Influence of Age on Clinical and Revascularization Outcomes in the North American Solitaire Stent-Retriever Acute Stroke Registry

Alicia C. Castonguay, PhD; Osama O. Zaidat, MD, MS; Roberta Novakovic, MD; Thanh N. Nguyen, MD; M. Asif Taqi, MD; Rishi Gupta, MD; Chung-Huan J. Sun, MD; Coleman Martin, MD; William E. Holloway, MD; Nils Mueller-Kronast, MD; Joey E. English, MD; Italo Linfante, MD; Guilherme Dabus, MD; Tim W. Malisch, MD; Franklin A. Marden, MD; Hormozd Bozorgchami, MD; Andrew Xavier, MD; Ansaar T. Rai, MD; Michael T. Froehler, MD, PhD; Aamir Badruddin, MD; Michael G. Abraham, MD; Vallabh Janardhan, MD; Hashem Shaltoni, MD; Albert J. Yoo, MD; Alex Abou-Chebl, MD; Peng R. Chen, MD; Gavin W. Britz, MD; Ritesh Kaushal, MD; Ashish Nanda, MD; Mohammad A. Issa, MD; Raul G. Nogueira, MD

Background and Purpose—The Solitaire With the Intention for Thrombectomy (SWIFT) and thrombectomy revascularization of large vessel occlusions in acute ischemic stroke (TREVO 2) trial results demonstrated improved recanalization rates with mechanical thrombectomy; however, outcomes in the elderly population remain poorly understood. Here, we report the effect of age on clinical and angiographic outcome within the North American Solitaire-FR Stent-Retriever Acute Stroke (NASA) Registry.

Methods—The NASA Registry recruited sites to submit data on consecutive patients treated with Solitaire-FR. Influence of age on clinical and angiographic outcomes was assessed by dichotomizing the cohort into ≤80 and >80 years of age.

Results—Three hundred fifty-four patients underwent treatment in 24 centers; 276 patients were ≤80 years and 78 were >80 years of age. Mean age in the ≤80 and >80 cohorts was 62.2±13.2 and 85.2±3.8 years, respectively. Of patients >80 years, 27.3% had a 90-day modified Rankin Score ≤2 versus 45.4% ≤80 years (P=0.02). Mortality was 43.9% and 27.3% in the >80 and ≤80 years cohorts, respectively (P=0.01). There was no significant difference in time to revascularization, revascularization success, or symptomatic intracranial hemorrhage between the groups. Multivariate analysis showed age >80 years as an independent predictor of poor clinical outcome and mortality. Within the >80 cohort, National Institutes of Health Stroke Scale (NIHSS), revascularization rate, rescue therapy use, and symptomatic intracranial hemorrhage were independent predictors of mortality.

Conclusion—Greater than 80 years of age is predictive of poor clinical outcome and increased mortality compared with younger patients in the NASA registry. However, intravenous tissue-type plasminogen activator use, lower NIHSS, and shorter revascularization time are associated with better outcomes. Further studies are needed to understand the endovascular therapy role in this cohort compared with medical therapy. (Stroke. 2014;45:3631-3636.)

Key Words: age groups ■ aged ■ stroke ■ thrombectomy

Received June 19, 2014; final revision received September 8, 2014; accepted September 25, 2014.

From the Departments of Neurology (A.C.C., O.O.Z., M.A.I.), Neurosurgery (O.O.Z.), and Radiology (O.O.Z.), Medical College of Wisconsin/Froedtert Hospital, Milwaukee, WI; Departments of Radiology and Neurology, UT Southwestern Medical Center, Dallas, TX (R.N.); Departments of Neurology, Neurosurgery, and Radiology, Boston Medical Center, Boston, MA (T.N.N.); Desert Regional Medical Center, Palm Springs, CA (M.A.T.); Wellstar Neurosurgery Kennesaw Hospital, Atlanta, GA (R.G.); Department of Neurology, Emory University School of Medicine, Atlanta, GA (C.-H.J.S., R.G.N.); Saint Luke’s Kansas City, Kansas City, MO (C.M., W.E.H.); Department of Neurology, Delray Medical Center, Delray Beach, FL (N.M.-K.); California Pacific Medical Center, San Francisco, CA (J.E.E.); Division of Interventional Neuroradiology, Baptist Cardiac and Vascular Institute, Miami, FL (I.L., G.D.); Alexian Brothers Medical Center, Elk Grove Village, IL (T.W.M., F.A.M.); Oregon Health and Science University, Portland, OR (H.B.); Department of Neurology, Wayne State University School of Medicine, Detroit, MI (A.X.); Department of Radiology, West Virginia University Hospital, Morgantown, WV (A.T.R.); Departments of Neurology, Neurosurgery, and Radiology, Vanderbilt University Medical Center, Nashville, TN (M.T.F.); Provena Saint Joseph Medical Center, Joliet, IL (A.B.); University of Kansas Medical Center, Kansas City, KS (M.G.A.); Texas Stroke Institute, Plano, TX (V.J., A.A.-C.); University of Texas Health Science Center, Houston, TX (H.S.); Department of Radiology, Division of Diagnostic and Interventional Neuroradiology, Massachusetts General Hospital, Boston, MA (A.J.Y.); University of Texas, Houston, TX (P.R.C.); Department of Neurosurgery, Methodist Neurological Institute, Houston, TX (G.W.B.); Saint Louis University, St. Louis, MO (R.K.); and University of Missouri, Columbia, MO (A.N.).

