Electrocardiographic parameters in clinically healthy Balouchi sheep

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Received: May 3, 2015       Accepted: Nov 15, 2015

Abstract

Electrocardiographic (ECG) parameters and cardiac rhythms have been evaluated and published in different breeds of beef and dairy cattle but there is limited information regarding these parameters in healthy sheep. This study is aimed to investigate the ECG parameters in Balouchi sheep. The ECG parameters including the amplitudes of P, Q, R, S and T waves, duration of P, QRS and T waves and P-R, Q-T and R-R intervals were evaluated in 44 male and female clinically healthy Balouchi sheep in standard and augmented limb leads (I, II, III, AVR, AVL, and AVF) and base-apex lead. The mean heart rate was 89.6 beats/minute which had a significant correlation with age (r=0.269, p=0.014). Different configurations of P-wave, QRS complex and T wave were observed in different ECG leads. It was found that age and gender affects some ECG parameters. In some leads, rams had significantly higher amplitudes of P, Q, R, S and T waves and longer duration of PRR interval than ewes. Also in some leads, the amplitudes of P, R and S waves were significantly higher and the duration of QRS complex was shorter in sheep less than one year old than sheep with age three years or older. The most common cardiac dysrhythmia observed on the ECG traces was Sinus arrhythmia. Sheep with this dysrhythmia had a significantly lower heart rate (p<0.05). Also, it was concluded that the base-apex lead was the most suitable lead for ECG evaluation in sheep.

Keywords: Arrhythmia, electrocardiogram, Balouchi, sheep

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Introduction

Electrocardiography (ECG) has been introduced as a non-invasive diagnostic method for disturbances in the genesis and spread of the cardiac impulses (Escurdo et al., 2009). In large animal medicine, ECG records have also been used as an accurate method in evaluation and comparison of cardiac function, and in diagnosis of cardiac arrhythmia and conduction abnormalities (Escudero et al., 2009; Rezakhani et al., 2004; Tajik et al., 2010).

Although, ECG parameters and cardiac rhythms have been evaluated and published in different breeds of beef and dairy cattle (Rezakhani et al., 2004), there is limited information regarding normal ECG parameters in healthy sheep. On the other hand, the importance of obtaining normal values of ECG for specific breeds of animals has also been emphasized (Escudero et al., 2009).

Sheep population in Iran is 54 million heads, including 27 breeds and ecotypes. The Balouchi breed is one of the most important multi-purpose sheep breeds, and it constitutes about 30% of the total sheep population of Iran and plays an important role in meat and wool production (Dashab et al., 2011) especially in the Khorsan Razavi province. Moreover, this breed has been considered for genetic improvement from several years ago. To the best of our knowledge, the normal ECG values in this breed are unjustified. This study was performed to evaluate these values, to compare different ECG leads, and to detect the probable effects of age and sex on normal ECG values in this breed.

Materials and methods

This study was performed on the Balouchi sheep kept on the Breeding and Research Centre of Balouchi Sheep in the north east of Iran (Mashhad, Abbas Abad) in September 2010. The ECGs were obtained from 44 clinically healthy pure Balouchi sheep. The animals used in this study were selected randomly and were divided into three groups consisting of 10 male and 10 female lambs (up to one year old), 12 ewes (1-5 years old) and 12 rams (1-4 years old). Also, the sheep were divided into three groups according to their age which are as follows: \( G_1 \leq 1 \) years, 1 years \( \leq G_2 \leq 3 \) years and, \( G_3 \geq 3 \) years.

