Comparison of admission random glucose, fasting glucose, and glycated hemoglobin in predicting the neurological outcome of acute ischemic stroke: A retrospective study

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Background. Hyperglycemia is a known predictor of negative outcomes in stroke. Several glycemic measures, including admission random glucose, fasting glucose, and glycated hemoglobin (HbA1c), have been associated with bad neurological outcomes in acute ischemic stroke, particularly in nondiabetic patients. However, the predictive power of these glycemic measures is yet to be investigated.

Methods. This retrospective study enrolled 484 patients with acute ischemic stroke from January 2009 to March 2013, and complete records of initial stroke severity, neurological outcomes at 3 months, and glycemic measures were evaluated. We examined the predictive power of admission random glucose, fasting glucose, and HbA1c for neurological outcomes in acute ischemic stroke. Furthermore, subgroup analyses of nondiabetic patients and patients with diabetes were performed separately.

Results. Receiver operating characteristic (ROC) analysis revealed that admission random glucose and fasting glucose were significant predictors of poor neurological outcomes, whereas HbA1c was not [areas under the ROC curve (AUCs): admission random glucose = 0.564, p = 0.026; fasting glucose = 0.598, p = 0.001; HbA1c = 0.510, p = 0.742]. Subgroup analyses of nondiabetic patients and those with diabetes revealed that only fasting glucose predicts neurological outcomes in patients with diabetes, and the AUCs of these three glycemic measures did not differ between the two groups. A multivariate logistic regression analysis of the study patients indicated that only age, initial stroke severity, and fasting glucose were independent predictors of poor neurological outcomes, whereas admission random glucose and HbA1c were not (adjusted odds ratio: admission random glucose = 1.002, p = 0.228; fasting glucose = 1.005, p = 0.039; HbA1c = 1.160, p = 0.076). Furthermore, subgroup multivariate logistic regression analyses of nondiabetic patients and those with diabetes indicated that none of the three glycemic measures were associated with poor neurological outcomes.

Discussion. Fasting glucose is an independent predictor of poor neurological outcomes in patients with acute ischemic stroke and had greater predictive power than that of admission random glucose and HbA1c. The predictive power of glycemic measures for poor neurological outcomes did not differ significantly between the nondiabetic patients and those with diabetes.

1   **Title**

2   Comparison of admission random glucose, fasting glucose, and glycated hemoglobin in

3   predicting the neurological outcome of acute ischemic stroke- A retrospective study

5   **Short Title**

6   Hyperglycemia in acute ischemic stroke

8   **Authors**

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28

29 **ABSTRACT**

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31 **Background**. Hyperglycemia is a known predictor of negative outcomes in stroke. Several
32 glycemic measures, including admission random glucose, fasting glucose, and glycated
33 hemoglobin (HbA1c), have been associated with bad neurological outcomes in acute ischemic
34 stroke, particularly in nondiabetic patients. However, the predictive power of these glycemic
35 measures is yet to be investigated.

36 **Methods**. This retrospective study enrolled 484 patients with acute ischemic stroke from January
37 2009 to March 2013, and complete records of initial stroke severity, neurological outcomes at 3
38 months, and glycemic measures were evaluated. We examined the predictive power of admission
39 random glucose, fasting glucose, and HbA1c for neurological outcomes in acute ischemic stroke.
40 Furthermore, subgroup analyses of nondiabetic patients and patients with diabetes were performed
41 separately.

42 **Results**. Receiver operating characteristic (ROC) analysis revealed that admission random glucose
43 and fasting glucose were significant predictors of poor neurological outcomes, whereas HbA1c
44 was not [areas under the ROC curve (AUCs): admission random glucose $= 0.564$, $p = 0.026$; fasting
45 glucose $= 0.598$, $p = 0.001$; HbA1c $= 0.510$, $p = 0.742$]. Subgroup analyses of nondiabetic patients
46 and those with diabetes revealed that only fasting glucose predicts neurological outcomes in
47 patients with diabetes, and the AUCs of these three glycemic measures did not differ between the
48 two groups. A multivariate logistic regression analysis of the study patients indicated that only
49 age, initial stroke severity, and fasting glucose were independent predictors of poor neurological
50 outcomes, whereas admission random glucose and HbA1c were not (adjusted odds ratio:
51 admission random glucose $= 1.002$, $p = 0.228$; fasting glucose $= 1.005$, $p = 0.039$; HbA1c $= 1.160$,
52 $p = 0.076$). Furthermore, subgroup multivariate logistic regression analyses of nondiabetic patients
53 and those with diabetes indicated that none of the three glycemic measures were associated with
54 poor neurological outcomes.

