Brief Report

Admission Neutrophil-to-Lymphocyte Ratio as a Prognostic Biomarker of Outcomes in Large Vessel Occlusion Strokes

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Background and Purpose**—**The purpose of this study is to evaluate the relationship between neutrophil-to-lymphocyte ratio (NLR) at admission with safety and efficacy outcomes in acute stroke patients with large vessel occlusion after mechanical thrombectomy.

Methods**—**Consecutive large vessel occlusion patients treated with mechanical thrombectomy during a 4-year period were evaluated. Outcome measures included symptomatic intracranial hemorrhage, 3-month mortality, successful reperfusion (modified Thrombolysis in Cerebral Infarction score of 2b/3), and 3-month functional independence (modified Rankin Scale scores of 0–2).

Results**—**A total of 293 large vessel occlusion patients underwent mechanical thrombectomy (median admission NLR, 3.5; interquartile range [IQR], 1.7–6.8). In initial univariable analyses, higher median admission NLR values were documented in patients with symptomatic intracranial hemorrhage (8.5; IQR, 4.7–11.3) versus (3.9; IQR, 1.9–6.5); $P<0.001$ and individuals who were dead at 3-months (5.4; IQR, 2.8–9.6) versus (4.0; IQR, 1.8–6.4); $P=0.004$. Lower NLR values were recorded in patients with 3-month functional independence (3.7; IQR, 1.7–6.5) versus (4.3; IQR, 2.6–8.3); $P=0.039$. After adjustment for potential confounders, a 1-point increase in NLR was independently associated with higher odds of symptomatic intracranial hemorrhage (odds ratio, 1.11; 95% CI, 1.03–1.20; $P=0.006$) and 3-month mortality (odds ratio, 1.08; 95% CI, 1.01–1.16; $P=0.014$).

Conclusions**—**Higher admission NLR is an independent predictor of symptomatic intracranial hemorrhage and 3-month mortality in large vessel occlusion patients treated with mechanical thrombectomy, and it may identify a target group for testing adjunctive anti-inflammatory therapies. **(*Stroke*. 2018;49:00-00. DOI: 10.1161/STROKEAHA.118.021477.)**

Key Words: lymphocyte count ■ mortality ■ neutrophils ■ stroke ■ thrombectomy

Admission neutrophil-to-lymphocyte ratio (NLR) predicts short- and long-term outcomes in acute ischemic stroke (AIS) patients.[1,2] Higher NLR suggests higher levels of inflammation.[1] In AIS patients receiving intravenous thrombolysis, high NLR values were associated with higher risk of hemorrhagic transformation.[1,2] Studies evaluating the potential prognostic role of admission NLR in patients with large vessel occlusion (LVO) undergoing mechanical thrombectomy (MT) are limited.[3] The aim of this study was to evaluate the relationships between NLR at admission with safety and efficacy outcomes in LVO patients treated with MT.

Methods

The data that support the findings of this study are available from the corresponding author on reasonable request. Detailed Methods section is available in the online-only Data Supplement.

Study Population and Baseline Characteristics

We performed a retrospective analysis of a prospectively collected database of consecutive LVO patients who underwent MT at a tertiary care stroke centers from January 2012 to June 2016. Blood samples were taken in all patients before the initiation of intravenous thrombolysis and MT as standard-of-care. NLR was calculated by dividing the neutrophil and lymphocyte counts obtained from the admission white blood cell counts.

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Outcome Measures

Safety outcomes included symptomatic intracranial hemorrhage (sICH) and 3-month mortality, whereas efficacy outcomes were characterized by successful reperfusion and 3-month functional independence. The study was approved by the institutional review board of the participating center (18-05830-XP) and did not require the patient's consent.

Statistical Analyses

Univariable and multivariable binary logistic regression models were used to evaluate associations between admission NLR with clinical outcomes before and after adjusting for all baseline characteristics.

Results

Our study population consisted of 293 AIS patients with LVO treated with MT. The distribution of NLR was skewed (*P* value for 1-sample Kolmogorov-Smirnov test: <0.001). Baseline characteristics of the study population are presented in the Table. sICH occurred in 21 patients (7%); sICH was diagnosed using computerized tomography head in 14 patients (67%) and brain magnetic resonance imaging in the remaining 7 patients (33%).