The animals were reared under the same husbandry conditions in different group pens. After routine clinical examinations and taking vital signs (TPR), the ECGs were obtained from each sheep on seven leads including standard and augmented limb leads (I, II, III, aVR, aVL, aVF) and bipolar base-apex lead, using a single channel ECG machine (Suzuken, Kenz 110, Japan) with a paper speed of 25 mm/s and calibration of 10 mm equal to 1 mV. The ECG was recorded when the animals were thought to be in a quiet standing position using an alligator-type electrode attached to the skin. In the case of bipolar (I, II, III) and augmented (aVR, aVL, aVF) limb leads, the electrodes were connected to the skin of the medial sides of the elbows and stifles (Rezakhani and Edjtehadi, 1980). In the case of base-apex lead, the positive electrode of lead I (left arm) was attached to the skin of the fifth intercostal space just caudal to the olecranon and the negative electrode (right arm) on the jugular furrow about the lower 1/3 of the left side of the neck, and the earth was attached away from these two electrodes (Tajik et al., 2010). Alligator clips were fixed to the skin after methyl alcohol application.

A magnifying glass was used for analyzing and measuring ECG parameters. Using the glass, the precision of duration and amplitude were 0.02 s. and 0.05 mV, respectively. Heart rate was calculated by measuring the average six R–R intervals of each trace and the mean heart rate of 7 leads was used as the heart rate of each of the sheep. To describe the QRS complex, the first negative deflection was designated as Q, the first positive wave was named R and the negative deflection after R was designated as S, and a second upward
deflection in the complex was labeled R'. If the QRS complex was a single negative deflection, it was described as the QS pattern. Lower case letters (q, r, and s) were used to indicate them, if the magnitudes of the waves were small (Deroth, 1980; Rezakhani et al. 2004). In the case of biphasic P or T waves (-/+ or +/-), the amplitudes of the two phases were summed.

Statistical analysis was performed using SPSS12 (Illinois, Chicago). Two sample t tests were used to detect differences in heart rate, waves' amplitude and duration, and P-R, Q-T and R-R intervals between the two sexes. Analysis of variance (ANOVA) tests were used for the comparison of the parameters between different age groups. Comparison of waves' conformation between the two sexes and different age groups were performed using Chi-square tests. Differences were considered significant at $p<0.05$.

### Results

The common observed irregularity in the ECG of most sheep was sinus arrhythmia. Two sample t tests showed that sheep with sinus arrhythmia had a significantly lower heart rate in II, III, aVR, aVL and aVF leads ($p<0.05$).

#### Table 1. Heart rate and amplitudes of ECG waves in Balouchi sheep in 7 leads

<table>
<thead>
<tr>
<th>Parameter Lead</th>
<th>Heart rate</th>
<th>P (mv)</th>
<th>Q (mv)</th>
<th>R (mv)</th>
<th>S (mv)</th>
<th>T (mv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>93.6±3.237</td>
<td>0.046±0.004</td>
<td>0.324±0.082</td>
<td>0.039±0.007</td>
<td>0.348±0.045</td>
<td>0.147±0.014</td>
</tr>
<tr>
<td>II</td>
<td>92.1±3.03</td>
<td>0.044±0.008</td>
<td>0.169±0.025</td>
<td>0.101±0.064</td>
<td>0.192±0.211</td>
<td>0.118±0.081</td>
</tr>
<tr>
<td>III</td>
<td>90.5±2.652</td>
<td>0.034±0.007</td>
<td>0.049±0.006</td>
<td>0.296±0.026</td>
<td>0.091±0.075</td>
<td>0.09±0.075</td>
</tr>
<tr>
<td>aVR</td>
<td>89.5±2.405</td>
<td>0.04±0.003</td>
<td>0.018±0.001</td>
<td>0.249±0.03</td>
<td>0.059±0.007</td>
<td>0.134±0.015</td>
</tr>
<tr>
<td>aVL</td>
<td>87.8±2.628</td>
<td>0.03±0.002</td>
<td>0.139±0.044</td>
<td>0.024±0.016</td>
<td>0.331±0.205</td>
<td>0.107±0.011</td>
</tr>
<tr>
<td>aVF</td>
<td>87±2.15</td>
<td>0.029±0.002</td>
<td>0.086±0.011</td>
<td>0.165±0.017</td>
<td>0.108±0.054</td>
<td>0.103±0.009</td>
</tr>
<tr>
<td>BA</td>
<td>84.8±1.871</td>
<td>0.114±0.012</td>
<td>0.021±0.003</td>
<td>0.086±0.015</td>
<td>0.541±0.037</td>
<td>0.338±0.035</td>
</tr>
</tbody>
</table>