The online-only Data Supplement is available with this article at http://stroke.ahajournals.org/lookup/suppl/doi:10.1161/STROKEAHA.114.006487/-/DC1.

Correspondence to Osama O. Zaidat, MD, MS, Department of Neurology, Radiology, and Neurosurgery, Neurointerventional Division, Medical College of Wisconsin/Froedtert Hospital, Milwaukee, WI 53226; E-mail szaidat@mcw.edu

© 2014 American Heart Association, Inc.

Stroke is available at http://stroke.ahajournals.org DOI: 10.1161/STROKEAHA.114.006487

3631
Mechanical thrombectomy using emerging stent-retriever technology has shown increasing promise as an effective treatment for acute ischemic stroke (AIS). The results of the Trevo versus Merci retrievers for thrombectomy revascularization of large vessel occlusions in AIS (TREVO 2) and the Solitaire With the Intention for Thrombectomy (SWIFT) clinical trials demonstrated superior revascularization rates and clinical outcomes compared with the first-generation Merci retriever device. Although the data from the SWIFT and TREVO 2 trials support the use of new-generation stent retrievers for the treatment of AIS, the safety and effectiveness of these devices have not been evaluated in the elderly population.

Several studies have previously examined the use of mechanical thrombectomy in octogenarians and have reported lower rates of good clinical outcome and higher rates of mortality in this age group. However, these initial studies were limited by their small patient size and inclusion of first-generation retrieval devices. Because the elderly population, which carries a higher incidence of stroke, is expected to nearly double over the next several decades, it is critical to investigate the benefit of newer treatments and to understand potential characteristics within this population, which may influence clinical outcome following endovascular therapy (ET).

The aim of this substudy was to examine the influence of age on clinical and revascularization outcomes within the North American Solitaire Acute (NASA) Stroke Registry, a multicenter postmarketing registry reporting the real-world clinical use of a newer generation stent retriever for the treatment of AIS.

Methods

The investigator-initiated multicenter NASA Registry recruited 24 US sites to submit retrospective demographic, clinical presentation, site-adjudicated angiographic, procedural, and clinical outcome data on consecutive AIS patients treated with the Solitaire-FR device from March 2012 to February 2013. All patients participating in the NASA registry received Solitaire-FR as the first-choice device to restore blood flow. Each site obtained local institutional review board approval for the study.

For the purpose of this substudy, the NASA cohort was dichotomized into 2 age groups based on previous studies: patients ≤80 years of age and those >80 years old. Thrombolysis in Myocardial Ischemia (TIMI) and Treatment in Cerebral Ischemia (TICI) revascularization grades were defined according to the SWIFT and TREVO 2 trial definitions, respectively. Clinical outcomes were 90-day modified Rankin Score (mRS), mortality, and symptomatic intracranial hemorrhage (sICH). Good clinical outcome was defined as a 90-day mRS≤2. sICH was defined as any parenchymal hematoma, subarachnoid hemorrhage, or intraventricular hemorrhage associated with a worsening of the National Institutes of Health Stroke Scale (NIHSS) by ≥4 within 24 hours. Interventional procedures and patient selection were performed according to the standards and protocols at each site. Angiographic and clinical outcome data were adjudicated by each site. This study was performed without funding or industry sponsorship.

Statistical Analysis

The data were stored and analyzed by the coordinating site, the Medical College of Wisconsin. Statistical analyses were performed using JMP 11 software (SAS Institute, Cary, NC). The NASA cohort was dichotomized into patients ≤80 years of age and those >80 years old. Univariate analysis comparing the baseline characteristics between the 2 groups was performed using the Student t test for continuous variables and χ² or Fisher exact test (when small cell sample size of a given variable existed) for binary variables. Variables with a P value of <0.10, and clinically relevant factors, were entered into a multivariate stepwise logistic regression model to determine predictors of clinical outcome and mortality.

Results

NASA Full Cohort

There were 354 patients from 24 US centers enrolled in the NASA Registry. The mean age for the total NASA cohort was 67.3±15.2 years (range, 20–100 years). For patients with good clinical outcome (mRS≤2), the mean age was 65±15.1 versus 69.2±15.1 years in those with a poor outcome (P=0.01).

