OPIS PRZYPADKU/CASE REPORT
Otrzymano/Submitted: 30.09.2015 • Zaakceptowano/Accepted: 03.12.2015

Cardiac arrest following electrocution using unconventional CPR: a case study

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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 CO_2 and SpO_2 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: - $EtCO_2$ 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 $EtCO_2$ 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 ($EtCO_2$ 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 $EtCO_2$ 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 $ETCO_2$ level. 4. A synchronous, 30:2 pattern of compression/ventilation after intubation provided appropriate levels of Et CO_2. 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, hight impact, push hard and fast, $EtCO_2$ 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 CO_2 and SpO_2 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 $EtCO_2$ probe attached, was introduced. The position of the tube was verified by $EtCO_2$ measurement - 19 mmHg just after inserting the distal end of endotracheal tube below epiglottis. After starting ventilation the $EtCO_2$ level rose to 23 mmHg. Until the next rhythm assessment the $EtCO_2$ 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.

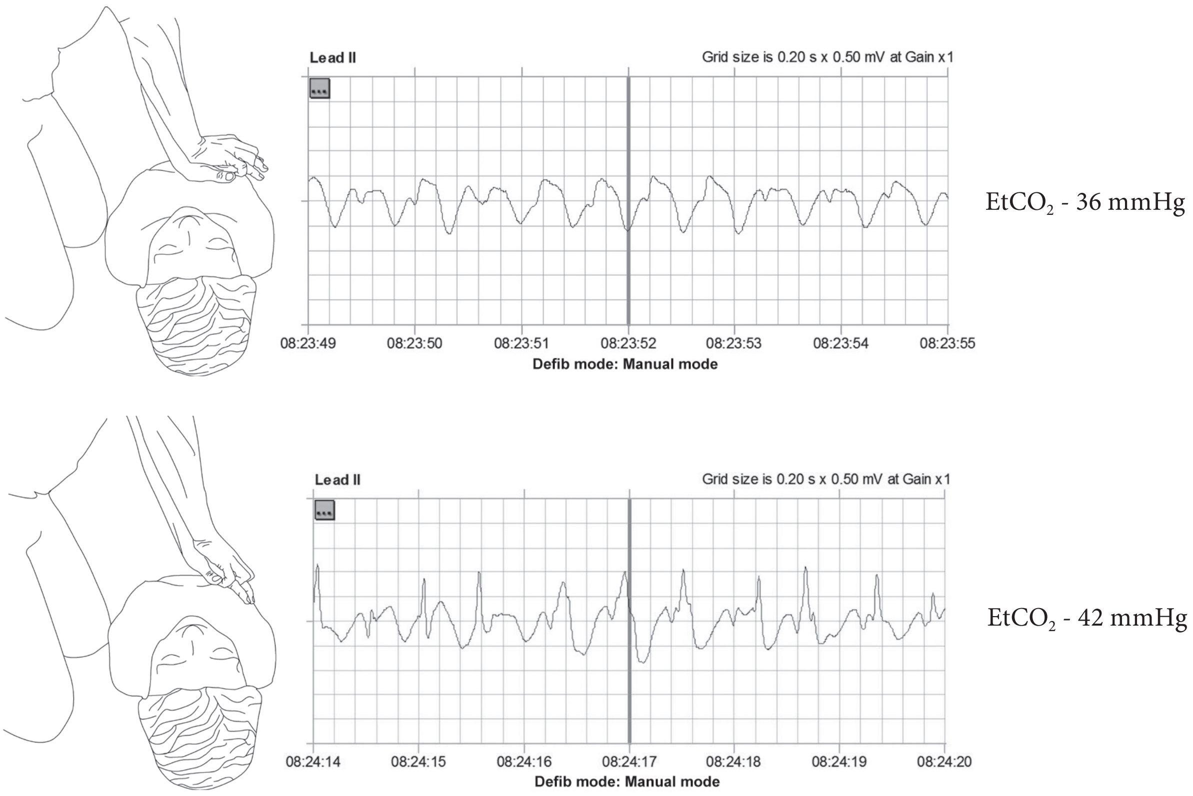

Figure 1. Comparison of two techniques of CPR - standard and hands off (immediate separation of palm form chest wall at the end of compression phase) presented as schematic pictures with relevant waveforms readings seen on ECG screen and $EtCO_2$ values

- **8:14**

ECG assessment: VF - defibrillation with 151 J.