Table I in the online-only Data Supplement summarizes the univariable associations of admission NLR values with safety and efficacy outcomes. No significant difference in admission NLR values was noted in LVO patients with or without successful reperfusion (3.9 versus 4.6; *P*=0.068). Higher median admission NLR values were documented in patients with sICH (8.5 versus 3.9; *P*<0.001), individuals who were dead at 3-months (5.4 versus 4.0; *P*=0.004), and patients with 3-month poor functional outcome (4.4 versus 3.6; *P*=0.033). Lower NLR values were recorded in patients with 3-month functional independence (3.7 versus 4.3; *P*=0.039). Increasing admission NLR values strongly correlated with longer symptom onset to emergency department arrival time (Spearman *r*, 0.208; *P*<0.001) and lower Alberta Stroke Program Early CT Score (Spearman *r*, −0.232; *P*<0.001). No association of admission NLR value with admission National Institutes of Health Stroke Scale was noted (Spearman *r*, 0.074; *P*=0.206).

Admission NLR was not associated with 3-month functional independence (*P*>0.1; Table II in the online-only Data Supplement) and 3-month poor functional outcome (modified Rankin Scale score of 3–6; *P*>0.1; Table III in the online-only Data Supplement) in initial univariable binary logistic regression analyses. A 1-point increase in admission NLR value was independently associated with higher odds of 3-month mortality (odds ratio, 1.08; 95% CI, 1.01–1.16; *P*=0.014; Table IV in the online-only Data Supplement), and higher odds of sICH (odds ratio, 1.11; 95% CI, 1.03–1.20; *P*=0.006; Table V in the online-only Data Supplement) after adjustment for potential confounders.

Receiving operating characteristic curve analyses demonstrated the predictive value of admission NLR for sICH (C statistics: 0.77 [95% CI, 0.68–0.86]; *P*<0.001; Figure IA in the online-only Data Supplement) and 3-month mortality (area under the curve: 0.61 [95% CI, 0.54–0.69]; *P*=0.004; Figure IB in the online-only Data Supplement). The best predictive cutoff values of admission NLR for sICH and 3-month mortality were 6.62 (sensitivity: 71% and specificity: 76%) and 4.29 (sensitivity: 59% and specificity: 56%), respectively. Admission NLR had a marginally significant (*P*=0.035) ability (C statistics: 0.57 [95% CI, 0.50–0.64]) to predict poor functional outcome at 3 months (modified Rankin Scale scores of 3–6). The predictive ability of NLR for successful reperfusion was not significant (C statistics: 0.43 [95% CI, 0.36–0.51]; *P*=0.068).

Table. Baseline Characteristics of the Study Population

Variable	n=293
Mean age, y, SD	62 (14)
Men, n (%)	147 (50)
Whites, n (%)	122 (42)
Black race, n (%)	168 (57)
Hypertension, n (%)	231 (79)
Diabetes mellitus, n (%)	102 (35)
Hypercholesterolemia, n (%)	127 (43)
Atrial fibrillation, n (%)	75 (26)
Smoking, n (%)	85 (29)
Coronary artery disease, n (%)	75 (26)
Congestive heart failure, n (%)	63 (22)
Median baseline NIHSS score, points (IQR)	16 (13–19)
Pretreatment with intravenous thrombolysis, n (%)	204 (70)
Mean admission systolic blood pressure, mm Hg (SD)	159 (32)
Mean admission diastolic blood pressure, mm Hg (SD)	91 (22)
Mean admission serum glucose, mg/dL (SD)	151 (73)
Mean admission low-density lipoprotein, mg/dL (SD)	96 (35)
Median admission NLR, points (IQR)	3.5 (1.7–6.8)
Median ASPECTS, points (IQR)	10 (8–10)
Good computed tomography angiogram collaterals, n (%)*	210 (72)
Median onset to tissue-type plasminogen activator bolus time, min (IQR)	121 (91–180)
Median onset to arterial puncture time, min (IQR)	232 (178–299)
Median arterial puncture to reperfusion time, min (IQR)	45 (30–70)
Median onset to emergency department arrival time, min (IQR)	134 (77–205)
Successful reperfusion, n (%)	200 (68)
Symptomatic intracranial hemorrhage, n (%)	21 (7)
Three-month mortality, n (%)	70 (24)
Three-month functional independence	134 (46)†

ASPECTS indicates Alberta Stroke Program Early CT Score; IQR, interquartile range; NIHSS, National Institutes of Health Stroke Scale; and NLR, neutrophil-to-lymphocyte ratio.