NASA ≤80 Years and >80 Years Cohorts

Baseline Characteristics

When dichotomizing the NASA cohort, 276 of 354 (78.0%) were ≤80 years (mean, 62.2±13.2) and 78 of 354 (22.0%) were >80 years of age (mean, 85.3±3.8). Baseline characteristics for the 2 cohorts are presented in Table 1. There was a greater percentage of women in the >80 years of age group than that in the ≤80 years cohort (65.4% versus 46.2%; P=0.003). The >80 years cohort had a greater prevalence of hypertension (P=0.003), atrial fibrillation (P=0.0001), hyperlipidemia (P=0.02), and coronary artery disease (P=0.004). There was no difference in the mean presenting NIHSS (P=0.2), baseline mRS≤2 (P=0.3), or prevalence of diabetes mellitus (0.8) in the 2 cohorts. In the ≤80 years cohort, a greater proportion of patients presented with internal carotid artery terminus (25.1%) and basilar occlusions (12.4%) compared with 16.7% and 2.6% in those patients >80 years old, respectively. No difference in the proportion of patients receiving intravenous tissue-type plasminogen activator (IV-tPA; P=0.4) was noted between the groups.

Procedural and Angiographic Characteristics

No difference in mean time from onset to groin puncture (364.7±228.5 minutes versus 358.9±272.9 minutes; P=0.9) or time to revascularization (71.7±89.5 minutes versus 93.1±114.5 minutes; P=0.08) was observed among the ≤80 or >80 years groups, respectively (Table 2). With regard to revascularization, there was no difference in TIMI ≥2 (84.0% versus 83.3%; P=0.9) or TICI ≥2b (73.1% versus 69.2%; P=0.5) in the ≤80 or >80 years groups. The number of passes, use of a balloon guide catheter, and use of rescue therapy were similar among the cohorts; however, the use of general anesthesia (73.0% versus 60.0%; P=0.05) was greater in the ≤80-year-old group and use of intra-arterial (IA)-tPA (25.4% versus 38.5%; P=0.02) was greater in those >80 years of age. Distal embolization and embolization into new territory was comparable in both cohorts (Table 2).

Clinical Outcome Data

Ninety-day mRS was reported in 249 of 276 (90.2%) and 66 of 78 (84.6%) patients ≤80 years and >80 years of age, respectively. On the univariate analysis, those >80 years demonstrated a lower rate of good clinical outcome (27.3% versus 45.4%; P=0.02) and increased mortality (43.9% versus 27.3%;
The multivariate analysis outcome (good versus poor) and mortality (Table I and II in the online-only Data Supplement) demonstrated a lower rate of good clinical outcome (27.3% versus 69.6%; \( P=0.01 \)) at 90 days compared with those in the \( \leq 80 \) years age group (Figure). Stratification by age showed that patients \( >80 \) years had poorer outcomes when compared with other age strata (Figure I in the online-only Data Supplement). No difference was seen in the rate of sICH (9.1% versus 12.8%; \( P=0.4 \)) in the \( \leq 80 \) years and \( >80 \) years cohorts, respectively (Table 2).

### Predictors of Clinical Outcome and Mortality

Age \( >80 \) years remained as an independent predictor of poor clinical outcome and mortality when adjusting for dichotomized age (\( >80 \) years), sex, hypertension, atrial fibrillation, hyperlipidemia, smoking, coronary artery disease, general anesthesia, and IA-tPA use on the multivariate analysis (Table 3).

### Greater Than 80 Years Cohort

To evaluate the characteristics within the \( >80 \) years of age cohort that may contribute to clinical outcome and mortality, the \( >80 \) years population was dichotomized by 90-day clinical outcome (good versus poor) and mortality (Table I and II in the online-only Data Supplement). The multivariate analysis (adjusting for time to revascularization, use of rescue therapy, number of passes, revascularization success [TICI \( \geq 2b \)], initial NIHSS, and IV-tPA use) showed initial NIHSS, time to revascularization, and IV-tPA use as independent predictors of clinical outcome in the \( >80 \) cohort (Table 4). Adjusting for initial NIHSS, hypertension, coronary artery disease, use of rescue therapy, TICI success (\( \geq 2b \)), and sICH, the multivariate analysis demonstrated that initial NIHSS, lack of revascularization success (TICI \( \geq 2b \)), use of rescue therapy, and sICH were independent predictors of mortality (Table 5).

### Discussion

Mechanical thrombectomy using newer generation stent-retriever technology has shown increasing promise as an effective treatment for AIS; however, the influence of age in patients treated with these devices has not been studied. In the present study, we examine the influence of age on patients treated with the stent retriever, Solitaire-FR, in the NASA Registry.

Compared with the younger cohort, patients \( >80 \) years demonstrated a lower rate of good clinical outcome (27.3%
found no difference in the rate of sICH between elderly and younger cohorts.3,5,11-15

Although patients >80 years of age demonstrated lower rates of good clinical outcome at 90 days, elderly patients achieved similar revascularization rates (TICI≥2b; 69.2% versus 73.1%; P=0.5), but at a slower duration (93.1±114.5 versus 71.7±89.5 minutes; P=0.08) than younger patients. Revascularization rates in several studies examining ET in the elderly ranged from 62% to 87.9%,3,5,11,12,16 which are comparable with the findings from the current study. All but one series found no correlation between age >80 years and the likelihood of revascularization.11 Interpretation of revascularization success in previous series is difficult because of variability in the grading scales used. This study reports TICI, which is the recommended revascularization scale by Zaidat et al.17

