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The evaluation of calcium as a prognostic factor in non-traumatic cardiopulmonary arrests

Travmatik olmayan kardiyopulmoner arrestlerde kalsiyumun prognostik bir faktör olarak değerlendirilmesi

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Abstract

Aim: Cardiopulmonary arrests (CPA) should be rapidly responded to in emergency departments (ED). Arrests associated with coronary cardiac diseases are held responsible for about 90% of sudden mortality over the age of 18 years. In our study, the effect of calcium on prognosis was investigated in patients who were admitted to our emergency department with non-traumatic CPA and underwent cardiopulmonary resuscitation (CPR).

Methods: The data of 132 non-traumatic CPA patients who were admitted to the emergency room between 1 January 2017 and 31 December 2019 were examined from the hospital registry for this cohort study. The demographic features (age, gender, mortality, and the presence of diseases in their medical history) were noted. Blood was collected from patients at the time of admission to the ED. Adjusted serum Ca^{+2}, potassium (K^{+}) and sodium (Na^{+}) electrolyte levels were evaluated among patients who were either admitted to the intensive care unit or died.

Results: Fifty-eight (43.93%) patients died in the emergency department, and 74 (56.07%) were admitted to intensive care units. There were no comorbid diseases in 50.76%. Coronary artery disease, respiratory diseases and others were found in 23.46%, 6.06% and 19.7% of the patients, respectively. In the patient group declared "exitus" in the intensive care unit after CPR, serum adjusted calcium levels were significantly higher compared to the surviving patient group (P=0.041)

Conclusion: It was noted that adjusted Ca^{+2} concentration can be a beneficial parameter in determining the prognosis in non-traumatic arrest cases.

Keywords: Adjusted calcium level, Cardiopulmonary resuscitation, Prognosis

Öz

Amaç: Kardiyopulmoner arrestler (KPA), acil servislerin en hızlı müdahale edilmesi gereken durumlardan birini oluşturmaktadır. Koroner kalp hastalıklarına bağlı arrestler, 18 yaş üstü ani ölümlerin yaklaşık %90'nından sorumlu tutulmaktadır. Çalışmamızda acil servisimize nontravmatik KPA olarak getirilen ve kardiyopulmoner resüsitasyon (KPR) yapılan hastalar üzerinde, kalsiyumun prognoza olan etkisi araştırdık.

Yöntemler: 1 Ocak 2017-31 Aralık 2019 yılları arasında acil servise başvuran 138 travmatik olmayan KPA hastasının verileri hastanenin otomasyon sisteminden kohort çalışması olarak incelendi. Olguların demografik özellikleri (yaş, cinsiyet, mortalite ve tıbbi geçmişlerinde hastalık varlığı) incelendi. Acil servise başvuru anında serum kalsiyum (Ca^{+2}), potasyum (K) ve sodyum (Na) düzeyleri ölçüldü. Daha sonra, exitus olan grup ile yoğun bakım ünitesine yatırılan hasta grupları arasında düzeltilmiş serum Ca^{+2} elektrolit düzeyleri değerlendirildi.

Bulgular: Bu hastaların 58'i (%43,93) acil serviste exitus kabul edildi ve 74'ü (%56,07) yoğun bakım ünitelerine yatırıldı. Hastaların %50,76'sında komorbid hastalıklar bulunmadı. Koroner arter hastalığı %23,46, solunum sistemi hastalığı %6,06, diğer hastalıklar %19,7 olarak bulundu. KPR sonrası yoğun bakım ünitesinde exitus olarak bildirilen hasta grubunda serum düzeltilmiş Ca^{+2} düzeyleri sağ kalan hasta grubuna göre istatistiksel olarak anlamlı derecede yüksek bulundu (P=0,041).

Sonuç: Düzeltilmiş Ca^{+2} konsantrasyonunun, travmatik olmayan arrest vakalarda prognozun belirlenmesinde faydalı bir parametre olabileceği düşünüldü.

Anahtar kelimeler: Düzeltilmiş kalsiyum seviyesi, Kardiopulmoner resusistasyon, Prognoz

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Introduction

Cardiopulmonary arrest (CPA) is a consequence of various conditions, such as ceased respiration and circulation, and is characterized by inability to get a pulse and sudden loss of consciousness [1]. Cardiopulmonary resuscitation (CPR) is defined as the revival effort to correct respiratory and circulatory functions [2]. The most common reason for cardiac arrest in adult patients is ischemic cardiovascular diseases [3]. Throughout the duration of the arrest, vital organs cannot function without external support. Unless rapidly intervened, the patient will be in somatic death within 8 minutes [4]. Studies have reported that the ischemia-reperfusion injury damages the organs in patients who underwent resuscitation after CPA [5,6].

It is known that serum Ca^{+2} level is related to the prognosis of many diseases. The Ca^{+2} ion plays a significant role in stimulating and contracting the heart muscle [7]. We therefore think that serum Ca^{+2} level can be associated with the prognosis of cardiac arrests.

