Objective: There are several prediction scales and parameters for prognosis after a cardiac arrest. One of these scales is the brain arrest neurological outcome scale (BrANOS), which consists of duration of cardiac arrest, Glasgow Coma Scale score and Hounsfield unit measured on cranial computed tomography (CT) scan. The objective of this study is to investigate the effectiveness of BrANOS on predicting the mortality and disability after a cardiac arrest.

Methods: We retrospectively investigated cardiac arrest patients who were hospitalized in our intensive care unit (ICU) within a 3-year period. Inclusion criteria were age over 18 years old, survival of more than 24 hours after cardiac arrest and availability of cranial CT. We recorded the age, sex, diagnosis, duration of cardiac arrest and hospital stay, mortality, Glasgow Outcome Score (GOS) and BrANOS score. The primary endpoint of the study was to establish the relationship between mortality and BrANOS score in patients who survived for more than 24 hours after a cardiac arrest. The secondary endpoint of the study was to determine the 2-year life expectancy and GOS after cardiac arrest.

Results: The mean age of the patients was 57±17 years (33 females, 67 males). ICU mortality rate was 57%. The BrANOS mean score was 10.3±3.2. There was a significant difference between survivors and non-survivors in terms of the BrANOS score (8.8±3.2 vs. 11.6±2.7; p<0.001). BrANOS reliably predicted the survival with a ROC area under the curve of 0.733. The scale of >14 predicted death with 100% accuracy. All the patients without disability had a BrANOS score of <10. The BrANOS score also correlated well with GOS (p<0.001). The 2-year life expectancy rate was 31% in patients who survived more than 24 hours after a cardiac arrest.

Conclusion: In this study, we demonstrated that BrANOS provided reliable data for prognostic evaluation after a cardiac arrest.

Keywords: Cardiac arrest, Glasgow Outcome Scale, multidetector computerized tomography, morbidity

Abstract

Introduction

In spite of the developments in resuscitation techniques and increased rate of successful resuscitations, most patients with cardiac arrest are discharged from the hospital with permanent brain damage. The rate of discharge without any sequelae varies from 1% to 16% (1-5). Similar to intensive care patients, various prognostic scoring systems have been used for following the success of cardiopulmonary resuscitation (CPR) and evaluating survival and prognosis after cardiopulmonary arrest (CPA). However, no singular valid method is available. There are certain studies showing that clinical neurological signs, various laboratory parameters (glucose, S-100B protein), electroencephalography (EEG) and sensory evoked potentials (SEP) are important (6, 7). Further, the Glasgow coma scale (GCS) and some neurological signs (pupil light reflex, vestibulo-ocular reflex, corneal reflex, spontaneous ventilation, pain localization, etc.) are clinical findings that can yield a prognosis (6, 7).

Magnetic resonance (MR) and computed tomography (CT) are the screening techniques frequently used for coma patients and they are less time consuming as compared to EEG and SEP. The use of MR is restricted due to its accessibility, its cost, difficulty in interfering with patient during the screening process and its prevalence in health centres (8). CT is preferred over MR because the former is more practical in the detection of cerebral pathologies. Moreover, it has been found that the density measurement of white and grey matter is a good criterion for estimating the life expectancy after CPA (9, 10).

In this study, the role of brain arrest neurological outcome scale (BrANOS) was investigated, which was developed by Torbey et al. (10) for predicting the prognosis in patients after cardiac arrest. It comprised the duration of CPA, GCS and Hounsfield unit (HU) measured on the CT, in the prediction of prognosis in patients with cardiac arrest.
Methods

After receiving approval from the Ege University School of Medicine, Clinical Research Ethics Committee (Date: 21 February 2013; No. 253) for this retrospective study, 100 adult patients older than 18 years old, who were hospitalized in the intensive care unit after cardiac arrest between 2004 and 2006, who underwent cranial CT after cardiac arrest and who survived for at least 24 h after cardiac arrest, were included. Patients having cerebral pathology and metabolic encephalopathy, undergoing head trauma and having incomplete recordings were excluded from the study.

