

# Effect of End-Tidal Carbon Dioxide Measurement on Resuscitation Efficiency and Termination of Resuscitation

## End Tidal Karbonmonoksit Ölçümünün Resüsitasyon Etkinliği ve Sonlandırılması Üzerine Etkisi

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### SUMMARY

#### Objectives

In this study, the value of end-tidal carbon dioxide (ETCO<sub>2</sub>) levels measured by capnometry were evaluated as indicators of resuscitation effectiveness and survival in patients presenting to the emergency department with cardiopulmonary arrest.

#### Methods

ETCO<sub>2</sub> was measured after 2 minutes of compression or 150 compressions. ETCO<sub>2</sub> values were measured in patients that were intubated and in those who underwent chest compression. The following parameters were recorded for each patient: demographic data, chronic illness, respiration type, pre-hospital CPR, arrest rhythm, arterial blood gas measurements, ETCO<sub>2</sub> values with an interval of 5 minutes between the measurement and the estimated time of arrest, time to return to spontaneous circulation.

#### Results

Cardiac arrest developed in 97 cases, including 56 who were out of the hospital and 41 who were in the hospital. Fifty of these patients returned to spontaneous circulation, and just one of these had an initial ETCO<sub>2</sub> value below 10 mmHg. The mean of the final ETCO<sub>2</sub> levels was 36.4±4.46 among Patients who Return to Spontaneous Circulation (RSCPs) and 11.74±7.01 among those that died. In all rhythms; Asystole, pulseless electrical activity (PEA) and VF/VT; Overall, RSCPs had higher ETCO<sub>2</sub> levels than the cases who died. Among the PEA patients undergoing in-hospital arrests and those asystolic patients undergoing out of hospital arrest, the ETCO<sub>2</sub> values of the RSCPs were significantly higher than those of the cases who died.

#### Conclusions

ETCO<sub>2</sub> levels predicted survival as well as the effectiveness of CPR for patients who received CPR and were monitored by capnometry in the emergency department. As a result, we believe that it would be suitable to use capnometry in all units where the CPR is performed.

**Key words:** Capnography; capnometry; cardiopulmonary arrest; resuscitation.

### ÖZET

#### Amaç

Çalışmamızda acil servise kardiopulmoner arrest ile gelen hastalarda kapnometre ile ölçülen endtidal karbondioksit seviyelerinin uygulanan KPR'nin etkinliği ve hasta sağkalımının göstergesi olarak kullanılabilmesinin araştırılması amaçlandı.

#### Gereç ve Yöntem

Acil servisimize göğüs kompresyonuna başlanarak entübe edilen (acil ambulansla getirilmişse tüp kontrolü yapılan) ve göğüs kompresyonunun ikinci dakikanın sonunda ya da 150 bası sonrası ilk ölçülen end-tidal karbondioksit (ETCO<sub>2</sub>) değeri 0. dakika ETCO<sub>2</sub> olarak kabul edildi. Daha sonra beşer dakika ara ile ETCO<sub>2</sub> değerleri kaydedildi. Hastaların demografik verileri, kronik hastalık varlığı, 112 ile gelmiş neyle solutulduğu, hastane öncesi KPR uygulanması, hasta arrest ritmi, kan gazı değerleri, tahmini arrest süresi ile hastanın spontan dolaşımın dönme süresini içeren parametreler kaydedildi.

#### Bulgular

Çalışmaya alınan 97 olgunun 56'sı hastane dışı (HDKA), 41'i hastane içi gelişen arrest (HİKA) hastalardan oluşmaktaydı. Spontan dolaşıma geri dönen (SDGD) 50 olgudan sadece bir tanesinin ilk ETCO<sub>2</sub> düzeyi 10 mmHg'nin altında olarak ölçüldü. Son ETCO<sub>2</sub> düzeyi ortalamaları SDGD'lerde 36.4±4.46, hayatını kaybedenlerde 11.74±7.01 olarak bulundu. Asistoli, NEA, VF/VT ritimlerinin tamamında SDGD olgularında ETCO<sub>2</sub> düzeyleri exitus olanlardan yüksekti (p=0.001). Hastane içi nabızsız elektriksel aktivite (NEA) hastaların ve hastane dışı asistolik hastaların, SDGD olgularında ETCO<sub>2</sub> değerleri eksitus olan olguların ETCO<sub>2</sub> değerlerinden yüksekti.