55 **Discussion**. Fasting glucose is an independent predictor of poor neurological outcomes in patients
56 with acute ischemic stroke and had greater predictive power than that of admission random glucose
57 and HbA1c. The predictive power of glycemic measures for poor neurological outcomes did not
58 differ significantly between the nondiabetic patients and those with diabetes.

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Introduction

Hyperglycemia may be present in more than half of patients with acute ischemic stroke (Scott et al., 1999). It is associated with an increased risk of infarction volume growth and hemorrhagic transformation (Paciaroni et al., 2009; Parsons et al., 2002), a decreased recanalization rate of thrombolytic therapy (Ribo et al., 2005), and an increased risk of poor neurological outcomes and stroke mortality (Capes et al., 2001). Several indices of hyperglycemia have been reported in stroke: elevated fasting glucose (Yao et al., 2016), elevated admission random glucose (Ahmed et al., 2010; Ribo et al., 2005), maximum glucose during the acute disease stage (Fuentes et al., 2009), and elevated glycated hemoglobin (HbA1c) (Kamouchi et al., 2011; Lattanzi et al., 2016). The levels of fasting glucose, admission random glucose, and maximum glucose have been associated with the stress response of stroke, particularly in nondiabetic patients (Capes et al., 2001; Stead et al., 2009), and HbA1c was considered as a marker for prestroke glycemic control (Kamouchi et al., 2011). Moreover, some studies have reported that in acute ischemic stroke, hyperglycemia is more detrimental in nondiabetic patients than in those with diabetes (Capes et al., 2001; Stead et al., 2009; Yao et al., 2016). Although these glycemic measures have been associated with neurological outcomes in acute ischemic stroke, the most predictive factor among these is yet to be reported. The present study compared the predictive performance of admission random glucose, fasting glucose, and HbA1c for poor neurological outcomes in acute ischemic stroke. Furthermore,

81   the predictive performance of these glycemic measures was evaluated through subgroup analysis

82   of patients with diabetes and nondiabetic patients.

83

84   **Materials & Methods**

85   **Study patients**

86   The present study was approved by the Joint Institutional Review Board of Taipei Medical

87   University (No. 201304008). Data were obtained by reviewing medical records of the patients with

88   acute ischemic stroke admitted to the hospitals affiliated with Taipei Medical University, Wan

89   Fang Hospital and Shuang Ho Hospital, between January 2009 and March 2013. Data were

90   included for analysis if the patients were aged $\geq$20 years, presented to the emergency department

91   with acute ischemic stroke and were subsequently admitted to the neurology department, and

92   complete records of admission random glucose, fasting glucose, HbA1c, National Institute of

93   Health Stroke Scale (NIHSS) scores at admission, and modified Rankin Scale (mRS) scores at 3

94   months after stroke were obtained. After reviewing the enrolled medical records, patients with a

95   history of stroke or who died or were lost to follow-up within 3 months after stroke were excluded.

96

97   **Definitions of clinical characteristics and neurological outcomes**

98   In the present study, acute ischemic stroke was confirmed by clinical symptoms and neuroimages.

99   The etiologic subtype of acute ischemic stroke was classified according to the Trial of Org 10172

100 in Acute Stroke Treatment (TOAST) study (Adams et al., 1993). Admission random glucose was

101 the first nonfasting plasma glucose measured at the emergency department. Fasting plasma glucose

102 and HbA1c were measured on the first morning of admission after at least 8 hours of fasting.

103 Hypertension was defined as a systolic blood pressure > 140 mmHg, a diastolic blood pressure >

104 90 mmHg, or current use of antihypertensive medicines. Diabetes was defined as HbA1c $\geqq$ 6.5%

105 or current use of antidiabetic medicines. Hyperlipidemia was defined as total cholesterol > 200

106 mg/dL or current use of cholesterol-lowering medicines. Atrial fibrillation was diagnosed

107 according to either a documented history or an electrocardiogram on admission. Initial stroke

108 severity was evaluated on the first day of admission on the basis of the NIHSS at admission, and

109 neurological outcomes were evaluated on the basis of the mRS at 3 months after stroke. Poor

110 neurological outcomes were defined as an mRS score =3, 4, or 5 at 3 months after stroke.