The natural history of ischemic stroke in the elderly is known to correlate with increased mortality and lower rates of good clinical outcome.18,19 Part of this effect may be because of a higher rate of withdrawal of care and medical comorbidities in this population.15 In our study, patients >80 years of age had higher rates of hypertension, atrial fibrillation, hyperlipidemia, smoking, and coronary artery disease than their younger counterparts. When adjusting for these comorbidities, age >80 years remained a strong independent predictor of poor clinical outcome and mortality. Our results are in agreement with 2 reports, which demonstrated that age >80 years was an independent predictor of poor outcome.11,14 The elderly also carry a higher burden of decreased neuronal plasticity, which also may contribute to the worse prognosis seen in this population.20

### Table 3. Multivariate Analysis: Independent Predictors of Clinical Outcome and Mortality in the ≤80 and >80 Group

<table>
<thead>
<tr>
<th>Variable</th>
<th>NParm</th>
<th>DF</th>
<th>χ²</th>
<th>P&gt;χ²</th>
<th>χ²</th>
<th>P&gt;χ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age&gt;80</td>
<td>1</td>
<td>1</td>
<td>7.97</td>
<td>0.005</td>
<td>5.63</td>
<td>0.018</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>1</td>
<td>0.17</td>
<td>0.68</td>
<td>0.011</td>
<td>0.92</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1</td>
<td>1</td>
<td>2.06</td>
<td>0.15</td>
<td>0.43</td>
<td>0.51</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>1</td>
<td>1</td>
<td>0.053</td>
<td>0.82</td>
<td>0.57</td>
<td>0.45</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>1</td>
<td>1</td>
<td>0.056</td>
<td>0.81</td>
<td>0.63</td>
<td>0.43</td>
</tr>
<tr>
<td>Smoking</td>
<td>1</td>
<td>1</td>
<td>0.036</td>
<td>0.85</td>
<td>0.88</td>
<td>0.35</td>
</tr>
<tr>
<td>CAD</td>
<td>1</td>
<td>1</td>
<td>0.0011</td>
<td>0.97</td>
<td>2.47</td>
<td>0.12</td>
</tr>
<tr>
<td>General anesthesia</td>
<td>1</td>
<td>1</td>
<td>9.38</td>
<td>0.002</td>
<td>3.92</td>
<td>0.048</td>
</tr>
<tr>
<td>IA-tPA</td>
<td>1</td>
<td>1</td>
<td>0.027</td>
<td>0.87</td>
<td>0.38</td>
<td>0.54</td>
</tr>
</tbody>
</table>

CAD indicates coronary artery disease; DF, degrees of freedom; and IA-tPA, intra-arterial tissue-type plasminogen activator.

### Table 4. Multivariate Analysis: Independent Predictors of Clinical Outcome in >80 Cohort

<table>
<thead>
<tr>
<th>Variable</th>
<th>NParm</th>
<th>DF</th>
<th>χ²</th>
<th>P&gt;χ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIHSSi</td>
<td>1</td>
<td>1</td>
<td>4.10</td>
<td>0.04</td>
</tr>
<tr>
<td>Time to revascularization</td>
<td>1</td>
<td>1</td>
<td>5.65</td>
<td>0.02</td>
</tr>
<tr>
<td>Number of passes</td>
<td>1</td>
<td>1</td>
<td>1.48</td>
<td>0.22</td>
</tr>
<tr>
<td>Rescue therapy</td>
<td>1</td>
<td>1</td>
<td>2.35</td>
<td>0.13</td>
</tr>
<tr>
<td>TICI success (≥2B)</td>
<td>1</td>
<td>1</td>
<td>0.233</td>
<td>0.63</td>
</tr>
<tr>
<td>IV-tPA</td>
<td>1</td>
<td>1</td>
<td>8.73</td>
<td>0.003</td>
</tr>
</tbody>
</table>

DF indicates degrees of freedom; IV-tPA, intravenous tissue-type plasminogen activator; NIHSSi, National Institutes of Health Stroke Scale initial; and TICI, Treatment in Cerebral Ischemia.

---

versus 45.4%; P=0.02) and increased mortality (43.9% versus 27.3%; P=0.01) at 90 days compared with those ≤80 years. Our results are similar to other series that reported lower rates of good clinical outcome and higher rates of mortality in elderly patients undergoing mechanical thrombectomy for AIS. In the Kurre et al3 series, which examined 109 patients ≥80 years of age who underwent mechanical thrombectomy, only 17.4% achieved a 90-day mRS≥2 and 47.7% were deceased. A single-center series that reported on the use of Merci, a first-generation retriever, showed that elderly patients had a mortality rate of 48% (15/31) versus 15% (11/75) in younger patients (odds ratio, 5.5; confidence interval, 2.1–14.2).4 Lower rates of good clinical outcome and higher rates of mortality have also been reported with multimodal treatment approaches in the elderly.5,11–13 In a separate study, Mono et al5 demonstrated less favorable outcome (28% versus 46%; P=0.019) and increased mortality (40% versus 22%; P=0.008) in octogenarians undergoing IA therapy (IV/IA thrombolysis, IA thrombolysis and mechanical thrombectomy) compared with patients <80 years of age. Similarly, lower rates of 90-day favorable outcome (28% versus 64.4%; P=0.002) and high rates of mortality (40% versus 15.3%) were also reported with a combined IV/IA approach in elderly patients versus their younger counterparts by Mazighi et al.12 Similar to other series, our study found no difference in the rate of sICH between elderly and younger cohorts.3,5,11-15