In this study, we aimed to determine whether serum adjusted Ca^{+2} levels are indicative for prognosis in successful resuscitation in patients who were brought to the emergency department with CPA.

Materials and methods

One hundred and thirty-two cases over the age of 18 years brought to our hospital's ED with non-traumatic CPA between 2017-2019 were examined in this retrospective cohort study. Data were obtained from the hospital registry. The demographic features (age, gender, mortality status and the presence of comorbid diseases in medical history) of the cases were evaluated. With the routine biochemistry analyzer (Cobas c501, Roche, Germany) total Ca^{+2} levels were measured upon arrival at the ED. The adjusted Ca^{+2} levels were calculated using the relevant formula in the literature, and the results were presented as the adjusted Ca^{+2} levels [8]. Patients whose hospital records could not be accessed, whose blood could not be examined during CPR, those with liver cirrhosis, malnutrition, hypo-hyperparathyroidism, patients with impaired serum electrolyte metabolism or patients who underwent a parathyroid operation, patients with malignancy, metabolic diseases, missing information in the patient files and cases of arrest under the age of 18 years were excluded. We examined our non-traumatic CPA cases in two groups, those who survived (surviving group) or died (exitus group) after CPR.

Statistical analysis

SPSS Windows 20 statistics program was used in all data analysis. The results were given as mean standard deviation (SD). Student's t test and Chi-square tests were applied to compare the variables between two groups. In all the tests, $P<0.05$ was considered significant.

Results

Between the study dates, 207 traumatic and non-traumatic CPA patients were admitted to ED. A total of 138 non-traumatic CPA patients were included in this study. However, six patients were excluded from the study because their laboratory data were insufficient. Flow diagram with exclusion criteria is summarized in Figure 1. When the demographic data of the 132 cases in the study was examined, it was found that 58 (43.93%) patients were terminated as exitus, and 74 (56.07%) were admitted to intensive care units.

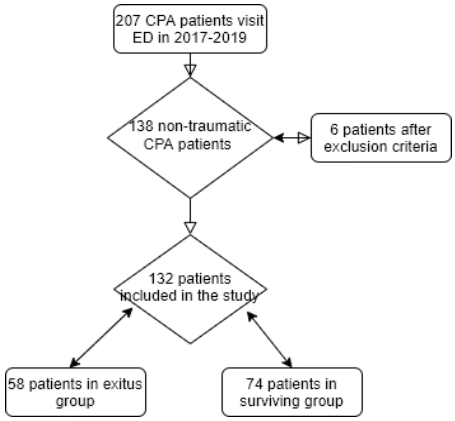

Figure 1: Flow diagram of the study ED: Emergency department, CPA: Cardiopulmonary arrest)

The mean age of all patients was 68.50 (13.45) years. The mean ages of the surviving and exitus groups were 68.86 (13.59) and 68.17 (13.33) years, respectively, which were similar (P=0.617) (Table 1). Among all, 56.06% (n=74) were male and 43.93% (n=58) were female. No statistically significant difference was found between the two groups in terms of the effect of gender on survival (P=0.214). No comorbid diseases were found in 50.76% of patients, whereas coronary artery disease was found in 23.48%, respiratory system diseases were found in 6.06%, and other diseases (diabetes mellitus, stroke, neurological diseases etc.) were present in 19.7%. No differences were found between exitus group and surviving group with respect to comorbid disease (P=0.552).

No statistically significant differences were found between the exitus and surviving groups in terms of average serum K (4.9 (0.17) mmol/L and 4.73 (0.12) mmol/L, respectively) and Na (139.9 (5.6) mmol/L and 138.49 (4.2) mmol/L, respectively) levels (P=0.398, P=0.118, respectively). Adjusted serum Ca^{+2} levels were higher in the exitus group than the surviving group (11.87 (1.4) mg/dL vs 9.77 (1.3) mg/dL) (P=0.041) (Table 2).

Table 1: Age comparison between the exitus and surviving groups

	Group	Mean	SD	*P*-value
Age	Surviving	68.86	13.59	0.617
	Exitus	68.17	13.33	

SD: Standard deviation

Table 2: Serum potassium, sodium, and calcium levels of the surviving and exitus groups

Serum levels	Surviving group (n=74)		Exitus group (n=58)		*P*-value
	Mean	SD	Mean	SD	
Potassium (K) mmol/L	4.73	0.12	4.9	0.17	0.398
Sodium (Na) mmol/L	138.49	4.2	139.9	5.6	0.118
Calcium (Ca) mg/dL	9.7	1.3	11.87	1.4	0.041

SD: Standard deviation

Discussion

CPAs, known as the sudden cease of respiratory and cardiac functions, have a prominent place in hospital morbidity and mortality [9]. The most common (60%) reason for sudden deaths in adults is arrests related to coronary cardiac diseases. On the other hand, the most commonly observed mortal arrhythmia in this patient group is ventricular fibrillation. Approximately 15-20% of mortalities consist of sudden cardiac deaths [10].