111

112 **Statistical analyses**

113 The continuous variables, rank variables, and proportions of categorical variables were compared

114 between the nondiabetic patients and those with diabetes by using the Student t, Mann–Whitney

115 U, and chi-squared tests, respectively. Receiver operating characteristic (ROC) analysis was

116 conducted for evaluating the predictive performance of the glycemic measures, namely admission

117   random glucose, fasting glucose, and HbA1c, in distinguishing between the favorable and poor

118   neurological outcomes. Specifically, the predictive performance of these glycemic measures was

119   evaluated by comparing their areas under the ROC curve (AUCs) (DeLong et al., 1988). A

120   univariate logistic regression analysis was conducted to estimate the odds ratio (OR) of poor

121   neurological outcomes for each variable. Age, sex, and variables with $p \leqq 0.2$ in the univariate

122   logistic regression analysis were included in a multivariate logistic regression model to adjust the

123   OR of poor neurological outcomes for the glycemic measures. Parametric and nonparametric data

124   were expressed as the mean ± standard deviation (SD) and as the median with the interquartile

125   range (IQR), respectively, and $p < 0.05$ was considered statistically significant. Statistical data

126   were analyzed using PASW Statistics for Windows version 18.0 (SPSS Inc, Chicago, IL, USA)

127   and MedCalc Statistical Software version 16.8 (MedCalc Software bvba, Ostend, Belgium,

128   https://www.medcalc.org, 2016).

129

130   **Results**

131   Table 1 summarizes the clinical characteristics of the study patients. Of the 484 patients enrolled

132   in the present study, 212 were nondiabetic and 272 had diabetes. Age, the proportion of

133   hypertension, admission random glucose, and fasting glucose in the patients with diabetes were

134   significantly higher than those in the nondiabetic patients, and the NIHSS score at admission, mRS

135   score at 3 months after stroke, and proportions of poor neurological outcomes and the stroke

136   etiology subtype did not differ between the two groups.

137   The AUCs of admission random glucose, fasting glucose, and HbA1c in all patients are

138   presented in Figure 1A. In all patients, admission random glucose and fasting glucose were

139   significant predictors of poor neurological outcomes [AUCs: admission random glucose = 0.564,

140   95% confidence interval (CI) = 0.519–0.609, p = 0.026; fasting glucose = 0.598, 95% CI = 0.553–

141   0.642, p = 0.001]; however, HbA1c was not a significant predictor (AUC = 0.510, 95% CI = 0.465–

142   0.556, p = 0.742). The cutoff values with the highest sensitivity and specificity were 127 mg/dL

143   for   admission random glucose (sensitivity = 74.6%, specificity = 39.3%) and 109 mg/dL for

144   fasting glucose (sensitivity = 67.8%, specificity = 51.6%). The AUCs of admission random

145   glucose and fasting glucose did not differ significantly (0.564 vs. 0.598, p = 0.194), and the AUCs

146   of admission random glucose and fasting glucose were significantly higher than that of HbA1c

147   (0.564 vs. 0.510, p = 0.038 and 0.598 vs. 0.510, p = 0.001, respectively). The ROC curves of

148   admission random glucose, fasting glucose, and HbA1c in the nondiabetic patients (n = 212) and

149   patients with diabetes (n = 272) are presented in Figures 1B and 1C, respectively. In the

150   nondiabetic patients, fasting glucose was not a significant predictor of poor neurological outcomes

151   (AUC = 0.593, 95% CI = 0.524–0.660, p = 0.071) with an optimal cutoff value of 109 mg/dL

152   (sensitivity = 39.6%, specificity = 84.8%), whereas admission random glucose and HbA1c were

153   nonsignificant predictors of poor neurological outcomes (AUCs: admission random glucose =

154   0.569, 95% CI = 0.499–0.636, p = 0.129; HbA1c = 0.510, 95% CI = 0.440–0.579, p = 0.837). In

155   the patients with diabetes, fasting glucose was a significant predictor of poor neurological

156   outcomes (AUC = 0.596, 95% CI = 0.535–0.655, p = 0.014) with an optimal cutoff value of 140

157   mg/dL (sensitivity = 62.9%, specificity = 54.5%), whereas admission random glucose and HbA1c

158   were nonsignificant predictors of poor neurological outcomes (AUCs: admission random glucose

159   = 0.544, 95% CI = 0.483–0.604, p = 0.247; HbA1c = 0.503, 95% CI = 0.442–0.564, p = 0.948).