### Figure.
Distribution of 90-day modified Rankin Score (mRS) in the ≤80 and >80 years cohorts. The large grey lines indicate mRS of ≤2 (good clinical outcome) and 6 (mortality) with associated P values among the 2 groups.
Proper patient selection is critical to determine which patients may benefit from ET. Large randomized controlled trials, including the Interventional Management of Stroke (IMS) III, TREVO 2, and SWIFT, excluded patients ≥85 years.\textsuperscript{1,2,21} The exclusion of the elderly population from RCTs has resulted in limited data on the benefit of ET in older patients. Previous studies, such as the randomized Third International Stroke Trial (IST-3) that included 1617 elderly patients, demonstrated the likely clinical benefit of intravenous thrombolysis in those >80 years of age and the association between thrombolysis and improved outcome.\textsuperscript{22,23} Our study also examined factors within the elderly patient population, which may aid in identifying predictors of clinical outcome. Our study showed that within the >80 years cohort, factors that may influence better outcomes include shorter procedural times, fewer device passes, and limited use of rescue therapy. In our multivariate analysis, initial NIHSS, time to revascularization, and IV-tPA use were found to be independent predictors of clinical outcome in the >80 population. In addition, initial NIHSS, revascularization success, use of rescue therapy, and sICH were all independent predictors of mortality in patients >80 years of age. Interestingly, all patients within the >80 years cohort who had a sICH (10/28) died, suggesting that sICH is particularly detrimental in this older group. Because a higher initial NIHSS was observed in the >80 years group, more severe strokes in this cohort may have contributed to worse outcomes compared with the ≤80 years group. Although use of general anesthesia was reported to negatively impact clinical outcome in AIS patients,\textsuperscript{24} we did not see this effect within the elderly cohort; however, this may be related to the sample size.

### Limitations

Our study has several limitations. This NASA substudy is limited by its retrospective nature and site-adjudicated clinical and revascularization outcomes. Information on collateral status, infarct volume, and palliative care/withdrawal rates were not available in the original NASA cohort; these factors may have contributed to the poor outcomes and mortality seen in the elderly population. Collateral circulation is thought to sustain ischemic territory viability during a stroke, and the presence of good collaterals has been associated with higher rates of improved clinical outcome.\textsuperscript{25} Elderly patients are believed to have poorer collaterals than their younger counterparts, and one study has reported that the odds of having decreased collateral circulation increases with age.\textsuperscript{15,26} Final infarct volume in ET has been shown as a strong independent predictor of good clinical outcome.\textsuperscript{15,27,28} Data suggest that smaller baseline infarct volumes in elderly AIS patients may be needed to increase the chances of a good clinical outcome.\textsuperscript{29}

Although this substudy compared patients >80 years of age with those ≤80 years who underwent ET with the Solitaire-FR device, this study lacks a comparator arm of patients who received standard medical therapy alone.

### Conclusions

To date, this is the largest study comparing the use of a newer generation retriever in a young and elderly cohort. Patients >80 years of age demonstrated a lower rate of good clinical outcome and increased mortality with ET compared with patients ≤80 years of age. However, use of IV-tPA, lower NIHSS, and shorter time to revascularization are associated with better outcomes in the elderly group. Further studies are needed to compare ET with standard medical therapy alone in this patient population.

### Disclosures

Dr Zaidat is a Consultant, Covidien, Stryker, and Penumbra. Dr Gupta is a Consultant, Stryker Neurovascular. Rapid Medical, Covidien. Dr Malisch is a member of Data and Safety Monitoring Board. Dr Taqi is a Consultant Stryker Neurovascular. Dr Nogueira is a Consultant/ advisory board Stryker Neurovascular (Trevo 2 Trial PI, DWI or CTP Assessment With Clinical Mismatch in the Triage of Wake-Up and Late Presenting Ischemic Strokes Undergoing Neurintervention [DAWN] Trial PI), Covidien (SWIFT and SWIFT-PRIME Steering Committee, Solitaire FR Thrombectomy for Acute Revascularization [STAR] study Trial Core Laboratory), Penumbra (3-D Separator Trial Executive Committee). Dr Linfante is a Consultant, Shareholder Stryker/Surpass; Consultant and Proctor for Covidien and Consultant for Codman Neurovascular. Dr Dabus is a Shareholder Stryker/ Surpass; Consultant and Proctor for Covidien and Consultant for Microvention. Dr Yoo received research grant, Penumbra, National Institutes of Health/National Institute of Neurological Disorders and Stroke, Dutch Heart Foundation. Dr Janardhan is a Board member, Insera Therapeutics, Inc; Advisory board, Penumbra; Research grant, Stryker Neurovascular, Cordis. Dr Mueller-Kronast is a member of Advisory Board, Covidien.