#### Sonuç

Acil servislerde KPR uygulanan ve kapnometre ile izlenen hastalarda ETCO<sub>2</sub> düzeyi sağ kalım, KPR'nin etkinliği ve devamı açısından yol göstericidir bu yüzden KPR uygulanan tüm birimlerde kapnometre kullanımının uygun olacağını düşünüyoruz.

**Anahtar sözcükler:** Kardiopulmoner arrest; kapnometre; resüsitasyon.

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## Introduction

Modern cardiopulmonary resuscitation (CPR) began with airway opening methods by Peter Safar in 1959 and external cardiac compression by William Kouwenhoven in 1960. However, resuscitation trials have been reported for several centuries.<sup>[1,2]</sup> Since modern resuscitation applications have been used, researchers have been studying ways to prevent cardiac arrest and have been working to develop effective resuscitation techniques.

Capnometry is a method used to verify the accuracy of the endotracheal tube placement in cardiopulmonary arrest patients.<sup>[3]</sup> High end-tidal carbon dioxide (ETCO<sub>2</sub>) level measurements by capnometry may be important to successful resuscitations.<sup>[4-6]</sup> In this study, we aimed to investigate the effect of quantitative ETCO<sub>2</sub> measurement with capnometry during CPR to determine the effectiveness of CPR and patient prognosis in cardiopulmonary arrest patients.

## Materials and Methods

After obtaining approval from the ethics committee and conforming to the provisions of the Declaration of Helsinki in 1995 (as revised in Seoul 2008), non-traumatic out-of-hospital and in-hospital cardiopulmonary arrest patients over 18 years of age were enrolled in this cross-sectional study between February 1, 2012 and June 30, 2012.

Resuscitations were performed according to the American Heart Association (AHA) Advanced Cardiac Life Support (ACLS) guidelines. ETCO<sub>2</sub> levels were measured and the time of admission to the emergency department was noted as was the time of intubation. ETCO<sub>2</sub> values were recorded after the 6th ventilation in patients who underwent cardiopulmonary arrest during the emergency service follow-up. ETCO<sub>2</sub> levels were measured and noted in five minute intervals starting at the time of resuscitation. Resuscitation time was determined by the responsible doctor who managed the resuscitation. Patients who underwent a second cardiopulmonary arrest and were resuscitated were excluded from the study.

The patients were divided into two groups: 1. Exitus patients (EP), and 2. Returned to spontaneous circulation patients (RSCP). Demographic data, chronic disease, ventilation method in the ambulance, out-of-hospital CPR application, arrest rhythm, blood gases, ETCO<sub>2</sub> levels recorded at intervals of five minutes, predicted arrest time period and return time of spontaneous circulation were recorded. Patients brought by ambulance who then underwent cardiac arrest in the emergency department were accepted as in-hospital cardiac arrest patients.

We used a standard capnography device (Medilab Cap 10) for ETCO<sub>2</sub> measurements.

SPSS 15.0 for Windows program was used for statistical evaluation. Chi-square test and Fisher's exact test was used to compare data between groups. One Way Anova and independent sample t-tests were used for parametric variables. Kruskal Wallis and Mann Whitney U-tests were used to compare nonparametric variables. Results were considered statistically significant at  $p < 0.05$ .

## Results

In our study, 37 (38.1%) of the 97 patients were female, and 60 (61.9%) were male. The mean age of the males was  $66.75 \pm 13.84$  years (min: 56, max: 89) and was  $71.57 \pm 11.52$  years (47-87) for females. The overall mean age of males and females combined was  $68.59 \pm 13.15$  years (26-89). The ages of the males and females were not significantly different ( $p > 0.05$ ).

Forty-one (42.3%) patients were In-hospital cardiac arrest patients (IHCAP) and 56 (55.7%) were Out-hospital cardiac arrest patients (OHCAP). Twenty two (75%) of the in-hospital arrest patients died and 19 (72%) of them returned to spontaneous circulation. Twenty-five (66.64%) out-of-hospital patients (OHCAP) died and 31 (63.55%) returned to spontaneous circulation. The mean ages of the patients who died and those who returned to spontaneous circulation were not significantly different ( $p > 0.05$ ).