160   The AUCs of glycemic measures were not significantly different between the nondiabetic patients

161   and those with diabetes (AUCs: admission random glucose = 0.569 vs. 0.544, p = 0.671; fasting

162   glucose = 0.593 vs. 0.596, p = 0.963; HbA1c = 0.510 vs. 0.503, p = 0.911).

163   Table 2 presents the results of univariate and multivariate logistic regression analyses of

164   variables potentially predicting poor neurological outcomes. In univariate logistic regression

165   analysis, age, the NIHSS score at admission, atrial fibrillation, and fasting glucose were significant

166   predictors of poor neurological outcomes in the study patients (crude OR for fasting glucose =

167   1.005, 95% CI = 1.002–1.008, p = 0.003). However, neither admission random glucose nor HbA1c

168   were significant predictors of poor neurological outcomes. The adjusted OR of admission random

169   glucose was determined using multivariate logistic regression model 1, which included age, sex,

170   the NIHSS score at admission, atrial fibrillation, and admission random glucose. Age and the

171   NIHSS score at admission were significant predictors of poor neurological outcomes, and

172   admission random glucose was not associated with poor neurological outcomes in model 1

173   (adjusted OR = 1.002, 95% CI = 0.999–1.005, p = 0.228). The adjusted OR for fasting glucose

174   was determined using multivariate logistic regression model 2, which included age, sex, the

175   NIHSS score at admission, atrial fibrillation, and fasting glucose. Age, the NIHSS score at

176   admission, and fasting glucose were significant predictors of poor neurological outcomes in model

177   2 (adjusted OR for fasting glucose = 1.005, 95% CI = 1.003–1.010, p = 0.039). The adjusted OR

178   of HbA1c was calculated using multivariate logistic regression model 3, which included age, sex,

179   the NIHSS score at admission, atrial fibrillation, and HbA1c. Age and the NIHSS score at

180   admission were significant predictors of poor neurological outcomes, and HbA1c was not

181   associated with poor neurological outcomes in model 3 (adjusted OR = 1.160, 95% CI = 0.985–

182   1.366, p = 0.076).

183   Subgroup univariate and multivariate logistic regression analyses were performed in the

184   nondiabetic patients and patients with diabetes (Table 2). In the univariate logistic regression

185   analysis, age, the NIHSS score at admission, atrial fibrillation, and fasting glucose were significant

186   predictors of poor neurological outcomes (crude OR for fasting glucose: nondiabetic patients =

187   1.025, 95% CI = 1.009–1.041, p = 0.002; patients with diabetes = 1.004, 95% CI = 1.001–1.008,

188   p = 0.003). However, after adjustment for the influence of age, sex, the NIHSS score at admission,

189   and atrial fibrillation, all three glycemic measures were not associated with poor neurological

190   outcomes in both groups.

191

192   **Discussion**

193   In the present study, of the three glycemic measures, fasting glucose was an independent predictor

194   and the most predictive factor of poor neurological outcomes in patients with acute ischemic

195   stroke. ROC analysis revealed that admission random glucose was a predictor of poor neurological

196   outcomes in all study patients; however, it was not associated with poor neurological outcomes in

197   the logistic regression analysis. Furthermore, ROC and logistic regression analyses revealed that

198   HbA1c was not a predictive factor of poor neurological outcomes. The predictive value of

199   glycemic measures for poor neurological outcomes did not differ significantly between the

200   nondiabetic patients and patients with diabetes.