Data about clinical course, age and gender of patient, duration of cardiac arrest, arrest rhythm at admission, duration of staying in intensive care and mechanical ventilation, discharge from hospital and BrANOS score were recorded. Discharged patients or their families were phoned and questioned for the Glasgow outcome score (GOS) in the 6th month, 1st year and 2nd year after the cardiac arrest and for the length of survival. The primary endpoint of the study is to determine the relationship between the BrANOS score and mortality in patients that survived for more than 24 h after cardiac arrest. The secondary endpoints are to reveal the GOS values, life expectancies in the 6th month, 1st year and 2nd year after cardiac arrest and their relationship with BrANOS.

BrANOS: It is a 16-point scoring system that indicates the neurological prognosis after cardiac arrest. Low points indicate a good prognosis, while high scores indicate neurological sequelae or mortality. The scale consists of three parameters:

1. Duration of Cardiac Arrest: It was defined as the time from the beginning of cardiac arrest to the return of spontaneous circulation (1 point for <5 min; 2 points for 6-15 min; 3 points for >15 min).

2. GCS: Reverse GCS (rGCS), which was defined as ‘15-GCS’, was used for preparing a schedule related to brain damage. The best GCS reports within the first 24 h were recorded and rGCS was scored from 0 to 12.

3. HU: This term was used for measuring the density of white and grey matter. Because the most critical changes for cardiac arrest were in the basal ganglions, the HU measurements were restricted to basal ganglions. The ratio of caudate nucleus (grey matter) density to internal capsule (white matter) density was called the HU ratio (HUR) (1 point if HUR<1.18; 0 point if HUR≥1.18) (8). The patients who underwent cranial CT within the first 72 h after arrest were included in the study and their brain CTs were evaluated by the same radiologist.

GOS values were calculated over 5 points:

5 points: Complete recovery; patient returned to his/her life before arrest.
4 points: Moderately dependent; patient with neurological sequelae can meet his/her own needs.
3 points: Severely dependent; patient needs help in daily activities.
2 points: Persistent vegetative condition; there is no finding related to high cortical functions.
1 point: Death

Statistical Analysis

Data were analysed using the SPSS 15.0 (Statistical Package for the Social Sciences Inc; Chicago, IL, USA) statistical software. Mean and standard deviation values were used for the descriptive statistics of data. In the analysis of quantitative data, independent samples t-test and Mann-Whitney U-test were employed. Pearson’s χ² test and Fisher’s test were used for the analysis of qualitative data. The strength of BrANOS in the prediction of mortality and morbidity was evaluated with receiver operating characteristic (ROC) curves. The area below the curve demonstrated the efficiency in the differentiation of mortality and morbidity. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated. Sensitivity demonstrated the ratio of non-survivors with high BrANOS scores to total non-survivors (low scores indicated a good prognosis); specificity demonstrated the ratio of surviving patients with low BrANOS scores to total survivors; PPV showed the rate of non-survivors among the ones with high BrANOS scores and NPV indicated the rate of surviving patients among those getting low scores. Kaplan-Meier survival curves were drawn and compared using the log-rank test. The value of p<0.05 was accepted to be statistically significant.

Results

The mean age of 100 patients included in the study was 57±17 years, and 67 of them were male. While the age range of non-surviving patients was between 18 and 87 years, it was between 18 and 80 years in surviving patients. Demographic and clinical features of the patients are presented in Table 1.