*Collateral score was available in 273 patients.

†Three-month modified Rankin Scale available in 276 patients.

Discussion

Our study shows that higher admission NLR values are independent predictors of sICH and 3-month mortality in LVO patients treated with MT.

Our study represents the largest study to date, evaluating the prognostic role of admission NLR in LVO patients treated with MT. A retrospective study by Brooks et al[3] demonstrated that high admission NLR values predict poor functional outcome in LVO patients after MT.[4] However, small sample size, use of older generation MT devices that are known to be associated with higher rates of sICH, and utilization of older Thrombolysis in Myocardial Infarction (TIMI) scale to characterize reperfusion are important methodological shortcomings of their study.

Our findings are partly in line with the observations of 2 studies where higher NLR values were associated with higher risk of hemorrhagic transformation or sICH in AIS patients receiving intravenous thrombolysis.[1,2] AIS has been shown to elicit a robust activation of the immune system in animal models of middle cerebral artery occlusion by potentiating the migration of neutrophils in the brain. This activates signaling cascades including protein kinase C and focal adhesion kinase, which leads to increased blood-brain barrier permeability.[5] Additionally, neutrophils have been shown to be an important source of MMP-9 (matrix metalloproteinase-9) within the first 24 hours of AIS.[5] This may explain the potential pathophysiological association of admission NLR with sICH in LVO patients post-MT as elevated levels of MMP-9 have been associated with blood-brain barrier disruption and sICH after thrombolysis in humans.[4]

NLR, easily calculated by point of care white blood cell count on admission, is a marker of immune regulation and can be potentially used as a prognostic biomarker in LVO patients. In addition to predicting a higher risk of sICH and mortality, high NLR values may also identify LVO patients who are at risk for other poststroke complications especially poststroke infection.[3] Additionally, NLR can be incorporated as one of the variables in various scoring tools, designed to facilitate patient selection for MT or to predict response after MT. Our findings are also corroborated by a recent study introducing the Poor Outcome of Endovascular Treatment With Successful Recanalization (PREDICT) scale as an independent predictor of poor outcome in LVO patients despite successful recanalization after MT. Notably, one of the individual components of PREDICT scale is admission NLR. PREDICT has been shown to have good discrimination and satisfactory calibration in a multicenter cohort of 332 LVO patients treated with MT.[6]

In addition to NLR, history of coronary artery disease was one of the predictors of sICH in our cohort. This association could be attributed to the more frequent prehospital utilization of double antiplatelet therapy (12% versus 1%) in patients with a history of coronary artery disease compared with the rest.

Several limitations of the present report need to be acknowledged. First, the modest sample size and retrospective analysis of prospectively collected data are important methodological shortcomings. Second, our outcomes lacked central adjudication. Third, we did not collect data on NLR variability. Fourth, the possibility of an unknown confounding factor affecting the results cannot be ruled out completely. Fifth, the imaging modalities used for diagnosis of sICH were not uniform in all patients, which could have affected the proportion of patients diagnosed with sICH. Sixth, the skewed distribution of admission NLR may account for the discrepant findings between Mann-Whitney *U* test and univariable logistic regression analyses evaluating the unadjusted association of admission NLR with 3-month functional independence. Finally, the observational study design did not allow us to establish a cause-effect relationship.

In conclusion, our study demonstrates that higher admission NLR values are independent predictors of sICH and 3-month mortality in LVO patients treated with MT. Future large cohort studies are needed to further explore the role of NLR as a prognostic biomarker.

Disclosures

Dr Arthur is a consultant for Codman, Medtronic, MicroVention, Penumbra, Sequent, Siemens, and Stryker and has received research support from Sequent and Siemens. Dr Elijovich is a consultant for Codman Neurovascular, Medtronic, MicroVention, Penumbra, Sequent, and Stryker. The other authors report no conflicts.