201   ROC analysis revealed that fasting glucose and admission random glucose have more

202   predictive value than HbA1c does for poor neurological outcomes in acute ischemic stroke. Studies

203   have reported that a high level of fasting or random glucose is associated with poor neurological

204   outcomes or mortality in acute ischemic stroke (Capes et al., 2001; Fang et al., 2013; Hu et al.,

205   2012), and hyperglycemia at the acute stage of the disease may be largely caused by stress

206   (Douketis, 2002). By contrast, HbA1c represents average glycemic levels in the preceding 6–8

207   weeks and is not affected by transient hyperglycemia; therefore, HbA1c has been perceived as a

208   marker for prestroke glycemic control (Kamouchi et al., 2011; Lattanzi et al., 2016). Furthermore,

209   HbA1c has been associated with increased mortality (Wu et al., 2014) and poor neurological

210   outcomes (Gao et al., 2016; Hjalmarsson et al., 2014; Lattanzi et al., 2016) in acute ischemic

211   stroke; however, it has also been reported to be nonpredictive of neurological outcomes (Shin et

212   al., 2015). Although many studies have reported the role of hyperglycemia in predicting poor

213   neurological outcomes in acute ischemic stroke, the inclusion criteria for patients, definition of

214   hyperglycemia, and outcome measures varied between these studies; therefore, the results are

215   difficult to compare. Moreover, no study has compared the predictive performance of different

216   definitions of hyperglycemia for neurological outcomes. The results of our study revealed that

217   stress hyperglycemia contributed more than prestroke glycemic control did in predicting negative

218   outcomes in acute ischemic stroke. The ROC analysis revealed that the AUCs of fasting glucose

219   and admission random glucose did not differ significantly; nevertheless, the AUC of fasting

220   glucose was the highest among the three glycemic measures. Furthermore, multivariate logistic

221   regression analysis revealed that fasting glucose was the only independent predictor of poor

222   neurological outcomes among the three glycemic measures (Table 2). Therefore, we speculate that

223   fasting glucose is superior to admission random glucose in predicting neurological outcomes.

224   However, why fasting glucose was more predictive than admission random glucose in this study

225   remains uncertain, and further investigations are warranted.

226   Some studies have reported that in acute ischemic stroke, hyperglycemia is more detrimental

227   in nondiabetic patients than in patients with diabetes (Capes et al., 2001; Stead et al., 2009; Yao et

228   al., 2016); however, the present findings are not consistent with the aforementioned results,

229   possibly because of the differences in study designs, statistical methods, definition of

230   hyperglycemia, and functional outcome measures. Most studies have used a cutoff value of blood

231   glucose as the criterion for defining hyperglycemia, such as fasting glucose > 140 mg/dL (Woo et

232   al., 1990) or nonfasting glucose > 130 mg/dL (Stead et al. 2009). However, we used ROC analysis

233   instead of a cutoff value because of the lack of a widely accepted criterion for defining

234   hyperglycemia in acute ischemic stroke. Moreover, ROC analysis enables the comparison of the

235   predictive performance of different glycemic measures and provides information on sensitivity

236   and specificity, which cannot be obtained by defining hyperglycemia on the basis of a cutoff value.

237   In preclinical animal studies, controlling hyperglycemia with insulin resulted in

238   heterogeneous neuroprotection outcomes (MacDougall & Muir, 2011). In randomized controlled

239   trials of intensive insulin treatment for glycemic control in patients with acute ischemic stroke,

240   there was no difference in death or dependency between the treatment and control groups, and the

241   results were the same in subgroup analyses of patients with diabetes and nondiabetic patients

242   (Bellolio et al., 2014). Therefore, the pathophysiology of hyperglycemia in acute ischemic stroke

243 probably involves other factors in addition to high blood glucose. Stress-related cytotoxic

244 neurotransmitters, inflammation, or insulin resistance could be associated with an increased risk

245 of poor neurological outcomes and mortality in patients with stroke and hyperglycemia (Arenillas

246 et al., 2007; Harada et al., 2012; Kruyt et al., 2010). The clinical guidelines published by the

247 American Heart Association/American Stroke Association and the European Stroke Organization

248 recommend that the glycemic levels of patients with acute ischemic stroke be maintained below

249 180 mg/dL. This recommendation is based on the consensus of experts because evidence does not

250 support maintaining the blood glucose at a specific level improves outcomes (European Stroke

251 Organisation Executive & Committee, 2008; Jauch et al., 2013). Therefore, although

252 hyperglycemia has been confirmed to be a predictor of negative outcomes in stroke, additional

253 investigations are warranted for elucidating the underlying mechanisms and treatment strategies.