Survival due to ventilation techniques (Laryngeal Mask Airway, Bad Valve, Combitube, etc.) performed on patients in the ambulance before admission to the emergency department admission of the IHCAPs and OHCAPs were not significantly different ( $p > 0.05$ ).

In our study ages of 72 (74.6%) patients were over 60 years of age. Seventy-one (73.2%) patients were brought to our emergency department by ambulance. There were no significant differences in the survival of the groups with regards to admission time, arrival by ambulance, location of cardiac arrest, and the diagnosis and presence of chronic disease ( $p > 0.05$ ). However, the survival of the patients with regards to arrest time period were significantly different ( $p < 0.05$ ).

CPR application ratios were not significantly different between the groups in OHCAPs ( $p > 0.05$ ). Survival due to arrest rhythm ( $p < 0.05$ ) and arrest time period ratios ( $p < 0.05$ ) were significantly different between groups ( $p = 0.001$ ). Eighty-one percent of asystole patients, 36% of pulseless electric activity (PEA) patients and 58% of the VF/VT patients died.

The exitus cases' arrest rhythms were 36.2% ( $n = 17$ ) asystole, 40.4% ( $n = 19$ ) PEA, and 23.4% ( $n = 11$ ) VF/VT. Of 50 RSCPs, 27

(54%) returned to spontaneous circulation in the first 15 minutes, 37 (74%) in first 20 minutes and 45 (90%) in the first 30 minutes.

The mean first  $\text{ETCO}_2$  measurement of RTSC patients was  $18.6 \pm 9.13$  and the mean final  $\text{ETCO}_2$  was  $36.4 \pm 4.46$ . The mean first  $\text{ETCO}_2$  value of exitus patients was  $15.91 \pm 8.35$  and the mean final  $\text{ETCO}_2$  value was  $11.74 \pm 7.06$  mm/Hg.

The difference between the first  $\text{ETCO}_2$  ( $18.6 \pm 9.13$ ) and the last  $\text{ETCO}_2$  ( $36.4 \pm 4.46$ ) levels were significantly different in RSCPs ( $p < 0.05$ ) and in EPs ( $p < 0.05$ ).

The  $\text{ETCO}_2$  levels of RSCPs varied between 26-48 mmHg (mean:  $36.4 \pm 4.46$ ). Age ( $p < 0.05$ ) and 45th min  $\text{ETCO}_2$  levels ( $p < 0.05$ ) of IHCAPs were higher than those of the OHCAPs in the EP group. The mean age of the IHCAPs was  $75.0 \pm 7.0$  years (57-87) and this value was  $66.64 \pm 14.56$  years (26-87) for OHCAPs. In the RSCP group, age ( $p < 0.05$ ), and the first ( $p < 0.05$ ), 5th ( $p < 0.05$ ), 10th ( $p < 0.05$ ), and 20th ( $p < 0.05$ )  $\text{ETCO}_2$  levels were significantly higher in IHCAPs than in OHCAPs (Table 1).

There were significant differences between the EP and RSCP groups with regards to gender, admission time, arrest rhythm, chronic disease and ventilation technique in the ambulance according to arrest place (in hospital/out-of hospital) (Table 2).

$\text{ETCO}_2$  levels of the RSCP group ranged between 26-48 mmHg ( $36.4 \pm 4.46$ ), and this level for the EP group was 2-23 mmHg ( $11.74 \pm 7.01$ ). The final  $\text{ETCO}_2$  level was related with survival ( $p < 0.05$ ).

In the asystole patients, the 15th, 20th, and 25th min  $\text{ETCO}_2$  ( $p = 0.009$ ,  $p = 0.028$ ,  $p = 0.033$ ) levels were higher in RSCPs

than in EPs. In PEA patients, the 10th, 15th, 20th, and 30th min  $\text{ETCO}_2$  values ( $p = 0.002$ ,  $p = 0.001$ ,  $p = 0.002$ ,  $p = 0.005$ ) were higher in RSCPs than EPs, and in VF/VT patients, the 15th and 30th min  $\text{ETCO}_2$  values ( $p = 0.044$ ,  $p = 0.038$ ) were higher in RSCPs than in EPs (Table 3).