The mean duration of cardiac arrest was 19.28±12.26 min in all the patients. While the duration of arrest varied from 3 to 60 min in non-survivors, it was between 1 and 60 min in survivors (p=0.005). The rate of life expectancy was 80% in patients whose arrest duration was 5 min and below, 50% in patients whose arrest duration was between 6 and 15 min and 32.8% in patients whose arrest duration was 15 min and above (p=0.013). The mean GCS of patients was 7.56±2.75 and only 2 out of the 20 patients who got 5 points and below were discharged from the hospital (p=0.001). Eighteen out of the 30 patients with GCS of 10 and above and 25 out of 70 patients with GCS below 10 were externed (p=0.029). All the patients with a GCS of 3 (7 patients) died in the 24th hour.

Regarding the HUR values of patients, 39 patients got scores below 1.18 and only 13 patients were discharged from the hospital. Thirty out of 61 patients whose HUR values were 1.18 and above were discharged (p=0.149). The HUR value below 1.18 was associated with 100% mortality.
The BrANOS values for discharged patients were significantly lower. The area under the curve (AUC) was determined to be 0.733 through the ROC analysis. The values of AUC, sensitivity, specificity, PPV and NPV were calculated to be 0.602, 26%, 97%, 93.75% and 50%, respectively, for BrANOS of 14 points. Further, these values were 0.619, 77%, 46%, 65.6% and 60.6%, respectively, for BrANOS of 10 points. All the patients scoring BrANOS of 14 points and above died within the first 6 months. The only patient that was discharged could survive outside the hospital for 3 days.

When the relationship between BrANOS and neurological outcome (GOS) was compared, 4 patients recovering without any sequelae were observed to get scores below 10. While all the 5 patients with 4 points and below were discharged, 2 patients healed without any sequelae. Severe mortality and morbidity were observed in patients with BrANOS values between 10 and 13; there was no patient recovering without any sequelae. On the other hand, only 1 patient with a BrANOS value of 14 and above (GSS:3) was discharged, but this patient died on the 129th day after the arrest event (p<0.001) (Table 2).

When the life expectancy of all the patients was examined with the Kaplan-Meier survival curves, it was found that 43% patients were discharged, 6-month life expectancy was 38%, 1-year life expectancy was 34% and 2-year life expectancy was 31%. Out of the 43 discharged patients, 5 died in the first 6 months; 4, between 6 months and 1 year and 3, within 1-2 years. Thus, the mortality increased to 69% in the 2-year period.

One out of the 5 patients with BrANOS values of 4 and below died on the 39th day and the others survived for 2 years. While 50% patients with BrANOS values between 5 and 9 died within 65 days, the 6-month, 1-year and 2-year survival expectancies were 42%, 39% and 35%, respectively. While 50% patients with BrANOS values between 10 and 13 died within the first 32 days, 6-month, 1-year and 2-year survival expectancies were 44%, 42% and 37%, respectively. Half of the patients whose BrANOS scores were between 14 and 16 died within the first 6 days and one patient that was discharged with the BrANOS score of 14 survived outside the hospital only for 3 days (Figure 1).

### Discussion

This study revealed the relationship between poor neurological outcome and mortality with high BrANOS score in cardiac arrest patients. On the other hand, the rates of discharge from the hospital and the 2-year life expectancy are quite high.

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Table 1. Demographic and clinical data of patients

