg amiodarone was commenced. Due to the fact that previous defibrillation was ineffective, the technique of chest compression was changed - from the standard one describe by ILCOR to push hard and push fast, hands off and hight impact technique in order to achieve the immediate chest recoil, better ventricular filling and increase in cardiac output. The compression frequency was approx. 120-130/ min. The EtCO₂ value - 42 mmHg, SpO₂ - up to 60%
- **8:23**
ECG assessment: VF - defibrillation with 186J.
After defibrillation 1 mg of epinephrine was administered and the flow of another 500 ml normal saline was commenced. During the first minute of this loop chest compressions were performed according to ILCOR recommendation (figure 1.1). Then compression techni-

que was again changed to the revised form (figure 1.2)

The portable ventilator was connected and set at: FiO₂ - 1.0, RR - 10/min, TV - approx. 600 ml, max. pressure 30 cmH₂O. The CPR pattern was changed from synchronous (30:2) to asynchronous with constant chest compressions. The EtCO₂ decreased to 24 mmHg, SpO₂ was approx. 60%.

- **8:26, 14 sec**
Rhythm assessment - VF high amplitude. Defibrillation with 188J. At this stage the SpO₂ varied between 71 and 78%
- **8:26, 33 sec**
The next dose of epinephrine was prepared but just before administration a sudden rise in EtCO₂ readings up to 70-72 mmHg was detected. Given the possibility of ROSC this dose was suspended. Simultaneously a supraventricular rhythm appeared on the screen. Because of the ECG change and the high level of EtCO₂, approx. 1000 ml of fluids delivered intravenously and visible pulsation in upper abdominal area, chest compressions were withdrawn immediately, before finishing the CPR loop. The pulse at left carotid artery was detected several seconds later.
- **8:30**
Patient assessment showed: NIBP - 157/92, HR - 145/min, EtCO₂ - 27 - 33 mmHg, SpO₂ - 95-98%, pupils slightly constricted, unreactive.

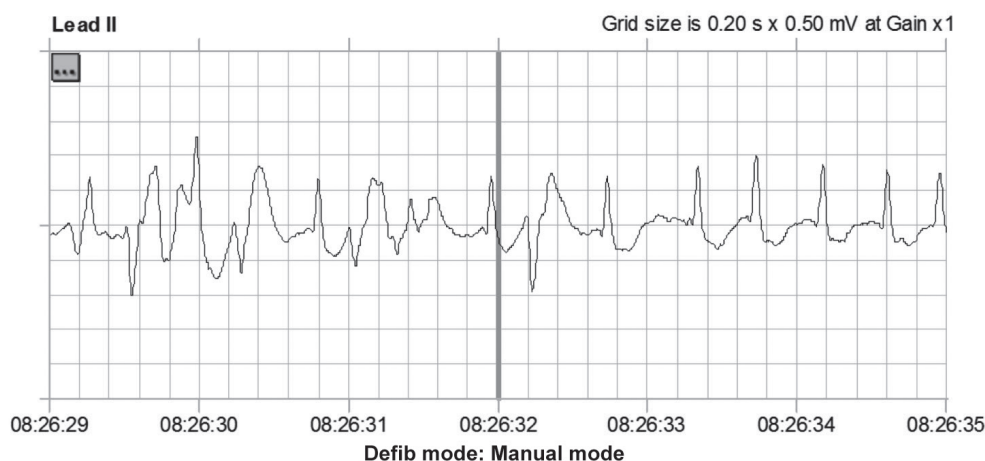


Figure 2. Chest compressions valves and return of supraventricular rhythm (associated with EtCO₂ rise)

■ 8:45

The casualty was transferred by rescue helicopter to the hospital. After 31 days of intensive care the patient was transferred to the internal medicine ward.

Discussion

We report the successful resuscitation of a victim of accidental electrocution but with some important deviations from the standard ILCOR resuscitation guidelines. These were as follow:

Breathing was assessed with the casualty lying in recovery position. Acting strictly according to ILCOR guidelines [1], if the breathing assessment had been performed in supine position there would have been a delay in starting CPR.

