

ORIGINAL ARTICLE

Effect of hunger strike on electrocardiographic parameters

Açlık grevinin elektrokardiyografik parametrelere etkisi

● Gültekin Faik Hobikoglu, M.D.,¹ ● Mehmet Urumdaş, M.D.,² ● Yalçın Özkurt, M.D.,²
 ● Regayip Zehir, M.D.,³ ● Ahmet Güner, M.D.³

¹Department of Cardiology, Karatay University Faculty of Medicine, İstanbul, Turkey

²Department of Cardiology, Silivri Prison State Hospital, İstanbul, Turkey

³Department of Cardiology, Kartal Koşuyolu Yüksek İhtisas Training and Research Hospital, İstanbul, Turkey

ABSTRACT

Objective: This study is a comparison of the electrocardiogram (ECG) findings of detainees and convicts who participated in a hunger strike recorded at the end of the strike and 2 months later.

Methods: A total of 81 male detainees and convicts (mean age 41±9.4 years) who participated in a hunger strike between September 2012 and November 2012 were included in this study. The mean duration of the fast was 45±9.6 days. Measurements of blood pressure, body weight, and serum electrolytes (sodium, potassium, calcium) obtained on the last day of the hunger strike and 2 months later were compared, as well as 12-lead ECG readings obtained at the same intervals, which were scanned and transferred to a high-resolution electronic format and evaluated.

Results: The mean weight loss for the 81 patients during the hunger strike was 6±3.7 kg. Early repolarization (ER) (inferior: 10, lateral: 5, inferolateral: 1) was detected in 16 (19.7%) ECGs taken on the last day of fasting, and in 4 (4.9%) (inferior: 3, lateral: 1) of those measured 2 months after the strike (p<0.001). A significant difference was observed in the PR interval (157±75 ms vs. 153±23 ms; p=0.035) and QRS duration (95±73 vs. 92±11; p=0.001), whereas there was no significant difference in heart rate (p=0.068). Additionally, there was no significant difference in terms of electrolyte levels between the last day of the hunger strike and 2 months after its conclusion.

Conclusion: This is the first time long-term lack of nutrition was demonstrated to be associated with ER.

ÖZET

Amaç: Bu çalışmada, açlık grevine devam eden tutuklu ve hükümlülerin elektrokardiyogramları (EKG) açlık grevi bitiminde ve 2 ay sonra alınanlarla karşılaştırılmıştır.

Yöntemler: Bu çalışmada, Eylül 2012 ile Kasım 2012 tarihleri arasında 45 erkek (ortalama yaş 41±9.4 yıl) tutuklu ve hükümlü yaklaşık 45±9.6 gün süren açlık grevi gerçekleştirdi. Ortalama açlık süresi 45±9.6 gündü. Açlık grevinin son gününde ve bundan iki ay sonra kan basınçları, vücut ağırlıkları ve serum elektrolitleri (sodyum, potasyum ve kalsiyum) elde edildi. Açlığın son gününde ve açlıktan iki ay sonra elde edilen 12 uçlu EKG'ler tarandı, yüksek çözünürlüklü bilgisayar ekranlarına aktarılarak değerlendirildi.

Bulgular: Açlık grevinde 81 hastada ortalama 6±3.7 kilo kaybı gözlemlendi. Açlık grevinin son gününde, hastalardan alınan EKG kayıtları değerlendirildiğinde, 16 (%19.7) erken repolarizasyon (ER) (inferiyor: 10, lateral: 5, inferolateral: 1) tespit edildi. Açlık greviden 2 ay sonra, hastalardan alınan EKG kayıtlarında 4 (%4.9) (inferiyor: 3, lateral: 1) (p<0.001) ER tespit edildi. PR aralığında (157±75 ms ve 153±23 ms, p=0.035) ve QRS süresinde (95±73 ve 92±11, p=0.001) anlamlı fark bulunurken, kalp hızı açısından fark yoktu (p=0.068). Ayrıca açlık grevinin son günü ile açlık greviden iki ay sonra elektrolit düzeyleri açısından anlamlı bir fark yoktu.

Sonuç: İlk kez uzun süreli açlığın ER ile ilişkili olduğu bulunmuştur.