<table>
<thead>
<tr>
<th></th>
<th>Discharge (Mean±SD)</th>
<th>Non-survivors (Mean±SD)</th>
<th>All patients (Mean±SD)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female/Male</td>
<td>13/30</td>
<td>20/37</td>
<td>0.609</td>
<td></td>
</tr>
<tr>
<td>Age (year)</td>
<td>52±15</td>
<td>58±17</td>
<td>57.5±17.01</td>
<td>0.485</td>
</tr>
<tr>
<td>Duration of arrest (min)</td>
<td>15.37±11.17</td>
<td>22.23±12.32</td>
<td>19.28±12.26</td>
<td>0.005</td>
</tr>
<tr>
<td>Comorbid disease (No/Yes)</td>
<td>23/20</td>
<td>9/48</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>Rhythm of Arrest</td>
<td>21/3/18/1</td>
<td>27/2/24/4</td>
<td>5.68±2.57</td>
<td>0.641</td>
</tr>
<tr>
<td>GCS (1st hour)</td>
<td>6.63±2.76</td>
<td>4.96±2.18</td>
<td>7.56±2.75</td>
<td>0.001</td>
</tr>
<tr>
<td>GCS (24th hour)</td>
<td>8.84±2.58</td>
<td>6.60±2.49</td>
<td>1.216±0.91</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>HUR</td>
<td>1.243±0.95</td>
<td>1.196±0.84</td>
<td>10.39±3.23</td>
<td>0.149</td>
</tr>
<tr>
<td>BrANOS</td>
<td>8.81±3.20</td>
<td>11.58±2.72</td>
<td>20.37±8.51</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>APACHE II</td>
<td>14.81±5.87</td>
<td>24.56±7.79</td>
<td>26.83±9.64</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Stay in IC (day)</td>
<td>38.98±39.98</td>
<td>17.67±37.16</td>
<td>10.92±15.81</td>
<td>0.007</td>
</tr>
<tr>
<td>Duration of MV (day)</td>
<td>9.84±9.76</td>
<td>11.74±19.2</td>
<td>32.71±43.45</td>
<td>0.555</td>
</tr>
<tr>
<td>Stay in hospital (day)</td>
<td>52.65±43.54</td>
<td>17.67±37.16</td>
<td>0.001</td>
<td></td>
</tr>
</tbody>
</table>

Rhythm of arrest, ventricular fibrillation/ventricular tachycardia/asystole/pulseless electrical activity; GCS: Glasgow coma scale; HUR: Hounsfield unit ratio; APACHE II: acute physiology and chronic health evaluation system II; Stay in IC: stay in the intensive care; Duration of MV: duration of mechanical ventilation; M: mean; SD: standard deviation

Table 2. BrANOS–GOS relationship

<table>
<thead>
<tr>
<th>BrANOS/GOS</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5 Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤4</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2 5</td>
</tr>
<tr>
<td>5–9</td>
<td>13</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>2 28</td>
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<tr>
<td>10–13</td>
<td>28</td>
<td>6</td>
<td>11</td>
<td>5</td>
<td>0 50</td>
</tr>
<tr>
<td>14–16</td>
<td>16</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0 17</td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
<td>7</td>
<td>20</td>
<td>12</td>
<td>4 100</td>
</tr>
</tbody>
</table>

BrANOS: Brain arrest neurological outcome scale; GOS: Glasgow outcome score

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Figure 1. Relationship of survival with BrANOS (Kaplan–Meier survival curves)
in patients having low BrANOS scores. In previous studies, the general opinion is that a poor prognosis usually occurs after CPA. In fact, low rates of discharge, as low as 1%-2%, are observed in patients undergoing CPR and some of the surviving patients are discharged with serious neurological sequelae. These patients need familial care together with medical treatment, which can be expensive and may continue for a longer period. Knowing if this expensive treatment contributes towards the prognosis for each patient is important for clinicians because of ethical and economic reasons. Reliable factors in the prediction of clinical outcomes after CPR can guide these decisions (4, 11).

The most important determinant for a prognosis has been suggested to be the duration of cardiac arrest in patients having undergone CPR. The duration of arrest has been found to be approximately 4.1 min in patients with a good prognosis and approximately 8 min in patients with a poor prognosis (6). Eisenberg et al. (12) reported the rate of discharge as 56% in cases with the duration of CPR shorter than 4 min, 35% in cases with the duration of CPR between 4 and 8 min and 17% in cases with the duration of CPR longer than 8 min. In our study, a significant relationship was found between the duration of cardiac arrest and mortality. In patients whose duration of arrest was shorter than 5 min, the rate of discharge was as high as 80%. With an increase in the duration of arrest, the rate of discharge decreased, but the rate of discharge with sequelae increased.