When the demographic data about cardiac arrest cases in the literature is examined, it has been noted that it is more

commonly found in males rather than females in terms of the distribution of the disease [11,12]. In our study, the number of male patients were insignificantly higher than that of females. The ages of the youngest and oldest of the patients included in the study were 24 and 95 years, respectively, with a mean overall age of 69.37 (13.64) years. In the study conducted by Geçmen et al. [13], the average age of cardiac arrest cases in the hospital was found as 61.7 (14.6) years.

In Özen's dissertation study [14] on the relationship between the ventricle movement examined via ultrasonography in patients who underwent CPR and prognosis, the mean age of CPA cases was 65.18 ± 16.3 years. The mean age of non-traumatic cardiac arrest cases admitted to our hospital was in consistency with the literature. The province our hospital is in and the surrounding provinces it serves have low populations, and thus the number of cases in our study was lower compared to international studies. Another reason is that the study we conducted is a 2-year retrospective study while other international studies are long-term cohort studies. The number of patients in our study was consistent the number of patients in national studies [12].

Cardiopulmonary arrests are examined in two groups according to their causes, as those related or unrelated to trauma. The patient group of this study consists of non-traumatic CPA cases. When previous studies are examined, the success rate for CPR in non-trauma cardiac arrests is reported as 14-17% [15]. In our study, the success rate was 56% after CPR in 132 patients were admitted to our ED with non-traumatic CPA. The reason for the high successful resuscitation rate can be explained with low population, a short transportation time of emergency ambulances due to transportation issues, the prompt initiation of medical first aid, and the sufficient number of medical staff serving in the ED.

It has been stated that various biochemical markers can be used as an early determiner of prognosis after cardiac arrest [12,16]. However, no studies showing the relationship between non-traumatic cardiopulmonary arrests admitted to the emergency room and adjusted Ca^{+2} levels to determine their prognosis are found. Thus, this study is the first to present the role of Ca^{+2} in determining prognosis in CPA patients. Although it is known that calcium has a critical role in bone mineralization, cardiac conductivity and contractility, vascular smooth muscular tonus regulation, coagulation and decreasing nervous conduction, the relationship between calcium and the heart muscle contraction is yet to be clarified [17]. In every heart cycle, with the stimulation of the heart muscle, extracellular Ca^{+2} ions start entering the cell [18]. In situations such as coronary failure and ischemia, Ca^{+2} release from sarcoplasmic reticulum, from where Ca^{+2} is released the most, is disrupted. After ischemia, the ion concentration in the cell starts changing; Ca^{+2}, K^{+} and Na^{+} increase. As the ischemia continues, the oxygen level in the tissue decreases and the oxidative mechanisms start malfunctioning. As the $Na^{+}K^{+}$ATPase pump malfunctions the Na^{+} ions moving into the cell increase, which causes the cell to swell, leading to necrosis [19]. In cardiac arrests, the cardiac ischemia is relevant. Therefore, as the arrest duration increases, the Ca^{+2} entrance from the SR to the cytoplasm increases. $Na^{+}K^{+}$ATPase pump loses its function and induces necrosis. In the study conducted by Ovbiagele et al. [20], it was noted that in ischemic stroke cases, serum Ca^{+2} levels measured early (the first 4,5 hours) were higher compared to later (72-96 hours) measurements of serum Ca^{+2} levels. However, it was found that this had no prognostic importance [20]. In our study, it has been revealed that there was a significant difference in the adjusted serum Ca^{+2} levels between the surviving group and the exitus group after CPR. Serum Ca^{+2} levels have been higher in patients accepted as exitus. We think the reason that the results of the study conducted by Ovbiagele et al. [20] is statistically different from our study results is the adjusted Ca^{+2} levels have not been examined.

Measuring the adjusted Ca^{+2} levels is important when CPR is being performed in ED. Thus, requesting serum albumin levels should not be ignored. For example, in traumatic situations such as burns and injuries with loss of blood, albumin concentration decreases. Moreover, it can also be affected by non-traumatic situations such as malnutrition, cirrhosis, hyperparathyroidism, hypoparathyroidism, malignancies, drug use and metabolic diseases.

Limitations

The limitations of our study included the more prominent elderly population of our province and collection of data from a single hospital.

Conclusion

It is known that electrolyte changes affect necrosis and tissue ischemia. Calcium levels increase in the serum depending on necrosis after ischemia. We compared some serum electrolyte differences between survivors after CPA and those who died. Only serum Ca^{+2} level was found to be significantly higher in exitus cases. In addition, we think that adjusted serum Ca^{+2} levels can be used as a successful resuscitation indicator in CPA cases. In this regard, we believe that further multicenter studies with larger sample sizes are needed.

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