In the IHCAPs, the PEA patients' first, 5th, 10th, 15th, 20th and 30th min  $\text{ETCO}_2$  levels ( $p = 0.034$ ,  $p = 0.014$ ,  $p = 0.001$ ,  $p = 0.001$ ,  $p = 0.002$ ,  $p = 0.013$ ) were higher in RSCPs than EPs (Table 4). In the OHCAPs, the asystolic patients' 15th, 20th and 25th min  $\text{ETCO}_2$  levels ( $p = 0.011$ ,  $p = 0.033$ ,  $p = 0.038$ ) were higher in RSCPs than in EPs (Table 5).

The 5th, 10th, 15th, 20th, 25th, 30th, 35th, 40th and 45th min  $\text{ETCO}_2$  levels ( $p = 0.001$ ,  $p = 0.001$ ,  $p = 0.001$ ,  $p = 0.001$ ,  $p = 0.001$ ,  $p = 0.001$ ,  $p = 0.003$ ,  $p = 0.001$ ,  $p = 0.030$ ) of EPs were lower than those of the RSCPs. The mean final  $\text{ETCO}_2$  level of RSCPs was  $36.4 \pm 4.46$  mmHg.

## Discussion

Cardiopulmonary arrest cases are common in the emergency department and should be attended to immediately. Cardiopulmonary arrest can result in death without rapid and effective intervention.<sup>[7]</sup> Survival decreases 6-7% per minute in patients that did not undergo chest compression.<sup>[8,9]</sup>

The IHCAPs' rate of return to spontaneous circulation is high because they are diagnosed early. However, most of these patients are elderly so mortality does not decrease.<sup>[10]</sup> In our study, 56 (58%) of 97 cases were OHCAPs.

Survival is related with pre-hospital factors in OHCAPs.<sup>[11-13]</sup> These factors include arrival time, basic life support education of the general public and medical service personnel,

**Table 1.** Age and  $\text{ETCO}_2$  level distributions of RSCPs and EPs according to place of arrest

	Arrest place						Total			p
	In-hospital			Out-of-hospital			Mean±SD	Min.	Max.	
	Mean±SD	Min.	Max.	Mean±SD	Min.	Max.				
EPs										
Age	75.0±7.0	57	87	66.64±14.56	26	87	70.55±12.28	26	87	0.038
$\text{ETCO}_2$ 45 min	22.5±6.36	18	27	9.25±4.5	4	18	11.9±7.17	4	27	0.044
RSCPs										
Age	71.95±12.4	47	89	63.55±13.81	39	86	66.74±13.79	39	89	0.047
$\text{ETCO}_2$ 0 min	24.47±8.79	5	36	15±7.38	3	35	18.6±9.13	3	36	0.001
$\text{ETCO}_2$ 5 min	25.84±7	6	35	19.13±5.89	7	35	21.68±7.08	6	35	0.001
$\text{ETCO}_2$ 10 min	30.17±8.33	18	44	23.57±7.86	13	48	26.04±8.58	13	48	0.011
$\text{ETCO}_2$ 20 min	33.88±8.64	20	43	25±7.57	14	36	28.09±8.88	14	43	0.023

**Table 2.** Gender, arrival time, arrest rhythm and chronic disease ratio distribution of RSCPs and EPs according to place of arrest