#### Table 2. Durations of ECG waves in Balouchi sheep in 7 leads

<table>
<thead>
<tr>
<th>Parameter Lead</th>
<th>P (sec)</th>
<th>QRS (sec)</th>
<th>T (sec)</th>
<th>P-R (sec)</th>
<th>Q-T (sec)</th>
<th>R-R (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0.036±0.002</td>
<td>0.039±0.001</td>
<td>0.068±0.006</td>
<td>0.106±0.003</td>
<td>0.279±0.004</td>
<td>0.668±0.02</td>
</tr>
<tr>
<td>II</td>
<td>0.042±0.013</td>
<td>0.037±0.013</td>
<td>0.065±0.013</td>
<td>0.105±0.019</td>
<td>0.289±0.024</td>
<td>0.674±0.115</td>
</tr>
<tr>
<td>III</td>
<td>0.038±0.002</td>
<td>0.051±0.001</td>
<td>0.058±0.002</td>
<td>0.099±0.003</td>
<td>0.289±0.004</td>
<td>0.682±0.017</td>
</tr>
<tr>
<td>aVR</td>
<td>0.041±0.002</td>
<td>0.06±0.002</td>
<td>0.061±0.002</td>
<td>0.1±0.002</td>
<td>0.286±0.004</td>
<td>0.687±0.016</td>
</tr>
<tr>
<td>aVL</td>
<td>0.037±0.002</td>
<td>0.043±0.002</td>
<td>0.064±0.006</td>
<td>0.098±0.003</td>
<td>0.294±0.004</td>
<td>0.704±0.017</td>
</tr>
<tr>
<td>aVF</td>
<td>0.038±0.0018</td>
<td>0.052±0.001</td>
<td>0.06±0.002</td>
<td>0.099±0.002</td>
<td>0.295±0.004</td>
<td>0.704±0.015</td>
</tr>
<tr>
<td>BA</td>
<td>0.045±0.002</td>
<td>0.055±0.009</td>
<td>0.064±0.003</td>
<td>0.127±0.014</td>
<td>0.293±0.004</td>
<td>0.717±0.014</td>
</tr>
</tbody>
</table>
The mean heart rate ranged from 71.9 to 136 beats/minute with an average of 89.6. The ewes had higher heart rate than the rams in all measured leads, which was statistically significant in base-apex lead (p<0.05). There was no significant difference between different age groups in the heart rate but it had a significant correlation with age (r=-0.269, p=0.014).