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SUPPLEMENTAL MATERIAL

Supplementary Methods:

Study population and baseline characteristics

We performed a retrospective analysis of a prospectively collected database of consecutive LVO patients who underwent MT (stent-retriever or aspiration) at a tertiary care stroke centers from January 2012 to June 2016 (293 patients).[1] AIS patients with CT angiography (CTA) confirmed LVO presenting within 6 hours of symptom onset were included. For patients presenting between 6 to 12 hours after symptom onset, additional imaging selection criteria were used such as ASPECTS score ≥ 6 on CT head and/or good collaterals on CTA. CT and CTA were performed on a 64-slice scanner. CT slice thickness was 1.25 mm with acquisitions in axial, sagittal, and coronal planes with 3D reformations. Neuroradiologists calculated ASPECTS (Alberta Stroke Program Early CT Score) and CTA collateral scores as previously reported.[1] Stroke severity at hospital admission was documented using National Institute of Health Stroke Scale (NIHSS) score by certified vascular neurologists. Baseline characteristics including demographics, vascular risk factors, admission NIHSS-scores, pretreatment with IVT, admission serum glucose, admission systolic blood pressure (SBP) and diastolic blood pressure (DBP) levels were recorded as previously described.[1]

Outcome measures

Safety outcomes included symptomatic intracranial hemorrhage (sICH) and 3-month mortality while efficacy outcomes were characterized by successful reperfusion (SR) and 3 month FI. SR after endovascular procedures was defined by modified Thrombolysis in Cerebral Infarction (mTICI) scores of 2b or 3.[1] mTICI scores were obtained from post-operative reports by endovascular specialists. sICH was defined as presence of a parenchymal hematoma type 2 (PH-2) on brain CT and/or MRI gradient recall echo (GRE) sequence and associated clinical deterioration with an increase in NIHSS-score (≥4 points) within 36 hours after treatment.[1] Functional outcome was evaluated at three months using the modified Rankin Scale scores (mRS-score). FI was defined as a three-month mRS-score of 0-2. Poor functional outcome was defined as a three-month mRS-score 3-6. The mRS scores were obtained either from a post hospital discharge clinic follow-up or from a hospital visit. Both endovascular specialists and NIHSS/mRS-certified assessors of stroke severity and functional outcomes were unaware of the purposes of the study and performed treatments and assessments as part of their clinical duties.

Statistical analyses

Continuous variables with normal distributions were presented as means with standard deviation (SD), while those with skewed distributions were presented as medians with interquartile range (IQR). Statistical comparisons between two groups were performed using the $\chi 2$ test or, in the case of small-expected frequencies, Fisher's exact test. Continuous variables were compared using the unpaired t test or the Mann–Whitney U test, as indicated. The predictive ability of NLR to discriminate clinical outcomes (sICH, three-month mortality and three-month functional independence) was evaluated using receiver-operating characteristic analysis and the c statistic (area under curve).

Univariable and multivariable binary logistic regression models were used to evaluate associations between admission NLR with clinical outcomes (three-month FI , three-month mortality and sICH) before and after adjusting for all baseline characteristics. A cut off of $p < 0.1$ was used to select candidate variables for inclusion in multivariable analyses. The univariable association of admission NLR values with SR was not significant in Mann-Whitney U test so additional logistic regression analyses was not performed. The Statistical Package for Social Science (SPSS Inc, version 25.0 for Mac) was used for statistical analyses

Supplementary Tables

Supplementary Table I: Admission NLR values in patients with different efficacy (complete revascularization and three-month FI) and safety (sICH and three-month mortality) outcomes

Outcome	Admission NLR Median (IQR)		p value
Safety	*Yes*	*No*	
Symptomatic Intracranial Hemorrhage	8.5 (4.7-11.3)	3.9 (1.9-6.5)	p<0.001
Three-month mortality	5.4 (2.8-9.6)	4.0 (1.8-6.4)	p=0.004
Efficacy	*Yes*	*No*	
Successful reperfusion	3.9 (1.8-6.4)	4.6 (2.2-8.4)	p=0.068
Three-month functional independence*	3.7 (1.7-6.5)	4.3 (2.6-8.3)	p=0.039
Three-month poor functional outcome**	4.3 (2.6-8.3)	3.7 (1.7-6.5)	p=0.039

NLR: Neutrophil Lymphocyte Ratio

*defined as three-month mRS-scores of 0-2

**defined as three-month mRS-scores of 3-6

Supplementary Table II. Univariable and multivariable logistic regression analyses depicting the associations of admission NLR and other baseline characteristics with three-month functional independence (mRS-score of 0-2) after mechanical thrombectomy.