Various studies investigating the reliability of different clinical scoring systems in determining the prognosis after CPA have been conducted. Sacco et al. (13) demonstrated that the possibility of resuscitation was 7 times higher in patients with baseline GCS values of 6-8 than in patients with the values of 3-5. Niskanen et al. (14) reported that 28% patients with GCS values of 14-15 and 81.4% patients with a GCS value of 3 died. Cho et al. (15) found the threshold value of GCS in the prediction of hospital mortality to be 5 points and the correct prediction index of this GCS value is 81.9%. They detected that the GCS yielded correct results in the evaluation of early mortality (death within 14 days following hospital admission). In the study of Grmec et al. (16), the threshold value of GCS in the prediction of mortality was found to be 5 and it was claimed that GCS was the most appropriate scoring system for non-traumatic coma patients.

In our study, GCS values were lower in non-surviving patients. Reperfusion damage after cardiac arrest and low GCS values due to medications is normal. An improvement was observed in the GCS values at the 24th hour after CPR. In our study, only 2 out of 20 patients whose GCS values were 5 and below at the 24th hour survived and the threshold value of 5 for GCS was found to be a good indicator of mortality. None of the patients whose GCS values were 3 at the 24th hour were discharged. Similar to the literature, a significant relationship was detected between a decreased GCS value and mortality and morbidity. It was suggested that the control of consciousness at the 24th hour after CPR was more significant when determining survival.

Torbey et al. (9) found that the disappearance of density difference between grey and white matter indicated a poor prognosis, and grey-white matter ratio (HUR) below 1.18 was associated with 100% mortality. In their studies, all the patients with the threshold values below 1.18 died and 46% of those with a threshold value of 1.18 survived. In the study of Gentsch et al. (17) including 98 patients, they used four different HUR values with HU that they measured in 16 regions instead of 4 regions. In their study, they stated that the HUR values varied between 1.1 and 1.161, and they were not associated with a poor prognosis. While HU values in the internal capsule (PLIC) were not different for patients with good and poor prognoses. In the study of Wu et al. (18) in which they examined 151 patients getting GCS scores ≤8, they demonstrated that decreased putamen and PLIC HU values resulted in a poor prognosis. It was stated that while putamen/PLIC HUR value was an indicator of a poor prognosis, CN/PLIC HUR value was insignificant in terms of indicating a poor prognosis. In their study, while the CN/PLIC HUR value was found to be 1.0 (0.96-1.04) in patients with a poor prognosis, it was 1.03 (0.97-1.04) in patients with a good prognosis (p=0.18).

Inamasu et al. (19) examined 75 cardiac arrest patients after dividing them into 2 groups. While the disappearance of grey-white matter differentiation in the brain was 24% in Group 1 (duration of cardiac arrest: ≤20 min), it was 83% in Group 2 (duration of cardiac arrest: >20 min) (p<0.001). Sulcal effacement in the brain sulci was at the rate of 0% in Group 1, but 34% in Group 2 (p=0.004). A total of 12 patients-6 patients from Group 1 and 6 patients from Group 2 were discharged with good neurological scores. While 98% patients whose grey-white matter differentiation disappeared, died, the HUR value varied between 0.98 and 1.18 (mean: 1.10±0.05). Out of the 23 patients whose grey-white differentiation did not disappear, 52% died and the HUR values ranged between 1.13 and 1.32 (mean: 1.26±0.6). While all the 20 patients with sulcal effacement died, 12 out of 13 patients without sulcal effacement were discharged from the hospital with good neurological scores.

In our study, 39 patients had HUR values below 1.18 and only 66% of these patients died. The HUR values ranged from 1.01 to 1.41. Different from other studies, all the patients with HUR values below 1.08 died. Since cerebral oedema was found in some of our patients, treatment for cerebral oedema was initiated. Although oedema did not develop in some patients, mannitol therapy was administered for them before taking cranial CT. Treatments for
brain oedema, sedation and hypothermia might have affected the density of the brain tissue. Therefore, it was concluded that only HUR value on the cranial CT was insufficient for survival and different clinical methods are needed.