	Arrest place				Total		p
	In-hospital		Ou-of-hospital		n	%	
	n	%	n	%			
EPs							
Gender							
Female	8	47.1	9	52.9	17	36.2	0.979
Male	14	46.7	16	53.3	30	63.8	
Arrival time							
00:01-04:00	2	28.6	5	71.4	7	14.9	0.486
04:01-08:00	1	25.0	3	75.0	4	8.5	
08:01-12:00	9	69.2	4	30.8	13	27.7	
12:01-16:00	4	44.4	5	55.6	9	19.1	
16:01-20:00	4	44.4	5	55.6	9	19.1	
20:01-24:00	2	40.0	3	60.0	5	10.6	
Arrest rthyhm							
Asystole	1	5.9	16	94.1	17	36.2	0.001
NEA	18	94.7	1	5.3	19	40.4	
VF/VT	3	27.3	8	72.7	11	23.4	
Arrest time period							
0 min	22	100.0	0	0.0	22	46.8	0.001
0-5 min	0	0.0	2	100.0	2	4.3	
6-10 min	0	0.0	7	100.0	7	14.9	
11-15 min	0	0.0	13	100.0	13	27.7	
16-20 min	0	0.0	3	100.0	3	6.4	
Chronic disease							
No	7	43.8	9	56.3	16	34.0	0.763
Yes	15	48.4	16	51.6	31	66.0	
RSCPs							
Gender							
Female	8	40.0	12	60.0	20	40.0	0.812
Male	11	36.7	19	63.3	30	60.0	
Arrival time							
00:01-04:00	1	16.7	5	83.3	6	12.0	0.716
04:01-08:00	1	20.0	4	80.0	5	10.0	
08:01-12:00	2	33.3	4	66.7	6	12.0	
12:01-16:00	4	40.0	6	60.0	10	20.0	
16:01-20:00	5	50.0	5	50.0	10	20.0	
20:01-24:00	6	46.2	7	53.8	13	26.0	
Arrest rthyhm							
Asistoli	0	0.0	4	100.0	4	8.0	0.006
NEA	18	52.9	16	47.1	34	68.0	
VF/VT	1	8.3	11	91.7	12	24.0	
Arrest time period							
0 min	18	100.0	0	0.0	18	36.0	0.001
0-5 min	1	6.3	15	93.8	16	32.0	
6-10 min	0	0.0	10	100.0	10	20.0	
11-15 min	0	0.0	4	100.0	4	8.0	
16-20 min	0	0.0	2	100.0	2	4.0	
Chronic disease							
No	5	35.7	9	64.3	14	28.0	0.836
Yes	14	38.9	22	61.1	36	72.0	

**Table 3.** ETCO<sub>2</sub> levels of arrest rhythms' according to survival

	EPs		RSCPs		Total		<i>p</i>
	n	Mean±SD	n	Mean±SD	n	Mean±SD	
Arrest rhythm = Asystole							
15 min	17	12.82±7.64	4	23.75±4.57	21	14.9±8.32	0.009
20 min	17	12.12±8.08	3	25.67±7.02	20	14.15±9.21	0.028
25 min	14	10.36±5.92	2	31±16.97	16	12.94±9.96	0.033
Arrest rhythm = PEA							
10 min	19	16.84±8.29	33	26.39±9.18	52	22.9±9.94	0.002
15 min	19	16.84±7.75	25	27.28±8.87	44	22.77±9.82	0.001
20 min	19	16.58±8.66	16	29.31±9.56	35	22.4±11.02	0.002
Arrest rhythm = VF/VT							
15 min	11	18.45±6.36	7	28.29±9.76	18	22.28±9.04	0.044
30 min	11	13.45±6.67	3	29.33±9.07	14	16.86±9.62	0.038

**Table 4.** ETCO<sub>2</sub> levels of arrest rhythms' in IHCAPs according to survival

	EPs				RSCPs				Total				<i>p</i>
	n	Mean±SD	Min.	Max.	n	Mean±SD	Min.	Max.	n	Mean±SD	Min.	Max.	
Arrest rhythm = PEA													
0 min	18	18.56±8.1	5	34	18	24.22±8.974	5	36	36	21.39±8.9	5	36	0.034
5 min	18	18.56±8.09	5	30	18	25.39±6.912	6	35	36	21.97±8.19	5	35	0.014
10 min	18	17.56±7.91	5	33	17	30.12±8.587	18	44	35	23.66±10.32	5	44	0.001
15 min	18	17.5±7.41	6	31	12	30.42±6.788	20	40	30	22.67±9.54	6	40	0.001
20 min	18	17.28±8.34	5	31	7	34.43±9.181	20	43	25	22.08±11.5	5	43	0.002
30 min	16	17.31±7.64	4	32	2	35±1.414	34	36	18	19.28±9.18	4	36	0.013