A hunger strike is unfortunately a common type of protest encountered in prisons. The World Medical Association defines a hunger strike as the refusal

of nutrition for a significant period by a mentally competent individual as a form of protest or demand.^[1] Another comprehensive definition of a hunger strike is

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Correspondence: Dr. Ahmet Güner. Kartal Koşuyolu Yüksek İhtisas Eğitim ve Araştırma Hastanesi, Kardiyoloji Kliniği, Kartal, İstanbul, Turkey.

Tel: +90 216 - 500 15 00 e-mail: ahmetguner489@gmail.com

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“an action in which a person or group of persons with decision-making capacity refuses to ingest vital nourishment until another party accedes to a specific demand.”^[2] Long-term starvation can cause many health problems, such as. This study is a comparison of electrocardiogram (ECG) measurements of detainees and convicts obtained at the conclusion of a hunger strike with recordings performed subsequently.

METHODS

A total of 81 male detainees and convicts who took part in a hunger strike between September 2012 and November 2012 were enrolled in this study. The mean duration of the fast was 45 ± 9.6 days. Serum electrolyte levels (sodium, potassium, calcium) were assessed on several occasions. Blood pressure, body weight, and serum electrolyte values used in the study were measured on the last day of the hunger strike and 2 months later. A standard 12-lead ECG (Cardioline AR600; ET Medical Devices SpA, Milan, Italy; filter 150 Hz, 25 mm/s, 10 mm/mV) recording was also obtained from all of the patients on the last day of the hunger strike and 2 months later. The ECGs were scanned at 300 dpi and the images were amplified 10x for analysis and calculation of the duration of the PR, P max, P min, QT, QT max, QT min, and QRS. When possible, parameters were determined in all 12 leads and the mean results were calculated from 3 consecutive cardiac cycles. The recordings were assessed by a blinded cardiologist. The QT intervals were measured manually from the onset of the QRS complex to the end of the T-wave (defined as the intersection of isoelectric line and the tangent of the maximal downward limb of the T-wave). The onset of the P-wave was defined as the point of first visible upward departure from the baseline for positive wave forms, and as the point of first downward departure from the baseline for negative wave forms. The return to the baseline was considered to be the end of the P-wave. The following criteria were used to identify early repolarization (ER): 1) The presence of an end-QRS notch or slur on the downslope of a prominent R-wave. A notch should lie entirely above the baseline. The onset of a slur should also be above the baseline; 2) The J_p was >0.1 mV (notch) in 2 or more contiguous leads, excluding leads V1 to V3; 3) The QRS duration was <120 milliseconds. ST-segment elevation in the absence of a slur or notch was not considered ER, The greatest Pmax mea-

sured in any of the 12 leads of the surface ECG was used as the longest atrial conduction time.

This study was approved by the ethics committee and written, informed consent was obtained from all of the participants.

Statistical analysis

Categorical and numerical variables are expressed as a percentage and mean \pm SD, respectively. The Kolmogorov-Smirnov test was used to determine the normality of distribution. Numerical variables were tested with a paired Student's t-test, and categorical variables were assessed using the McNemar test. Spearman's test or Pearson's procedure was used for correlation analysis. A p-value of <0.05 was regarded as significant for all analyses. All of the statistical tests were performed using SPSS for Windows, Version 16.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

A total of 81 males (mean age: 41 ± 9.4 years) participated in a hunger strike for a mean of 45 ± 9.6 days. A mean weight loss of 6 ± 3.7 kg was observed in the group.

Weight, heart rate, blood pressure, electrolyte levels, and ECG parameters obtained on the last day of the hunger strike and 2 months afterwards are displayed in Table 1. Significant differences were observed in weight, systolic blood pressure, and heart rate after 2 months. Furthermore, there were significant differences determined in measurements of the PR interval, QT, QT max, QT min, QRS duration, and ER frequency.

In the ECG recordings evaluated on the last day of the hunger strike, 16 (19.7%) instances of ER (inferior: 10, lateral: 5, inferolateral: 1) (Fig. 1a) were observed, and 2 months after the strike, 4 (4.9%) examples of ER (inferior: 3, lateral: 1) were seen. ($p < 0.0001$) Twelve (14.63%) cases demonstrating ER improved once the hunger strike was terminated (Fig. 1b). No significant change in electrolyte levels was observed.