254   The present study had some limitations. First, most patients enrolled had mild to moderate

255 initial stroke severity (median NIHSS score at admission = 4, IQR = 2–8), and the influence of

256 hyperglycemia might be more prominent in patients with severe stroke. However, only 84 patients

257 in the present study had an NIHSS score at admission $\geq$ 10, and a subgroup analysis of these

258 patients would not have yielded sufficient statistic power. Second, mortality was not included as

259 an outcome because the timing of and reason for mortality could not be assessed accurately in the

260 retrospective medical review. Some patients might have died or received follow-up in facilities

261 other than the two hospitals included in the present study; therefore, the patients who died or were

262 lost to follow-up within 3 months after stroke were not included in this study. Because of the

263 aforementioned limitations, the results of this study cannot be generalized to all ischemic stroke

264 patients. Third, diabetes was defined as HbA1c < 6.5% or as medication usage; therefore, patients

265 with diabetes who were on dietary modification alone with satisfactory HbA1c may have been

266 misclassified as nondiabetic patients.

267

268 **Conclusions**

269 Fasting glucose is an independent predictor of poor neurological outcomes in patients with acute

270 ischemic stroke, with more predictive power than that of admission random glucose and HbA1c.

271 The predictive value of glycemic measures for poor neurological outcomes in acute ischemic

272 stroke did not differ significantly between the nondiabetic patients and those with diabetes.

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372 **Figure Legend**

373 Receiver operating characteristic (ROC) curves of admission random glucose, fasting glucose,

374 and HbA1c for predicting poor neurological outcomes (modified Rankin Scale = 3, 4, or 5 at 3

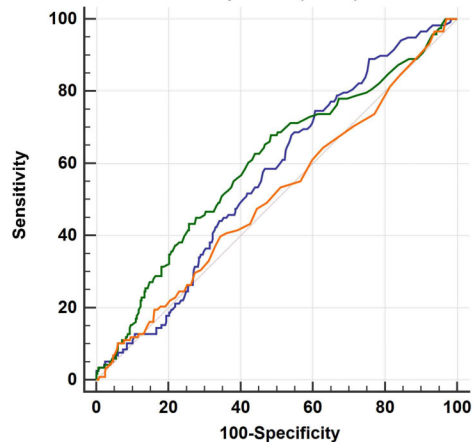
375 months) in (A) all study patients, (B) nondiabetic patients, and (C) patients with diabetes

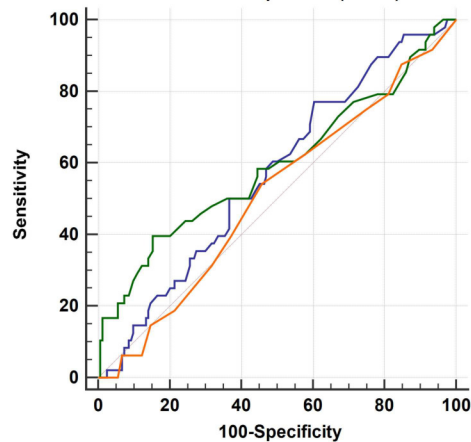
376 * $p < 0.05$

377

Figure 1

Receiver operating characteristic (ROC) curves of admission random glucose, fasting glucose, and HbA1c for predicting poor neurological outcomes (modified Rankin Scale = 3, 4, or 5 at 3 months) in (A) all study patients, (B) nondiabetic patients, and (C) patients with diabetes. * $p < 0.05$

(A) All patients (n=484)

Random, AUC=0.564 (0.519-0.609, p=0.026*)
Fasting, AUC=0.598 (0.553-0.642, p=0.001*)
HbA1c, AUC=0.510 (0.465-0.556, p=0.742)

(B) Nondiabetic patients (n=212)

Random, AUC=0.569 (0.499-0.636, p=0.129)
Fasting, AUC=0.593 (0.524-0.660, p=0.071)
HbA1c, AUC=0.510 (0.440-0.579, p=0.837)

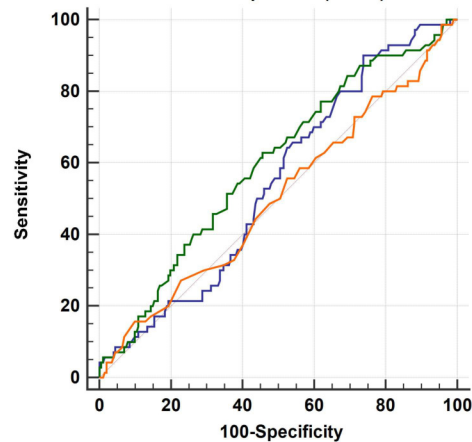
(C) Diabetic patients (n=272)