Opening the airway was achieved by means of head tilt and pulling the jaw with mouth open [2], not chin lift [3] which closes the mouth and in case of nasal obstruction it would lead to failure in opening airways.

It should be noted that maintenance of open airways during chest compressions may lead to small flow of gases in airways, as indicated by several authors [4].

Following intubation the position of endotracheal tube was confirmed by EtCO₂ detection and the shape of capnographic curve [5] as well as by auscultation.

The 19 mmHg of EtCO₂ detection appeared just after inserting the distal end of endotracheal tube below epiglottis. This early measurement of EtCO₂ was facilitated by attaching the EtCO₂ probe to the endotracheal tube before intubation. This reading was probably caused by minimal ventilation associated with chest compressions or by mass movement of gases along the trachea [4,6]. Deakin [7] noticed, that average expiration volume appearing at the chest compression is 41,5 ml and is significantly smaller, than dead space in the same patients. Considering the small size of this volume (in comparison to average dead space of 63 ml in intubated patients [8]), it seems more likely, that it was the mass movement of gases that caused so early detection of the presence of CO₂ during the intubation.

During chest compressions the EtCO₂ readings varied, depending on compression technique used. The technique applied at the beginning of CPR followed conventional ILCOR guidelines requiring the extended elbows and constant contact of rescuer's hands with chest wall, also during recoil phase [1]. This may cause an extension of the recoil time, as this time depends on the abilities of muscular system of the rescuer who

has to extend vertebral column after each compression. With this technique applied Tomlinson estimated average residual force remaining on chest wall during decompression phase at the level of 1.7 ± 1.0 kg, which corresponded to an average residual depth of 3 ± 2 mm [9], which may cause the decrease of chest capacity at the end of recoil phase. In our case the standard technique described above gave EtCO₂ between 19 and 36 mmHg.

After the third defibrillation the chest compression technique was changed. This alternate technique was based on high-impact [10], push hard, push fast [11] and hands off [12] approach. This technique would follow the physiological mode of ventricular contraction by brief compression phase and would facilitate the immediate chest recoil by interrupting the contact of rescuer's hand with chest wall in decompression phase. Aufderheide [12] noted that hands off technique decreased compression duty cycle and was 129 times more likely to provide complete chest wall recoil compared to the standard hand position without differences in accuracy of hand placement and depth of compression.

It is thought that this technique may:

- increase aortal pressure during rapid compression [10], improving cerebral perfusion and accelerate the closing of heart valves which may improve coronary blood flow;
- shorten the time of elevated intrathoratic pressure - this leads to extension of chest filling time;
- facilitate the natural, fast and full chest recoil that accelerates the blood flow to the chest and extends the inflow time before the next compression.

The modified chest compression technique changed the waveform seen on the ECG screen and altered EtCO₂ readings. The amplitude of the curve increased and the average time decreased from approx. 0,1 sec to 0,06, and was accompanied by an EtCO₂ increase to 42 mmHg. As the ventilation pattern remained unchanged this reading may suggest, that the venous return increased, as well as pulmonary flow and cardiac output [13]. Moreover it should be noted that in cases with a median chest compression release velocity (CCRV) of 301–400 mm/s and median CCRV of > 400 mm/s were associated with greater survival to hospital discharge when compared to the reference group with CCRV < 300 mm/s [14].

Also the relative hypovolemia [10,12] that may occur due to lack of muscle tension of blood vessels walls as well as muscles surrounding blood vessels,

was considered while choosing the frequency of chest compressions and volume of fluids administered.

In order to shorten the breaks in chest compressions, the CPR loops were finished at the end of the last, 5th series of compressions, without two breaths, which are recommended in ILCOR ALS algorithm.

After some 19 seconds of chest compressions following the 5th defibrillation a rapid rise of EtCO₂ level, from 24 mmHg to 72-74 mmHg, was observed indicating ROSC [5, 16]. Compressions were discontinued, the CPR loop was not completed, signs of circulation were observed. According to Axelsson, a palpable pulse might appear even a minute after significant rise of EtCO₂ level [15].

ROSC in this case was associated with effective defibrillation following the appropriate CPR and rapid infusion of approx. 1000 ml of fluids in order to compensate relative hypovolemia. This activity prepared the heart for return of supraventricular rhythm, although routine fluidotherapy during CPR remains controversial [4].