	Univariable Logistic Regression Analysis		Multivariable Logistic Regression Analysis*	
Variable	Odds Ratio (95%CI)	p*	Odds Ratio (95%CI)	p
Age(per 10 year increase)	0.87 (0.74-1.02)	0.094	0.80 (0.65-0.97)	**0.030**
Hypertension	0.74 (0.41-1.33)	0.323		
Diabetes mellitus	0.85 (0.52-1.39)	0.525		
Hyperlipidemia	1.04 (0.65-1.68)	0.842		
Atrial fibrillation	1.04 (0.60-1.78)	0.882		
Coronary artery disease	0.73 (0.43-1.26)	0.270		
Congestive heart failure	1.23 (0.69-2.20)	0.467		
Smoking	0.74 (0.44-1.26)	0.274		
Intravenous thrombolysis	1.32 (0.85-2.05)	0.215		
Serum glucose at admission (per 10mg/dL increase)	0.95 (0.91-0.99)	0.012	0.94 (0.90-0.98)	0.013
Serum LDL (per 10mg/dL increase)	0.97 (0.90-1.03)	0.397		
Admission NLR (per 1 point increase)	0.96 (0.91-1.01)	0.143		
SBP at admission (per 10mmHg increase)	0.91 (0.85-0.99)	0.028	0.92 (0.84-1.01)	0.099
DBP at admission (per 10mmHg increase)	0.93 (0.83-1.04)	0.213		
NIHSS-score at admission	0.92 (0.87-0.96)	<0.001	0.93 (0.89-0.97)	**0.002**
ASPECTS at baseline	1.28 (1.06-1.52)	0.009	1.14 (0.90-1.45)	0.258
Good collaterals	1.79 (1.00-3.22)	0.050	1.77 (0.87-3.58)	0.112

Symptom onset to emergency department arrival time	0.99 (0.99-1.00)	0.010	0.99 (0.99-1.00)	0.058
Symptomatic intracranial hemorrhage	0.24 (0.07-0.73)	0.013	0.28 (0.07-1.08)	0.066

NIHSS: National Institutes of Health Stroke Scale; ASPECTS: Alberta Stroke Program Early CT score; LDL: low density lipoprotein; SBP: systolic blood pressure; DBP: diastolic blood pressure; NLR: neutrophil to lymphocyte ratio

*cutoff of $p< 0.1$ was used for selection of candidate variables for inclusion in multivariable logistic regression models

Supplementary Table III. Univariable and multivariable logistic regression analyses depicting the associations of admission NLR and other baseline characteristics with three-month poor functional outcome (mRS-score of 3-6) after mechanical thrombectomy.

	Univariable Logistic Regression Analysis		Multivariable Logistic Regression Analysis*	
Variable	Odds Ratio (95%CI)	p*	Odds Ratio (95%CI)	p
Age(per 10 year increase)	1.12 (0.94-1.32)	0.185		
Hypertension	1.39 (0.77-2.50)	0.269		
Diabetes mellitus	1.31 (0.79-2.16)	0.291		
Hyperlipidemia	1.04 (0.64-1.68)	0.857		
Atrial fibrillation	1.02 (0.59-1.76)	0.941		
Coronary artery disease	1.23 (0.71-2.12)	0.443		
Congestive heart failure	0.71 (0.39-1.26)	0.247		
Smoking	1.16 (0.69-1.97)	0.564		
Intravenous thrombolysis	0.73 (0.46-1.14)	0.174		
Serum glucose at admission (per 10mg/dL increase)	1.05 (1.01-1.09)	0.012	1.05 (1.00-1.09)	0.022
Serum LDL (per 10mg/dL increase)	1.03 (0.96-1.10)	0.375		
Admission NLR (per 1 point increase)	1.04 (0.98-1.09)	0.126		
SBP at admission (per 10mmHg increase)	1.11 (1.02-1.20)	0.009	1.11 (0.98-1.26)	0.082
DBP at admission (per 10mmHg increase)	1.12 (1.00-1.26)	0.046	0.97 (0.81-1.16)	0.768
NIHSS-score at admission	1.08 (1.04-1.12)	<0.001	1.07 (1.02-1.12)	0.001
ASPECTS at baseline	0.77 (0.64-0.93)	0.008	0.91 (0.71-1.15)	0.443
Good collaterals	0.49 (0.26-0.89)	0.020	0.51 (0.25-1.04)	0.066