Random, AUC=0.544 (0.483-0.604, p=0.247)
Fasting, AUC=0.596 (0.535-0.655, p=0.014*)
HbA1c, AUC=0.503 (0.442-0.564, p=0.948)

Table 1. Clinical characteristics of the patients

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	Total patients (n=484)	Nondiabetic patients (n=212)	Diabetic patients (n=272)	*p* value
Age, mean ± SD, years	67.9 ± 13.7	65.9 ±15.3	69.5 ± 12.2	0.004*
Male sex, n (%)	315 (65.1%)	145 (68.4%)	170 (62.5%)	0.177
Comorbidities, n (%)				
Hypertension	346 (71.5%)	132 (62.3%)	214 (78.7%)	<0.001*
Diabetes	272 (56.2%)	0 (0%)	212 (100%)	N.A.
Hyperlipidemia	147 (30.4%)	62 (29.2%)	85 (31.2%)	0.635
Atrial fibrillation	74 (15.3%)	38 (17.9%)	36 (13.2%)	0.155
NIHSS at admission, median (IQR)	4 (2 - 8)	4 (2 - 8)	4 (2 - 7)	0.972
mRS at 3 months, median (IQR)	1 (1 - 2)	1 (1 - 2)	1 (1 - 3)	0.654
poor neurological outcome, n (%)	118 (24.4%)	48 (22.6%)	70 (25.7%)	0.432
Stroke etiology subtypes, n(%)				0.658
Large artery atherosclerosis	133 (27.5%)	56 (26.4%)	77 (28.3%)	
Small artery occlusion	166 (34.3%)	69 (32.5%)	97 (35.7%)	
cardioembolism	26 (5.4%)	12 (5.7%)	14 (5.1%)	
other determined etiology	1 (0.2%)	1 (0.5%)	0 (0%)	
undermined etiology	158 (32.6%)	74 (34.9%)	84 (30.9%)	
Admission random glucose, mean ± SD, mg/dL	175.5 ± 86.8	129.5 ±34.8	211.4 ± 97.6	<0.001*
fasting glucose, mean ± SD, mg/dL	132.9 ± 58.7	102.1 ±19.9	156.9 ± 67.3	<0.001*

| HbA1c, mean ± SD, % | 7.0 ±1.8 | 5.8 ±0.4 | 8.0 ±1.8 | <0.001* |

* p<0.05, IQR: interquartile range, SD, standard deviation

Table 2. Univariate and multivariate logistic regression analyses of clnicical characteristics and glycemic measures to poor neurological outcome

Table 2. Univariate and multivariate logistic regression analyses of clinical characteristics and glycemic measures to poor neurological outcome