Torbey et al. (10) evaluated the neurological condition after cardiac arrest in their study and they found the mean BrANOS score to be 12±1: 8±2 in survivors and 13±1 in non-survivors. Out of these 32 patients, 4 could survive with serious sequelae and 2 with mild sequelae. They detected the threshold value for mortality to be 14 and above, the area under ROC to be 0.86 and PPV value to be 100%. They reported that all the patients with scores of 14 and above died within 10 days and the mean duration of survival was 5±1 days. For the patients with BrANOS values below 14, the mean duration of survival was 20±4 days.

In our study, the mean BrANOS score was found to be 10.39±3.23 and it was higher in non-surviving patients. Although the area under the curve was lower in the ROC analysis for BrANOS, a value of 14 and above was found to be an indicator of mortality. Further, a BrANOS value between 10 and 13 was found to be an indicator of survival with sequelae, as in the study of Torbey et al. (10). Different from Torbey, 16 patients were discharged with good neurological scores (4 of them recovered without any sequelae) and 28 were discharged with severe sequelae or as confined to the bed (8 patients were vegetative). On the other hand, the durations of stay in the intensive care unit and hospital were longer for surviving and non-surviving patients in the study of Torbey. Some of the patients were followed-up in other units of our hospital after being discharged from the intensive care unit because of insufficient homecare services.

In the study of Kuilman et al. (20), which included 441 patients with cardiac arrest outside the hospital, the rate of discharge was 63%. Among the surviving patients, 1-year, 3-year, 5-year and 7-year life expectancies were found to be 88%, 81%, 77% and 73%, respectively. On the other hand, Holler et al. (21) reported the rate of discharge to be 8.7%. The 1-year, 3-year, 5-year and 10-year life expectancies were 87%, 73%, 65% and 46%, respectively. In our study, mortality was detected to be higher in patients who were discharged and who had high BrANOS scores in the first month. In the discharged patients, the 6-month, 1-year and 2-year life expectancies were 88%, 79% and 72%, respectively, and this result was consistent with the literature. An improvement was observed in the GOS values in some of our patients in the second year following arrest (GOS 4-5: 21 patients; GOS 2-3: 10 patients).

This study has some limitations: First of all, the study was designed as a retrospective study. It included patients that were hospitalized in the intensive care unit and that survived for at least 24 h. Another limitation was that the scoring system was independent of the treatment given to the patient and the study ignored comorbid diseases.

Conclusion

BrANOS is a useful scoring system for the prediction of prognosis and life expectancy after cardiac arrest. This scoring system is easy and it combines the clinical course and radiological findings of the patient. In our study, BrANOS scores of all the patients healing without any sequelae were below 10. The BrANOS score of ≥4 was accepted as an indicator of discharge from the hospital and the BrANOS score of ≥14 as an indicator of mortality. It was concluded that the reliability of BrANOS must be investigated in further prospective studies with larger series.

Ethics Committee Approval: Ethics committee approval was received for this study from the Clinical Research Ethical Committee of Ege University School of Medicine.

Informed Consent: Written informed consent wasn’t obtained from patients who participated in this study since our study is a retrospective study and the data were obtained by screening of the patient files.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - C.Ş., M.U., K.D.; Design - M.U., H.I., A.R.M.; Supervision - M.U., K.D., A.R.M.; Resources - C.Ş., H.I.; Materials - C.Ş., H.I.; Data Collection and/or Processing - C.Ş., H.I.; Analysis and/or Interpretation - C.Ş., M.U., K.D., H.I.; Literature Search - C.Ş., H.I.; Writing Manuscript - C.Ş., M.U., K.D.; Critical Review - M.U., K.D., A.R.M.; Other - C.Ş.

Conflict of Interest: No conflict of interest was declared by the authors.

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