Symptom onset to emergency department arrival time	1.002 (1.001-1.004)	0.003	1.002 (1.000-1.004)	0.017
Symptomatic intracranial hemorrhage	3.75 (1.22-11.53)	0.021	3.55 (0.91-13.80)	0.067

NIHSS: National Institutes of Health Stroke Scale; ASPECTS: Alberta Stroke Program Early CT score; LDL: low density lipoprotein; SBP: systolic blood pressure; DBP: diastolic blood pressure; NLR: neutrophil to lymphocyte ratio

*cutoff of $p< 0.1$ was used for selection of candidate variables for inclusion in multivariable logistic regression models

Supplementary Table IV. Univariable and multivariable logistic regression analyses depicting the associations of admission NLR and other baseline characteristics with three-month mortality after mechanical thrombectomy.

	Univariable Logistic Regression Analysis		Multivariable Logistic Regression Analysis*	
Variable	Odds Ratio (95%CI)	p*	Odds Ratio (95%CI)	p
Age (per 10 year increase)	0.98 (0.81-1.19)	0.875		
Hypertension	0.88 (0.46-1.69)	0.720		
Diabetes mellitus	1.70 (0.97-2.96)	0.060	0.95 (0.43-2.07)	0.905
Hyperlipidemia	0.63 (0.36-1.10)	0.107		
Atrial fibrillation	0.83 (0.44-1.58)	0.583		
Coronary artery disease	1.40 (0.77-2.53)	0.265		
Congestive heart failure	0.85 (0.44-1.67)	0.651		
Smoking	1.61 (0.91-2.86)	0.101		
Intravenous thrombolysis	0.55 (0.31-0.96)	0.037	0.84 (0.36-1.93)	0.688
Serum glucose at admission (per 10mg/dL increase)	1.05 (1.01-1.08)	0.005	1.07 (1.02-1.12)	**0.006**
Serum LDL (per 10mg/dL increase)	1.00 (0.92-1.08)	0.975		
Admission NLR (per 1 point increase)	1.06 (1.01-1.12)	0.012	1.08 (1.01-1.16)	**0.014**
SBP at admission (per 10mmHg increase)	1.15 (1.05-1.25)	0.001	1.13 (0.98-1.31)	0.092
DBP at admission (per 10mmHg increase)	1.19 (1.05-1.35)	0.005	1.02 (0.82-1.26)	0.855
NIHSS-score at admission	1.09 (1.05-1.14)	<0.001	1.09 (1.03-1.15)	**0.001**
ASPECTS at baseline	0.88 (0.73-1.06)	0.194		
Good collaterals	0.46 (0.24-0.88)	0.020	0.43 (0.20-0.92)	0.031
Symptom onset to emergency department arrival time (per 1 min	1.001 (1.000-1.003)	0.050	1.00 (0.99-1.00)	0.922

increase)				
Symptomatic intracranial hemorrhage	4.26 (1.68-10.78)	0.002	3.07 (0.98-9.62)	0.053

NIHSS: National Institutes of Health Stroke Scale; ASPECTS: Alberta Stroke Program Early CT score; LDL: low density lipoprotein; SBP: systolic blood pressure; DBP: diastolic blood pressure; NLR: neutrophil to lymphocyte ratio

*cutoff of p< 0.1 was used for selection of candidate variables for inclusion in multivariable logistic regression models