**Table 5.** ETCO<sub>2</sub> levels of arrest rhythms' in OHCAPs according to survival

	EPs				RSCPs				Total				<i>p</i>
	n	Mean±SD	Min.	Max.	n	Mean±SD	Min.	Max.	n	Mean±SD	Min.	Max.	
Arrest rhythm =													
Asystole													
15 min	16	13.31±7.61	3	29	4	23.75±4.573	19	30	20	15.4±8.21	3	30	0.011
20 min	16	12.69±7.98	2	31	3	25.67±7.024	19	33	19	14.74±9.07	2	33	0.033
25 min	13	10.85±5.86	2	24	2	31±16.971	19	43	15	13.53±10.01	2	43	0.038

presence of resuscitation centers, and the presence of automatic external defibrillator in public places.

The duration between the time of cardiac arrest and alerting the emergency medical service is the first step of survival,

and is directly related to the long term prognosis of cardiac arrest patients. One study reported that survival significantly decreased if the emergency service was not called within 6 minutes in OHCAPs.<sup>[14]</sup> In our study, there was a significant difference between survival ratios of the groups according

to the period between arrest and the call to emergency services.

In the meta-analysis by Sasson et al, although 53% (n=75.800) of 143.000 cases were reported as witnessed arrest cases, only 32% (n=24.250) of the cases were resuscitated at the arrest place by a rescuer.<sup>[15]</sup> In our study, 13 cases who were not brought to the hospital in an ambulance did not undergo cardiopulmonary resuscitation before arrival. Survival has been reported to be less than 5% in OHCAPs.<sup>[16]</sup> In our hospital, survival was 32% (n=31) in OHCAPs.

In OHCAPs, low survival is related with the presence of asystole and PEA as the first rhythm.<sup>[16,17]</sup> In our study, there was no significant difference between the RSCP and EP groups according to arrest rhythm and arrest time period in IHCAPs. However, there was a significant difference between these groups in OHCAPs. In OHCAPs, 80% of asystolic patients died, while 94.1% of PEA patients and 57.9% of VF/VT patients returned to spontaneous circulation.

Similar to the study by Takei et al.,<sup>[14]</sup> we also found a relationship between arrest time period and survival. Return to spontaneous circulation rate decreases and exitus ratio increases with a longer arrest time period. Mortality was high in asystole and PEA.

In our study, 27 (54%) of 50 cases returned to spontaneous circulation within the first 15 mins, 37 (74%) returned in the first 20 mins, and 45 (90%) patients returned in the first 30 mins. The return to spontaneous circulation ratio decreased with longer cardiopulmonary resuscitation times.

Hodgetts et al reported that survival of IHCAPs was high.<sup>[18]</sup> The presence of a chronic disease negatively effects survival, and the best chances at survival are provided with early defibrillation.<sup>[19]</sup> In our study, when we considered the arrest places of the EPs, age and 45th min ETCO<sub>2</sub> levels of IHCAPs were significantly higher than those of OHCAPs. In RSCPs, the first, 5th, 10th and 20th min ETCO<sub>2</sub> levels of IHCAPs were higher than those of OHCAPs. Similar to the literature, in our study, the ETCO<sub>2</sub> level of RSCPs varied between 26-48 mmHg (36.4±4.46).<sup>[20]</sup>

A sudden increase in ETCO<sub>2</sub> indicates the return to spontaneous circulation.<sup>[4-6]</sup> White reported that rhythm changes and ETCO<sub>2</sub> levels can be used as an early indication of pulmonary perfusion even in pulseless cases, but only in OHCAPs.<sup>[21]</sup> Also, a relationship between coronary perfusion pressure and ETCO<sub>2</sub> has been reported.<sup>[22,23]</sup> If ETCO<sub>2</sub> remains under 10 mmHg for a long time during CPR, it is quite likely that a return to spontaneous circulation will not occur.<sup>[24-28]</sup> One study reported that just one case survived whose ETCO<sub>2</sub> level remained under 10 mmHg.<sup>[29]</sup> In our study, just one of

the RSCPs' ETCO<sub>2</sub> levels was under 5 mmHg. Similar to the literature, we found a relationship between final ETCO<sub>2</sub> level and survival.