	Poor neurological outcome (mRS ≧3 at 3 months)							
	All patients (n = 484)							
Characteristics	Crude OR (95% CI)	p value	Adjusted OR model 1 (95% CI)	p value	Adjusted OR model 2 (95% CI)	p value	Adjusted OR model 3 (95% CI)	p value
Age	1.059 (1.040 - 1.080)	<0.001*	1.056 (1.032 - 1.080)	<0.001*	1.059 (1.034 - 1.084)	<0.001*	1.059 (1.034 - 1.084)	<0.001*
Male sex	0.755 (0.492 - 1.159)	0.199	0.816 (0.472 - 1.411)	0.467	0.811 (0.468 - 1.404)	0.453	0.833 (0.481 - 1.443)	0.515
NIHSS at admission	1.320 (1.246 - 1.398)	<0.001*	1.313 (1.237 - 1.395)	<0.001*	1.312 (1.235 - 1.392)	<0.001*	1.319 (1.241 - 1.402)	<0.001*
Hypertension	1.159 (0.726 - 1.851)	0.535						
Hyperlipidemia	0.768 (0.482 - 1.223)	0.266						
Atrial fibrillation	2.870 (1.710 - 4.817)	0.001*	1.387 (0.679 - 2.833)	0.370	1.373 (0.668 - 2.822)	0.388	1.452 (0.706 - 2.986)	0.311
Admission random glucose	1.002 (0.999 - 1.004)	0.158	1.002 (0.999 - 1.005)	0.228				
Fasting glucose	1.005 (1.002 - 1.008)	0.003*			1.005 (1.003 - 1.010)	0.039*		
HbA1c	1.032 (0.919 - 1.158)	0.600					1.160 (0.985 - 1.366)	0.076
	Nondiabetic patients (n = 212)							
Characteristics	Crude OR (95% CI)	p value	Adjusted OR model 1 (95% CI)	p value	Adjusted OR model 2 (95% CI)	p value	Adjusted OR model 3 (95% CI)	p value
Age	1.0061 (1.033 - 1.089)	<0.001*	1.065 (1.027 - 1.103)	0.006*	1.067 (1.028 - 1.106)	0.006*	1.066 (1.028 - 1.106)	0.006*
Male sex	0.632 (0.323 - 1.233)	0.178	0.722 (0.292 - 1.782)	0.479	0.711 (0.288 - 1.758)	0.461	0.685 (0.275 - 1.702)	0.415
NIHSS at admission	1.347 (1.231 - 1.473)	<0.001*	1.355 (1.229 - 1.493)	<0.001*	1.345 (1.220 - 1.482)	<0.001*	1.359 (1.232 - 1.500)	<0.001*
Hypertension	1.013 (0.521 - 1.968)	0.969						
Hyperlipidemia	0.659 (0.311 - 1.394)	0.275						
Atrial fibrillation	2.787 (1.313 - 5.916)	0.008*	1.424 (0.498 - 4.076)	0.510	1.334 (0.471 - 3.792)	0.586	1.396 (0.494 - 5.859)	0.529
Admission random glucose	1.003 (0.995 - 1.012)	0.453	0.999 (0.987 - 1.012)	0.886				

Characteristics	Crude OR (95% CI)	p value	Adjusted OR model 1 (95% CI)	p value	Adjusted OR model 2 (95% CI)	p value	Adjusted OR model 3 (95% CI)	p value
Fasting glucose	1.025 (1.009 - 1.041)	0.002*			1.011 (0.992 - 1.031)	0.272		
HbA1c	1.124 (0.493 - 2.564)	0.782					1.700 (0.494 - 5.859)	0.400

Diabetic patients (n = 272)								
Characteristics	**Crude OR (95% CI)**	*p* value	**Adjusted OR model 1 (95% CI)**	*p* value	**Adjusted OR model 2 (95% CI)**	*p* value	**Adjusted OR model 3 (95% CI)**	*p* value
Age	1.057 (1.030 - 1.086)	<0.001*	1.049 (1.017 - 1.082)	0.002*	1.053 (1.021 - 1.087)	0.001*	1.055 (1.021 - 1.089)	0.001*
Male sex	0.867 (0.497 - 1.514)	0.616	0.892 (0.445 - 1.788)	0.747	0.873 (0.434 - 1.755)	0.703	0.914 (0.455 - 1.837)	0.801
NIHSS at admission	1.304 (1.209 - 1.407)	<0.001*	1.291 (1.194 - 1.395)	<0.001*	1.286 (1.190 - 1.389)	<0.001*	1.295 (1.197 - 1.400)	<0.001*
Hypertension	1.257 (0.632 - 2.500)	0.515						
Hyperlipidemia	0.843 (0.464 - 1.531)	0.575						
Atrial fibrillation	3.089 (1.500 - 6.361)	0.002*	1.436 (0.527 - 3.915)	0.480	1.361 (0.493 - 3.761)	0.552	1.496 (0.545 - 4.111)	0.435
Admission random glucose	1.001 (0.999 - 1.004)	0.319	1.002 (0.998 - 1.006)	0.319				
Fasting glucose	1.004 (1.001 - 1.008)	0.003*			1.005 (0.999 - 1.010)	0.110		
HbA1c	1.000 (0.863 - 1.161)	0.992					1.163 (0.945 - 1.430)	0.154

* p<0.05, OR: odds ratio

model 1 included age, sex, NIHSS at admission, atrial fibrillation, and admission random glucose

model 2 included age, sex, NIHSS at admission, atrial fibrillation, and fasting glucose

model 3 included age, sex, NIHSS at admission, atrial fibrillation, and HbA1c