Conclusions

We report a successful monitored resuscitation following cardiac arrest due to electrocution with deviations from the conventional ILCOR CPR guidelines. The results are summarized as follow:

1. Breathing assessment was performed along with analysis of the level of consciousness in patient lying in recovery, not supine, position.

2. Opening the airways was performed by head tilt and pulling the jaw and keeping the mouth open. In case of an obstruction of nasal ducts chin lift may not open the airways.
3. Push hard, push fast, high impact and hands off chest compressions facilitated the immediate chest recoil and may have improved cardiac output during CPR.
4. CPR loops, before rhythm assessment, were finished after last, 5th series of compressions and not 2 breaths according to ALS-ERC algorithm.
5. EtCO₂ readings and signs of circulation allowed for stopping the chest compressions before finishing the CPR loop.

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Conflict of interest

None

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References

1. The European Resuscitation Council Guidelines for Resuscitation. Section 2. Adult basic life support and use of automated external defibrillators. *Resuscitation*. 2010;81.
2. Safar P. Failure of manual respiration. *J. Appl. Physiol.* 1959;14:84.
3. Guildner CW. Resuscitation: opening the airway. A comparative study of techniques for opening an airway obstructed by the tongue. *JACEP*. 1976;5:588-90.
4. Geddes LA, Rundell A, Otlewski M, Pargett M. How much lung ventilation is obtained with only chest-compression CPR? *Cardiovasc Eng.* 2008;8:145-8.
5. The European Resuscitation Council Guidelines for Resuscitation, 2010. Section 4. Adult advanced life support. *Resuscitation*. 2010;81.
6. Nunn JF. *Applied Respiratory Physiology with special reference to anesthesia*. Butterworth Ltd. 1969;319.
7. Deakin CD, O'Neill JF, Tabor T. Does compression-only cardiopulmonary resuscitation generate adequate passive ventilation during cardiac arrest? *Resuscitation*. 2007;75:53-9.
8. Nunn JF, Hill DW. Respiratory dead space and arterial to end-tidal CO₂ tension difference in anesthetized man. *J Appl Physiol.* 1960;15:383-9.
9. Tomlinson A.E, Nysaether J, Kramer-Johansen J. et al. Compression force–depth relationship during out-of-hospital cardiopulmonary resuscitation. *Resuscitation*. 2007; 72: 364–370.

10. Swenson RD, Weaver WD, Niskanen RA, Martin J, Dahlberg S. Hemodynamics in humans during conventional and experimental methods of cardiopulmonary resuscitation. *Circulation*. 1988;78:630-9.
11. Sayre MR, Berg RA, Cave DM, Page RL, Potts J, White RD. Hands-only (compression-only) cardiopulmonary resuscitation: a call to action for bystander response to adults who experience out-of-hospital sudden cardiac arrest: a science advisory for the public from the American Heart Association Emergency Cardiovascular Care Committee. *Circulation*. 2008;117:2162-7.
12. Aufderheide TP, Pirrallo RG, Yannopoulos D. Incomplete chest wall decompression: a clinical evaluation of CPR performance by EMS personnel and assessment of alternative manual chest compression–decompression techniques. *Resuscitation*. 2005; 64:353-62.
13. Pernat A, Weil MH, Sun S, Tang W. Stroke volumes and end-tidal carbon dioxide generated by precordial compression during ventricular fibrillation. *Crit Care Med*. 2003;31:1819-23.
14. Cheskes S, Commonc MR, Byersc AP, Zhanc C, et al. The association between chest compression release velocity and outcomes from out-of-hospital cardiac arrest. *Resuscitation*. 2015; 86:38–43.
15. Axelsson Ch. Evaluation of various strategies to improve outcome after out-of- hospital cardiac arrest with particular focus on mechanical chest compressions. University of Gothenburg. 2010;36.
16. Sanders AB, Kern KB, Otto CW, Milander MM, Ewy GA. End-tidal carbon dioxide monitoring during cardiopulmonary resuscitation. A prognostic indicator for survival. *Jama*. 1989;262:1347-51.