Heradstveit et al reported significant differences between RSCPs and ETCO<sub>2</sub> in all asystole, PEA, and VF/VT rhythms.<sup>[30]</sup> When we grouped cases according to arrest rhythms, the 15th, 20th, and 25th min ETCO<sub>2</sub> levels of asystole patients, the 10th, 15th, 20th, and 30th min ETCO<sub>2</sub> levels of PEA patients, and the 15th and 30th min ETCO<sub>2</sub> levels of VF/VT patients were higher in RSCPs than in EPs. When we considered the IHCAPs according to arrest rhythm, the first, 5th, 10th, 15th, 20th and 30th min ETCO<sub>2</sub> levels of PEA patients were higher in RSCPs than in EPs. In OHCAPs, the 15th, 20th and 25th min ETCO<sub>2</sub> levels of asystole patients were higher in RSCPs than in EPs.

## Conclusion

As suggested in the guidelines, ETCO<sub>2</sub> follow-up of the cardiopulmonary arrest patients with capnography would be helpful in the continuation of CPR and in predicting the survival of the patient. Capnography use is suitable in emergency services and in ambulances.

## Limitations

Patients were excluded if they underwent a second cardiopulmonary arrest, and this limited our study, as we could not determine the effectiveness of ETCO<sub>2</sub> measurements in these patients.

## Conflict of Interest

The authors declare that there is no potential conflicts of interest.

## References

1. Safar P, Escarraga LA, Chang F. Upper airway obstruction in the unconscious patient. *J Appl Physiol* 1959;14:760-4.
2. Kouwenhoven WB, Jude JR, Knickerbocker GG. Closed-chest cardiac massage. *JAMA* 1960;173:1064-7.
3. Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Part 6: advanced cardiovascular life support: section 1: Introduction to ACLS 2000: overview of recommended changes in ACLS from the guidelines 2000 conference. The American Heart Association in collaboration with the International Liaison Committee on Resuscitation. *Circulation* 2000;102(8 Suppl):186-9.
4. Entholzner E, Felber A, Mielke L, Hargasser S, Breinbauer B, von Hundelshausen B, et al. The determination of end-expiratory CO<sub>2</sub> during resuscitation. Experience and results with the Normocap 200 (Fa. Datex) in preclinical resuscitation conditions. [Article in German] *Anesthesiol Intensivmed Notfallmed Schmerzther* 1992;27:473-6. [Abstract]