All of the participants had gained weight 2 months after the end of the hunger strike (5.07 ± 2.32 kg). There was a weak correlation between the weight gain and systolic blood pressure increase ($r = 0.285$; $p = 0.009$),

Abbreviations:

ECG Electrocardiogram

ER Early repolarization

Table 1. Comparison of electrocardiographic parameters between the last day of a hunger strike and 2 months later

	Last day of hunger strike	2 months after hunger strike	<i>p</i>
	Mean±SD	Mean±SD	
Heart rate (/minute)	64.47±10.62	68.56±8.61	0.002
Systolic blood pressure (mm Hg)	120.63±12.21	130.96±13.97	<0.0001
Diastolic blood pressure (mm Hg)	73.59±9.84	74.63±9.33	0.343
Weight (kg)	68.86±9.89	73.94±10.03	<0.0001
PR interval (ms)	157.76±26.32	153.73±22.31	0.035
P max (ms)	91.8537±8.49	92.49±7.55	0.538
P min (ms)	61.84±7.22	62.29±6.50	0.643
QT (ms)	390.49±24.96	368.94±22.31	<0.0001
QT max (ms)	410.54±24.20	392.46±21.99	<0.0001
QT min (ms)	373.04±23.16	356.52±21.30	<0.0001
QRS (ms)	95.73±10.62	93.06±11.39	0.001
Early repolarization, n (%)	16 (19.5)	4 (4.9)	<0.0001
Potassium (mEq/L)	3.98±0.40	3.59±0.84	0.653
Sodium (mEq/L)	134.81±2.87	136.36±7.60	0.088
Calcium (mg/dL)	9.15±0.97	8.97±0.67	0.114

SD: Standard deviation.

but there was no correlation between weight gain and changes in the ECG parameters monitored. Only a weak correlation was found between improvement in ER and weight gain ($r=0.229$; $p=0.039$).

DISCUSSION

For the first few days of starvation, the body uses its stores of glycogen in the liver and muscle. This is

accompanied by glucagon-induced natriuresis once there is substantial weight loss. The next phase lasts through approximately days 10 to 14, when glycogen stores become exhausted and certain amino acids take over as the substrate for gluconeogenesis. This is associated with muscle loss, including the heart muscle. In the final phase, protein is conserved and forms only about 10% of the energy source. Ketones produced by the breakdown of fatty acids compensate for most of