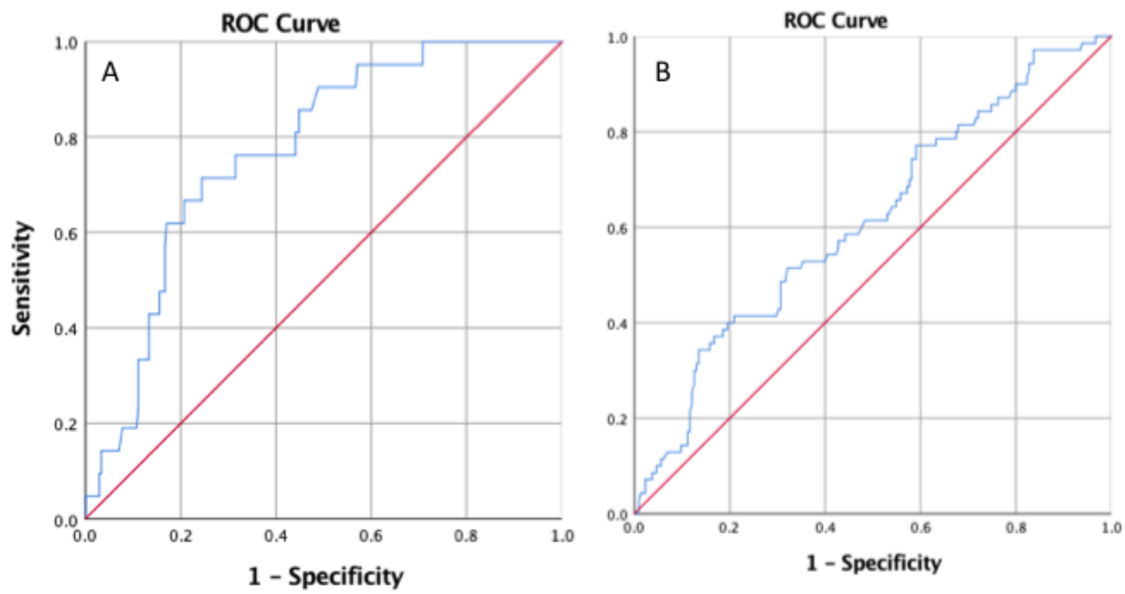
Supplementary Table V. Univariable and multivariable logistic regression analyses depicting the associations of admission NLR and other baseline characteristics with symptomatic intracranial hemorrhage after mechanical thrombectomy

	Univariable Logistic Regression Analysis		Multivariable Logistic Regression Analysis*	
Variable	Odds Ratio (95%CI)	p*	Odds Ratio (95%CI)	p
Age (per 10 year increase)	1.06 (0.78-1.46)	0.679		
Hypertension	2.70 (0.61-11.92)	0.190		
Diabetes mellitus	1.54 (0.61-3.84)	0.356		
Hyperlipidemia	1.21 (0.49-2.95)	0.668		
Atrial fibrillation	2.52 (1.00-6.39)	0.049	0.93 (0.29-2.99)	0.909
Coronary artery disease	2.86 (1.16-7.05)	0.022	3.66 (1.08-12.41)	**0.037**
Congestive heart failure	3.25 (1.28-8.25)	0.013	1.46 (0.42-5.02)	0.547
Smoking	2.06 (0.82-5.18)	0.122		
Intravenous thrombolysis	0.97 (0.44-2.11)	0.946		
Serum glucose at admission (per 10mg/dL increase)	1.03 (0.98-1.08)	0.136		
Serum LDL (per 10mg/dL increase)	0.93 (0.82-1.07)	0.338		
Admission NLR (per 1 point increase)	1.13 (1.05-1.21)	<0.001	1.11 (1.03-1.20)	**0.006**
SBP at admission (per 10mmHg increase)	0.95 (0.82-1.09)	0.489		
DBP at admission (per 10mmHg increase)	0.99 (0.81-1.22)	0.982		
NIHSS-score at admission	1.05 (0.99-1.11)	0.083	1.04 (0.97-1.13)	0.233
ASPECTS at baseline	0.61 (0.47-0.79)	<0.001	0.65 (0.48-0.88)	**0.005**
Good collaterals	0.83 (0.28-2.41)	0.736		
Symptom onset to emergency department arrival time (per 1 min increase)	1.00 (0.99-1.00)	0.840		

NIHSS: National Institutes of Health Stroke Scale; ASPECTS: Alberta Stroke Program Early CT score; LDL: low density lipoprotein; SBP: systolic blood pressure; DBP: diastolic blood pressure; NLR: neutrophil to lymphocyte ratio

*cutoff of $p < 0.1$ was used for selection of candidate variables for inclusion in multivariable logistic regression models

Supplementary Figure:



Receiver Operator Characteristic Curve analyses showing the predictive ability of Neutrophil to Lymphocyte Ratio for symptomatic intracranial hemorrhage (A) and three-month mortality (B).

Supplementary Reference:

1. Pandhi A, Tsivgoulis G, Krishnan R, Ishfaq MF, Singh S, Hoit D, et al. Antiplatelet pretreatment and outcomes following mechanical thrombectomy for emergent large vessel occlusion strokes. [published online ahead of print December l9, 2017]. *J Neurointerv Surg*. 2018. http://jnis.bmj.com/content/early/2017/12/19/neurintsurg-2017-013532. Assessed January 12 2018