### Table 3. Configurations of P and T waves in Balouchi sheep in 7 leads

<table>
<thead>
<tr>
<th>Shape</th>
<th>Lead</th>
<th>(+)</th>
<th>(-)</th>
<th>(+/-)</th>
<th>(+/+)</th>
<th>flat</th>
<th>(+)</th>
<th>(-)</th>
<th>(+/-)</th>
<th>(+/+)</th>
<th>flat</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>37</td>
<td>(90.2%)</td>
<td>1</td>
<td>(2.4%)</td>
<td>2</td>
<td>(4.9%)</td>
<td>1</td>
<td>(2.4%)</td>
<td>21</td>
<td>(51.2%)</td>
<td>10</td>
</tr>
<tr>
<td>II</td>
<td>31</td>
<td>(75.6%)</td>
<td>1</td>
<td>(2.4%)</td>
<td>7</td>
<td>(17.1%)</td>
<td>2</td>
<td>(4.9%)</td>
<td>6</td>
<td>(14.6%)</td>
<td>31</td>
</tr>
<tr>
<td>III</td>
<td>10</td>
<td>(24.4%)</td>
<td>16</td>
<td>(39%)</td>
<td>7</td>
<td>(17.1%)</td>
<td>3</td>
<td>(7.3%)</td>
<td>4</td>
<td>(9.8%)</td>
<td>27</td>
</tr>
<tr>
<td>avR</td>
<td>2</td>
<td>(4.9%)</td>
<td>29</td>
<td>(70.7%)</td>
<td>6</td>
<td>(14.6%)</td>
<td>3</td>
<td>(7.3%)</td>
<td>1</td>
<td>(2.4%)</td>
<td>23</td>
</tr>
<tr>
<td>avL</td>
<td>32</td>
<td>(78%)</td>
<td>3</td>
<td>(7.3%)</td>
<td>3</td>
<td>(7.3%)</td>
<td>2</td>
<td>(4.9%)</td>
<td>33</td>
<td>(56.1%)</td>
<td>8</td>
</tr>
<tr>
<td>avF</td>
<td>23</td>
<td>(56.1%)</td>
<td>9</td>
<td>(22%)</td>
<td>9</td>
<td>(7.3%)</td>
<td>3</td>
<td>(9.8%)</td>
<td>6</td>
<td>(14.6%)</td>
<td>33</td>
</tr>
<tr>
<td>BA</td>
<td>34</td>
<td>(82.9%)</td>
<td>-</td>
<td>-</td>
<td>5</td>
<td>(12.2%)</td>
<td>2</td>
<td>(4.9%)</td>
<td>35</td>
<td>(85.4%)</td>
<td>-</td>
</tr>
</tbody>
</table>

The results of the measurement of the heart rate, the mean and ranges of P, Q, R, S and T waves amplitudes, and the mean and ranges of P, QRS, T, P-R, Q-T and R-R intervals of the sheep are shown in Table 1 and Table 2.

The configurations of P wave in leads I, II, aVL, aVF and base-apex were mainly simple positive, and in leads III and aVR were mainly simple negative. A biphasic P wave (-/+ or +/−) was observed in all leads. A notched P wave was diagnosed in leads III and base-apex (Table 3). There was no significant difference between the two sexes as well as different age groups in the configurations of P wave.

The rams had higher mean P amplitude than the ewes in all the measured leads, which was statistically significant in aVF lead (p<0.05). The G3 group had lower mean P amplitude in all leads, and in lead aVF, G3 and G2 groups had significantly lower mean P amplitudes than G1 group.

There was no significant difference between the two sexes and between different age groups in P duration in different measured leads.

Seventeen different patterns of QRS complex were observed in ECGs. In total, 7 patterns in lead I; 3 patterns in lead II; 4 patterns in lead III; 10 patterns in lead aVR; 7 patterns in aVL; 3 patterns in aVF and 3 patterns in base-apex lead were observed (Table 4). The configurations of QRS complex had significant difference between the two sexes in leads III and base-apex (p<0.05). There was no significant difference between different age groups.

Male sheep had a higher Q amplitude in comparison with females in all 7 leads, which was statistically significant in leads I, II, aVF (p<0.05). R wave amplitude of rams was significantly higher than ewes in leads II, III and aVR. In leads I and base-apex, rams had significantly higher S wave than ewes.

In comparison between different age groups, Q amplitude showed no significant difference. G3 had lower R amplitude than other age groups in leads III, aVR and aVF. S wave amplitude was significantly higher in G1 than G3 in aVL.
In lead II, III and aVF, QRS complex duration was significantly higher in G3 than G1. Also, G3 had significantly higher QRS complex duration than other age groups in lead I.

Female sheep had significantly higher QRS complex duration than male sheep in leads II, III, aVR and aVF.

The configurations of T wave in leads I, aVR, aVL and base-apex were mainly simple positive, and in leads II, III and aVF were mainly simple negative. In all leads, a biphasic T wave was observed (Table 2). T wave configurations showed a significant difference between the two sexes in base-apex lead (p<0.05).