### References


### Table 5. Multivariate Analysis: Independent Predictors of Mortality in >80 Cohort

<table>
<thead>
<tr>
<th>Variable</th>
<th>NParam</th>
<th>DF</th>
<th>$\chi^2$</th>
<th>$P&gt;\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIHSSi</td>
<td>1</td>
<td>1</td>
<td>4.97</td>
<td>0.026</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1</td>
<td>1</td>
<td>3.43</td>
<td>0.064</td>
</tr>
<tr>
<td>CAD</td>
<td>1</td>
<td>1</td>
<td>2.24</td>
<td>0.13</td>
</tr>
<tr>
<td>TICI success (≥2B)</td>
<td>1</td>
<td>1</td>
<td>5.59</td>
<td>0.018</td>
</tr>
<tr>
<td>Rescue therapy</td>
<td>1</td>
<td>1</td>
<td>4.77</td>
<td>0.029</td>
</tr>
<tr>
<td>sICH</td>
<td>1</td>
<td>1</td>
<td>10.7</td>
<td>0.0011</td>
</tr>
</tbody>
</table>

CAD indicates coronary artery disease; DF, degrees of freedom; NIHSSi, National Institutes of Health Stroke Scale initial; sICH indicates symptomatic intracranial hemorrhage; and TICI, Treatment in Cerebral Ischemia.
Influence of Age on Clinical and Revascularization Outcomes in the North American Solitaire Stent-Retriever Acute Stroke Registry


Stroke. 2014;45:3631-3636; originally published online October 30, 2014; doi: 10.1161/STROKEAHA.114.006487

Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2014 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/45/12/3631

Data Supplement (unedited) at:
http://stroke.ahajournals.org/content/suppl/2014/10/30/STROKEAHA.114.006487.DC1
http://stroke.ahajournals.org/content/suppl/2016/04/06/STROKEAHA.114.006487.DC2

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Stroke can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Stroke is online at:
http://stroke.ahajournals.org/subscriptions/
## Supplementary Table I. Characteristics of >80 years cohort dichotomized by 90-day clinical outcome.

<table>
<thead>
<tr>
<th></th>
<th>mRS ≤2 (N=19)</th>
<th>mRS &gt;2 (N=47)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)(mean (SD))</td>
<td>85.0 (4.8)</td>
<td>85.6 (3.7)</td>
<td>0.6</td>
</tr>
<tr>
<td>Median (IQR, R)</td>
<td>84 (81-86)</td>
<td>85 (83-89)</td>
<td></td>
</tr>
<tr>
<td>Gender (female)</td>
<td>12 (63.2)</td>
<td>33 (70.2)</td>
<td>0.6</td>
</tr>
<tr>
<td>Race (white)</td>
<td>16 (84.2)</td>
<td>38 (80.9)</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Vascular Risk Factors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>15 (79.0)</td>
<td>44 (93.62)</td>
<td>0.08</td>
</tr>
<tr>
<td>Atrial Fibrillation</td>
<td>15 (79.0)</td>
<td>31 (66.0)</td>
<td>0.3</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
<td>5 (26.3)</td>
<td>10 (21.3)</td>
<td>0.7</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>12 (63.2)</td>
<td>31 (66.0)</td>
<td>0.8</td>
</tr>
<tr>
<td>Smoking history</td>
<td>3 (15.8)</td>
<td>6 (12.8)</td>
<td>0.7</td>
</tr>
<tr>
<td>Coronary Artery Disease</td>
<td>8 (42.1)</td>
<td>23 (48.9)</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Clinical Presentation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial NIHSS (mean (SD))</td>
<td>18.5 (5.0)</td>
<td>19.4 (6.2)</td>
<td>0.5</td>
</tr>
<tr>
<td>Occlusion Site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCA/M1</td>
<td>17 (89.5)</td>
<td>36 (76.6)</td>
<td>0.6</td>
</tr>
<tr>
<td>ICA terminus</td>
<td>2 (10.5)</td>
<td>9 (19.2)</td>
<td></td>
</tr>
<tr>
<td>Vertebro-basilar</td>
<td>0 (0)</td>
<td>2 (4.3)</td>
<td></td>
</tr>
<tr>
<td>Initial Systolic BP (mean (SD))</td>
<td>139.3 (29.1)</td>
<td>148.2 (30.8)</td>
<td>0.3</td>
</tr>
<tr>
<td>Initial Diastolic BP (mean (SD))</td>
<td>77.1 (20.9)</td>
<td>77.4 (21.3)</td>
<td>1.0</td>
</tr>
<tr>
<td>IV tPA</td>
<td>12 (63.2)</td>
<td>21 (44.7)</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Procedural Factors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time from onset to groin puncture (min) (mean (SD))</td>
<td>278.2 (196.8)</td>
<td>381.3 (294.7)</td>
<td>0.1</td>
</tr>
<tr>
<td>Fluoroscopic Time (min) (mean (SD))</td>
<td>24.1 (22.4)</td>
<td>41.3 (35.6)</td>
<td>0.04</td>
</tr>
<tr>
<td>Time to revascularization or end of procedure (min) (mean (SD))</td>
<td>43.1 (15.6)</td>
<td>101.5 (114.0)</td>
<td>0.01</td>
</tr>
<tr>
<td>General Anesthesia</td>
<td>5 (41.7)</td>
<td>23 (62.2)</td>
<td>0.3</td>
</tr>
<tr>
<td>IA t-PA</td>
<td>5 (26.3)</td>
<td>19 (40.4)</td>
<td>0.4</td>
</tr>
<tr>
<td>Use of Balloon Guide Catheter</td>
<td>11 (61.1)</td>
<td>16 (34.8)</td>
<td>0.06</td>
</tr>
<tr>
<td>Number of Passes (mean SD)</td>
<td>1.4 (0.8)</td>
<td>1.9 (1)</td>
<td>0.02</td>
</tr>
<tr>
<td>Use of Rescue Therapy</td>
<td>1 (5.3)</td>
<td>16 (34.0)</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Angiographic Outcome</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIMI ≥ 2</td>
<td>18 (94.7)</td>
<td>37 (78.7)</td>
<td>0.1</td>
</tr>
<tr>
<td>TICI ≥ 2a</td>
<td>18 (94.7)</td>
<td>41 (87.2)</td>
<td>0.7</td>
</tr>
<tr>
<td>TICI ≥ 2b</td>
<td>17 (89.5)</td>
<td>29 (63.0)</td>
<td>0.04</td>
</tr>
<tr>
<td>Distal Embolization</td>
<td>1 (5.3)</td>
<td>11 (24.4)</td>
<td>0.09</td>
</tr>
<tr>
<td>Embolization into New Territory</td>
<td>1 (5.3)</td>
<td>2 (4.4)</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Clinical Outcome</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NIHSS at 90 days (mean (SD))</td>
<td>1.3 (1.8)</td>
<td>35.8 (12.4)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Mortality at 90 days</td>
<td>0 (0)</td>
<td>28 (59.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>sICH</td>
<td>0 (0)</td>
<td>10 (21.3)</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Supplementary Table II. Characteristics of >80 years cohort dichotomized by mortality.