5. Garnett AR, Ornato JP, Gonzalez ER, Johnson EB. End-tidal carbon dioxide monitoring during cardiopulmonary resuscitation. *JAMA* 1987;257:512-5.
6. Bhende MS, Karasic DG, Karasic RB. End-tidal carbon dioxide changes during cardiopulmonary resuscitation after experimental asphyxial cardiac arrest. *Am J Emerg Med* 1996;14:349-50.
7. Walker WM. Dying, sudden cardiac death and resuscitation technology. *Int Emerg Nurs* 2008;16:119-26.
8. Srinivasan V, Nadkarni VM, Helfaer MA, Carey SM, Berg RA; American Heart Association National Registry of Cardiopulmonary Resuscitation Investigators. Childhood obesity and survival after in-hospital pediatric cardiopulmonary resuscitation. *Pediatrics* 2010;125:e481-8.
9. Jain R, Nallamothu BK, Chan PS; American Heart Association National Registry of Cardiopulmonary Resuscitation (NRCPR) investigators. Body mass index and survival after in-hospital cardiac arrest. *Circ Cardiovasc Qual Outcomes* 2010;3:490-7.
10. Schein RM, Hazday N, Pena M, Ruben BH, Sprung CL. Clinical antecedents to in-hospital cardiopulmonary arrest. *Chest* 1990;98:1388-92.
11. Hollenberg J, Lindqvist J, Ringh M, Engdahl J, Bohm K, Rosenqvist M, et al. An evaluation of post-resuscitation care as a possible explanation of a difference in survival after out-of-hospital cardiac arrest. *Resuscitation* 2007;74:242-52.
12. Herlitz J, Ekström L, Axelsson A, Bång A, Wennerblom B, Waagstein L, et al. Continuation of CPR on admission to emergency department after out-of-hospital cardiac arrest. Occurrence, characteristics and outcome. *Resuscitation* 1997;33:223-31.
13. van der Hoeven JG, Waanders H, Compier EA, van der Weyden PK, Meinders AE. Prolonged resuscitation efforts for cardiac arrest patients who cannot be resuscitated at the scene: who is likely to benefit? *Ann Emerg Med* 1993;22:1659-63.
14. Takei Y, Inaba H, Yachida T, Enami M, Goto Y, Ohta K. Analysis of reasons for emergency call delays in Japan in relation to location: high incidence of correctable causes and the impact of delays on patient outcomes. *Resuscitation* 2010;81:1492-8.
15. Sasson C, Rogers MA, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. *Circ Cardiovasc Qual Outcomes* 2010;3:63-81.
16. Bunch TJ, Hammill SC, White RD. Outcomes after ventricular fibrillation out-of-hospital cardiac arrest: expanding the chain of survival. *Mayo Clin Proc* 2005;80:774-82.
17. Weisfeldt ML, Everson-Stewart S, Sitlani C, Rea T, Aufderheide TP, Atkins DL, et al. Ventricular tachyarrhythmias after cardiac arrest in public versus at home. *N Engl J Med* 2011;364:313-21.
18. Hodgetts TJ, Kenward G, Vlachonikolis IG, Payne S, Castle N. The identification of risk factors for cardiac arrest and formulation of activation criteria to alert a medical emergency team. *Resuscitation* 2002;54:125-31.
19. Peberdy MA, Kaye W, Ornato JP, Larkin GL, Nadkarni V, Mancini ME, et al. Cardiopulmonary resuscitation of adults in the hospital: a report of 14720 cardiac arrests from the National Registry of Cardiopulmonary Resuscitation. *Resuscitation* 2003;58:297-308.
20. Morgan GE, Mikhail MS. *Clinical anesthesiology*. 1st ed. Norwalk: Appleton & Lange; 1992. p. 90-2.
21. White RD, Asplin BR. Out-of-hospital quantitative monitoring of end-tidal carbon dioxide pressure during CPR. *Ann Emerg Med* 1994;23:25-30.
22. Lewis LM, Stothert J, Standeven J, Chandel B, Kurtz M, Fortney J. Correlation of end-tidal CO<sub>2</sub> to cerebral perfusion during CPR. *Ann Emerg Med* 1992;21:1131-4.
23. Sanders AB, Atlas M, Ewy GA, Kern KB, Bragg S. Expired PCO<sub>2</sub> as an index of coronary perfusion pressure. *Am J Emerg Med* 1985;3:147-9.
24. Grmec S, Kupnik D. Does the Mainz Emergency Evaluation Scoring (MEES) in combination with capnometry (MEESc) help in the prognosis of outcome from cardiopulmonary resuscitation in a prehospital setting? *Resuscitation* 2003;58:89-96.
25. Callahan M, Barton C. Prediction of outcome of cardiopulmonary resuscitation from end-tidal carbon dioxide concentration. *Crit Care Med* 1990;18:358-62.
26. Grmec S, Klemen P. Does the end-tidal carbon dioxide (EtCO<sub>2</sub>) concentration have prognostic value during out-of-hospital cardiac arrest? *Eur J Emerg Med* 2001;8:263-9.
27. Levine RL, Wayne MA, Miller CC. End-tidal carbon dioxide and outcome of out-of-hospital cardiac arrest. *N Engl J Med* 1997;337:301-6.
28. Wayne MA, Levine RL, Miller CC. Use of end-tidal carbon dioxide to predict outcome in prehospital cardiac arrest. *Ann Emerg Med* 1995;25:762-7.
29. Ahrens T, Schallom L, Bettorf K, Ellner S, Hurt G, O'Mara V, et al. End-tidal carbon dioxide measurements as a prognostic indicator of outcome in cardiac arrest. *Am J Crit Care* 2001;10:391-8.
30. Heradstveit BE, Sunde K, Sunde GA, Wentzel-Larsen T, Heltne JK. Factors complicating interpretation of capnography during advanced life support in cardiac arrest—a clinical retrospective study in 575 patients. *Resuscitation* 2012;83:813-8.