In base-apex lead, rams had a significantly higher T amplitude than ewes. There was no significant difference between different age groups. T duration showed no significant differences between different sexes and age groups.

P-R interval was significantly longer in rams than ewes in lead II, aVR, aVL and aVF (p<0.05). In aVL lead, G1 had significantly shorter P-R interval than other age groups.

Although, rams showed a longer R-R interval in comparison to ewes in all leads, the differences were not statistically significant (p>0.05). G1 had a significantly shorter R-R interval than G3 in leads aVL and base-apex.

In all leads, Q-T interval showed no significant difference between the two sexes (p>0.05). In base-apex lead, G1 had a significantly shorter Q-T interval than G3.

### Discussion

There are few previous studies regarding normal ECG parameters in healthy sheep. According to the results, sinus arrhythmia was diagnosed in 89.9% of Balouchi sheep and those sheep had lower heart rate than sheep with normal rhythm. Rezakhani and Edjtehadi (1980) found sinus arrhythmia as a common irregularity in fat-tailed sheep, which is more prevalent in sheep with lower heart rates. In other studies, sinus arrhythmia has been reported in 23-33% of sheep (Pourjafar et al., 2011; Torio et al., 1997).

The mean heart rate of Balouchi sheep was 89.6 beats/minute which was within the reported normal range of sheep (60-160) (Smith et al., 2009), and was higher than that reported in Garole sheep breed (Ahmed and Sanyal, 2008) and lower than that reported in non-specified breed of fat-tailed sheep (Rezakhani and Edjtehadi, 1980).

The P wave configurations in leads I, II, aVL, aVF in Balouchi sheep were mainly simple positive, and in leads III and aVR were mainly simple negative. Additionally, a biphasic P wave was observed in all leads. Rezakhani and Edjtehadi (1980) reported same results in non-specified breed of fat-tailed sheep. According to our results, in base-apex lead, the main P wave configuration was simple positive. Similar results have been reported in Gallega sheep in base-apex lead (Torio et al., 1996).

According to our result, the Balouchi rams had higher P and QRS components amplitudes than the ewes. Higher P amplitude in male animals than females has been also reported in

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**Table 4: Configurations of QRS complex in Balouchi sheep in 7 leads**

<table>
<thead>
<tr>
<th>Lead</th>
<th>QR</th>
<th>QR</th>
<th>QR</th>
<th>QR</th>
<th>QR</th>
<th>QR</th>
<th>RS</th>
<th>R</th>
<th>RS</th>
<th>R</th>
<th>Rs</th>
<th>Rs</th>
<th>Rare shapes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>22</td>
<td>23</td>
<td>25</td>
<td>77%</td>
</tr>
<tr>
<td>II</td>
<td>31</td>
<td>31</td>
<td>35</td>
<td>34</td>
<td>39</td>
<td>39</td>
<td>59</td>
<td>69</td>
<td>69</td>
<td>69</td>
<td>69</td>
<td>69</td>
<td>100%</td>
</tr>
<tr>
<td>III</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>100%</td>
</tr>
<tr>
<td>aVR</td>
<td>-</td>
<td>-</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>100%</td>
</tr>
<tr>
<td>aVL</td>
<td>-</td>
<td>-</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>100%</td>
</tr>
<tr>
<td>aVF</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>100%</td>
</tr>
<tr>
<td>BA</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>100%</td>
</tr>
</tbody>
</table>

In lead II, III and aVF, QRS complex duration was significantly higher in G3 than G1. Also, G3 had significantly higher QRS complex duration than other age groups in lead I.

Female sheep had significantly higher QRS complex duration than male sheep in leads II, III, aVR and aVF.

The configurations of T wave in leads I, aVR, aVL and base-apex were mainly simple positive, and in leads II, III and aVF were mainly simple negative. In all leads, a biphasic T wave was observed (Table 2). T wave configurations had a significant difference between the two sexes in base-apex lead (p<0.05).