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Alive (N=37) N (%)</th>
<th>Deceased (N=28) N (%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)(mean (SD))</td>
<td>84.9 (3.9)</td>
<td>86.3 (4.2)</td>
<td>0.2</td>
</tr>
<tr>
<td>Median (IQR, R)</td>
<td>84 (82-87)</td>
<td>85 (83-90)</td>
<td></td>
</tr>
<tr>
<td>Gender (female)</td>
<td>23 (62.2)</td>
<td>21 (75.0)</td>
<td>0.3</td>
</tr>
<tr>
<td>Race (white)</td>
<td>30 (81.1)</td>
<td>23 (82.1)</td>
<td>1</td>
</tr>
</tbody>
</table>

| Vascular Risk Factors | | | |
| Hypertension | 30 (81.1) | 28 (100.0) | 0.01 |
| Atrial Fibrillation | 28 (75.7) | 17 (60.7) | 0.2 |
| Diabetes Mellitus | 9 (24.3) | 6 (21.4) | 0.8 |
| Hyperlipidemia | 23 (62.2) | 19 (67.9) | 0.6 |
| Smoking history | 4 (10.8) | 4 (14.3) | 0.7 |
| Coronary Artery Disease | 12 (32.4) | 18 (64.3) | 0.01 |

| Clinical Presentation | | | |
| Initial NIHSS (mean (SD)) | 18.2 (4.8) | 20.7 (6.7) | 0.1 |
| Occlusion Site | | | |
| MCA/M1 | 27 (73.0) | 17 (60.7) | 0.6 |
| ICA terminus | 4 (10.8) | 7 (25) | |
| Vertebro-basilar | 1 (2.7) | 1 (3.6) | |
| Initial Systolic BP (mean (SD)) | 141.1 (27.4) | 152.2 (34.0) | 0.2 |
| Initial Diastolic BP (mean (SD)) | 77.1 (19.1) | 77.4 (24.0) | 1 |
| IV tPA | 16 (43.2) | 16 (57.1) | 0.3 |

| Procedural Factors | | | |
| Time from onset to groin puncture (min) (mean (SD)) | 327.9 (219.9) | 384.2 (337.2) | 0.5 |
| Fluoroscopic Time (min) (mean (SD)) | 29.0 (21.3) | 39.0 (32.0) | 0.2 |
| Time to revascularization or end of procedure (min) (mean (SD)) | 74.6 (89.4) | 95.5 (110.0) | 0.5 |
| General Anesthesia | 13 (50.0) | 14 (63.6) | 0.3 |
| IA t-PA | 13 (35.1) | 10 (35.7) | 1 |
| Use of Balloon Guide Catheter | 15 (41.7) | 11 (40.7) | 0.9 |
| Number of Passes (mean SD) median (IQR, R) | 1.7 (1.0) | 1.9 (0.9) | 0.3 |
| Use of Rescue Therapy | 6 (16.2) | 10 (35.7) | 0.1 |