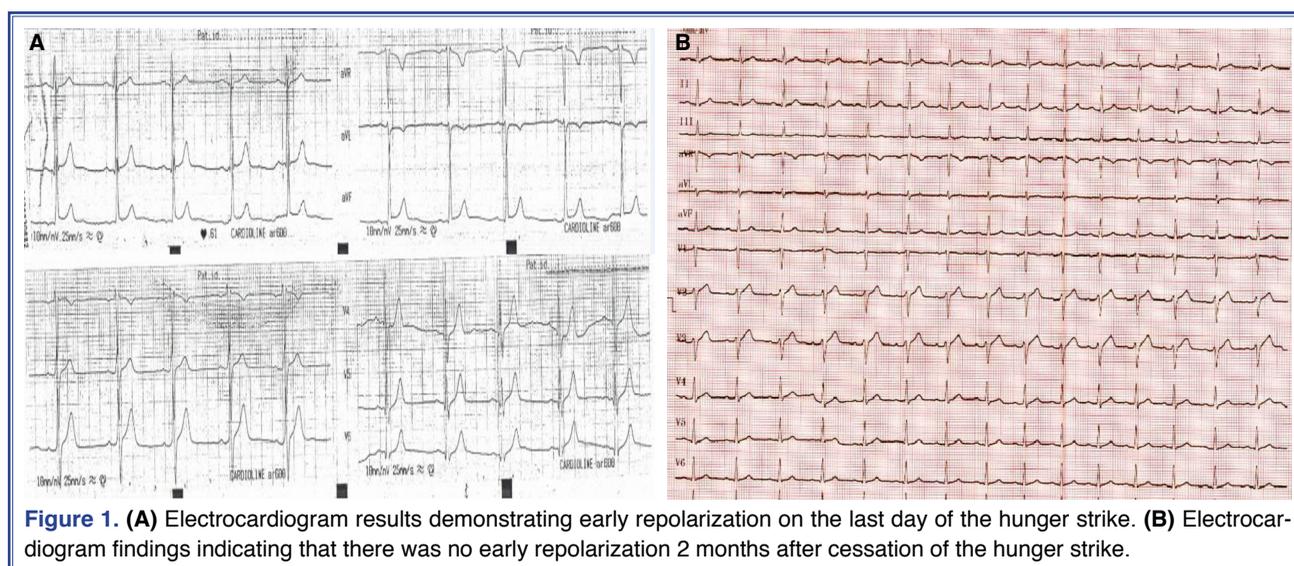


Figure 1. (A) Electrocardiogram results demonstrating early repolarization on the last day of the hunger strike. (B) Electrocardiogram findings indicating that there was no early repolarization 2 months after cessation of the hunger strike.

the energy. When metabolism consumes the fat stores, inevitable protein catabolism begins, but generally, other complications arise first. Major problems arise at a weight loss of about 18%.^[3,4] Acute starvation can cause significant myocardial dysfunction that may even be fatal. Gelatinous atrophy of pericardial fat, brown atrophy of cardiac muscle, serous pericardial effusion, and interstitial edema are common findings in autopsy studies of hunger strikers.^[5] Gordon et al.^[6] reported that the most common clinical symptom of those participating in a hunger strike was chest pain, and that it also caused structural abnormalities due to muscle loss or the lack of thiamine. Similarly, we did not observe a significant difference between the last day of the hunger strike and 2 months after the hunger strike. Beriberi due to thiamine deficiency can lead to heart failure (wet beriberi). Thiamine deficiency can lead to impaired oxidative phosphorylation, increased levels of pyruvate, and decreased transketolase activity in the heart, red blood cells, and liver.^[7] Wet beriberi related to malnutrition is typically seen with high-output cardiac failure, peripheral dilatation, and sodium and water retention. Wet beriberi may occur as soon as 14 days after initiating complete fasting.^[7]

Bradycardia and a decrease in blood pressure are well-recognized effects of short-term fasting and were observed in all of the study individuals. Orthostatic hypotension was present at about day 20 in all cases in which it was recorded, and in at least 1 case, was almost disabling.^[8,9]

In our study, the frequency of ER seen on the ECGs performed on the last day of the hunger strike was 19.7%. Large population studies have reported ER findings of between 6% and 13%.^[10-12] Previously, ER had been thought to be a sign of good health, due to its prevalence in athletes, young individuals, and those with a slower heart rate. However, numerous recent reports have suggested a relationship between ER and an increased risk for arrhythmic death, idiopathic ventricular fibrillation, and all-cause mortality.^[11-16]

We were unable to compare our results with previous studies because the ECG manifestations of a prolonged hunger strike have not yet been reported. But there are numerous studies about ECG findings in cases of anorexia nervosa that have characterized the effects of prolonged dietary restriction and overt malnutrition. At least one-third of all deaths in patients with anorexia nervosa have been estimated to be due

to cardiac causes, such as sudden cardiac death.^[17-19] Cardiovascular complications of anorexia nervosa are common, and seen in up to 80% of cases. Bradycardia, hypotension, arrhythmias, repolarization abnormalities, and sudden death have been reported in as many as 10%.^[19-21] Electrolyte imbalances are considered a predisposing factor for arrhythmias.^[22] Since electrolytes are important factors for ECG changes, electrolyte fluctuations should be kept in mind when interpreting an ECG. As seen in our study, Faintuch et al.^[23] reported no serious electrolyte alteration after long-term starvation. Other underlying reasons, such as hormones, may be responsible for ECG changes.^[24] The mechanics of ER cannot be fully explained using the data obtained in this study. This is an issue that needs further investigation.

Study limitations

The present study has several limitations. First, there were no baseline ECG data from before the hunger strike. This was also a single-center study and had a small patient population. In addition, renal function tests were not performed and evaluated before and after the hunger strike. Finally, ER mechanics cannot be fully explained with the current data.

Conclusion

To the best of our knowledge, this is the first time that long-term starvation has been associated with ER. A hunger strike should therefore be included in the list of conditions potentially related to ER. A hunger strike was also demonstrated to be associated with QT interval prolongation.

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Anahtar sözcükler: Erken repolarizasyon; elektrokardiyogram; açlık grevi.