In base-apex lead, rams had a significantly higher T amplitude than ewes. There was no significant difference between different age groups. T duration showed no significant difference between different sexes and age groups.

P-R interval was significantly longer in rams than ewes in lead II, aVR, aVL and aVF (p<0.05). In aVL lead, G1 had significantly shorter P-R interval than other age groups.

Although, rams showed a longer R-R interval in comparison to ewes in all leads, the differences were not statistically significant (p>0.05). G1 had a significantly shorter R-R interval than G3 in leads aVL and base-apex.

In all leads, Q-T interval showed no significant difference between the two sexes (p>0.05). In base-apex lead, G1 had a significantly shorter Q-T interval than G3.
horses and donkeys (Scudero et al., 2009). Higher myocardial mass in male animals may cause higher P, Q, R and S wave amplitudes. In Balouchi sheep, G3 group had lower P, R and S amplitudes. Tovar et al. (1985) reported a negative correlation between age and P wave amplitude in merino sheep. In camels, higher S amplitude has been reported in younger animals than the old animals (Pourjafar et al., 2011). It is believed that gradual development of body mass may cause difficulty in the waves reaching the body surface in adults (Pourjafar et al., 2011).

In Balouchi sheep, G3 had lower P, R and S amplitudes. Tovar et al. (1985) reported a negative correlation between age and P wave amplitude in merino sheep. In camels, higher S amplitude has been reported in younger animals than the old animals (Pourjafar et al., 2011). It is believed that gradual development of body mass may cause difficulty in the waves reaching the body surface in adults (Pourjafar et al., 2011).

In the present study, T wave configuration and amplitude showed significant differences between both sexes and different age groups in Balouchi sheep. Similar results have been reported for donkeys (Scudero et al., 2009). However, it is believed that T wave is the most variable wave in ECG and it could be influenced by several factors such as animal excitement, drugs, vagal tone and etc. (Marr, 1999; Holmes & Rezakhani 1975).

There are little previous studies regarding the effects of age and sex on ECGs intervals in animals. We found longer P-R interval and R-R interval in Balouchi rams than ewes. Alidadi et al. (2002) reported longer P-R and Q-T intervals in Turkmen stallions than mares. In Balouchi sheep, G3 showed lower P-R, R-R and Q-T intervals than G1. Similar results have been reported for horses (Razavizadeh, 2007; Alidadi et al., 2002) and camel (Pourjafar et al., 2011). Larger myocardial mass in adults has been proposed as the probable cause (Pourjafar et al., 2011).

According to our results, less configuration variation and higher amplitude of waves in base-apex lead make ECG interpretation easier and more accurate, and candidate this lead as the preferred lead for ECG evaluation in sheep. Pugh (2002) has also recommended the base-apex lead for the ECG evaluation of sheep.

The finding of the present study can be used in diagnosis of ECG abnormalities in this breed.

References


تعیین پارامترهای الکتروکاردیوگرافی در گوسفندهای سالم نژاد بلوچی

چکیده

پارامترهای الکتروکاردیوگرافی و ریتم قلبی در گو‌های شیری و گوشتی هم به فراوانی مطالعه شده است ولی در مورد گوسفندهای انتحال آبادی موجود در این زمینه محدود است. این مطالعه با هدف تعیین پارامترهای الکتروکاردیوگرافی و ریتم قلبی در گوسفندهای سالم نژاد بلوچی انجام شد. برای این منظور، الکتروکاردیوگرافی انجام شد. نتایج نشان داد که پارامترهای الکتروکاردیوگرافی در گوسفندهای سالم نژاد بلوچی در مقایسه با دام‌های سالم دیگر بزرگ‌تر است.

واژگان کلیدی: الکتروکاردیوگرافی، نژاد، گوسفند

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Iranian Journal of Veterinary Science and Technology, Vol. 7, No. 2

پدرش نهایی: ۱۳۹۲/۱۳/۲۴

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