$EtCO_2$ oscillating between 32 - 36 mmHg, no SpO_2 readings.

- **8:15**

1 mg of epinephrine was administered, the infusion of normal saline was maintained, CPR 30:2. The first reading of SpO_2 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 $EtCO_2$ value - 42 mmHg, SpO_2 - 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 technique was again changed to the revised form (figure 1.2)

The portable ventilator was connected and set at: FiO_2 - 1.0, RR - 10/min, TV – approx. 600 ml, max. pressure 30 cmH_2O. The CPR pattern was changed from synchronous (30:2) to asynchronous with constant chest compressions. The $EtCO_2$ decreased to 24 mmHg, SpO_2 was approx. 60%.

- **8:26, 14 sec**

Rhythm assessment - VF high amplitude. Defibrillation with 188J. At this stage the SpO_2 varied between 71 and 78%

- **8:26, 33 sec**

The next dose of epinephrine was prepared but just before administration a sudden rise in $EtCO_2$ 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 $EtCO_2$, 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, $EtCO_2$ - 27 - 33 mmHg, SpO_2 - 95-98%, pupils slightly constricted, unreactive.

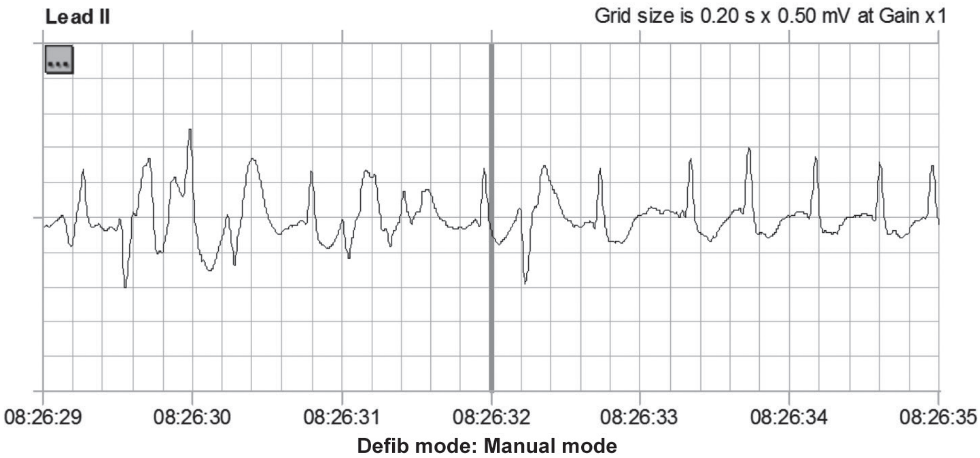

Figure 2. Chest compressions valves and return of supraventricular rhythm (associated with $EtCO_2$ rise)

- **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 $EtCO_2$ detection and the shape of capnographic curve [5] as well as by auscultation.

The 19 mmHg of $EtCO_2$ detection appeared just after inserting the distal end of endotracheal tube below epiglottis. This early measurement of $EtCO_2$ was facilitated by attaching the $EtCO_2$ 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 CO_2 during the intubation.

During chest compressions the $EtCO_2$ 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 $EtCO_2$ 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 $EtCO_2$ 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 $EtCO_2$ 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 $EtCO_2$ 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 $EtCO_2$ 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, 5 th series of compressions and not 2 breaths according to ALS-ERC algorithm.
5. $EtCO_2$ readings and signs of circulation allowed for stopping the chest compressions before finishing the CPR loop.

Acknowledgments

The authors take this opportunity to gratefully acknowledge the assistance and contribution of Prof. David Baker from Neckar Hospital in Paris who reviewed the whole manuscript carefully and provided us with some important suggestions.

Conflict of interest

None

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