| Angiographic Outcome | | | |
| TIMI ≥ 2 | 33 (89.2) | 22 (78.6) | 0.2 |
| TICI ≥ 2a | 34 (91.9) | 24 (85.7) | 0.4 |
| TICI ≥ 2b | 32 (86.5) | 14 (50) | 0.001 |
| Distal Embolization | 6 (16.7) | 6 (21.4) | 0.6 |
| Embolization into New Territory | 1 (2.7) | 1 (3.7) | 0.8 |

| Clinical Outcome | | | |
| NIHSS at 90 days (median (IQR, R)) | 3 (0-14) | 42 (42-42) | <0.0001 |
| sICH | 0 (0) | 10 (35.7) | 0.001 |
Supplementary Figure I. Distribution of good clinical outcome (mRS≤2) by age strata (in years).
Abstract 13

Influence of Age on Clinical and Revascularization Outcomes in the North American Solitaire-Stent-Retriever Acute Stroke Registry

Alicia C. Castonguay, PhD; Osama O. Zaidat, MD, MS; Roberta Novakovic, MD; Thanh N. Nguyen, MD; M. Asif Taqi, MD; Rishi Gupta, MD; Chung-Huan J. Sun, MD; Coleman Martin, MD; William E. Holloway, MD; Nils Mueller-Kronast, MD; Joey E. English, MD; Iitalo Linfante, MD; Guilherme Dabus, MD; Tim W. Malisch, MD; Franklin A. Marden, MD; Hormozd Bozorgchami, MD; Andrew Xavier, MD; Ansaar T. Rai, MD; Michael T. Froehler, MD, PhD; Aamir Badruddin, MD; Michael G. Abraham, MD; Vallabh Janardhan, MD; Hashem Shaltoni, MD; Albert J. Yoo, MD; Alex Abou-Chebl, MD; Peng R. Chen, MD; Gavin W. Britz, MD; Ritesh Kaushal, MD; Mohammad A. Issa, MD; Raoul G. Nogueira, MD

(Stroke. 2014;45:3631-3636.)

Key Words: age groups ■ aged ■ stroke ■ thrombectomy

Table 3. Multivariate Analysis: Independent Predictors of Clinical Outcome and Mortality in the <80 and >80 Group

<table>
<thead>
<tr>
<th>Variable</th>
<th>N Parm</th>
<th>DF</th>
<th>χ²</th>
<th>P &gt; χ²</th>
<th>χ²</th>
<th>P &gt; χ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 80</td>
<td>1</td>
<td>1</td>
<td>7.97</td>
<td>0.005</td>
<td>5.63</td>
<td>0.018</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>1</td>
<td>0.17</td>
<td>0.68</td>
<td>0.011</td>
<td>0.92</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1</td>
<td>1</td>
<td>2.06</td>
<td>0.15</td>
<td>0.43</td>
<td>0.51</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>1</td>
<td>1</td>
<td>0.053</td>
<td>0.82</td>
<td>0.57</td>
<td>0.45</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>1</td>
<td>1</td>
<td>0.056</td>
<td>0.81</td>
<td>0.63</td>
<td>0.43</td>
</tr>
<tr>
<td>Smoking</td>
<td>1</td>
<td>1</td>
<td>0.036</td>
<td>0.85</td>
<td>0.88</td>
<td>0.35</td>
</tr>
<tr>
<td>CAD</td>
<td>1</td>
<td>1</td>
<td>0.0011</td>
<td>0.97</td>
<td>2.47</td>
<td>0.12</td>
</tr>
<tr>
<td>General anesthesia</td>
<td>1</td>
<td>1</td>
<td>9.38</td>
<td>0.002</td>
<td>3.92</td>
<td>0.048</td>
</tr>
<tr>
<td>IV-PA</td>
<td>1</td>
<td>1</td>
<td>0.027</td>
<td>0.87</td>
<td>0.38</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Table 4. Multivariate Analysis: Independent Predictors of Clinical Outcome in >80 Cohort

<table>
<thead>
<tr>
<th>Variable</th>
<th>N Parm</th>
<th>DF</th>
<th>χ²</th>
<th>P &gt; χ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIHSSi</td>
<td>1</td>
<td>1</td>
<td>4.10</td>
<td>0.04</td>
</tr>
<tr>
<td>Time to revascularization</td>
<td>1</td>
<td>1</td>
<td>5.65</td>
<td>0.02</td>
</tr>
<tr>
<td>Number of passes</td>
<td>1</td>
<td>1</td>
<td>1.48</td>
<td>0.22</td>
</tr>
<tr>
<td>Rescue therapy</td>
<td>1</td>
<td>1</td>
<td>2.35</td>
<td>0.13</td>
</tr>
<tr>
<td>TICI success (≥ 2B)</td>
<td>1</td>
<td>1</td>
<td>0.233</td>
<td>0.63</td>
</tr>
<tr>
<td>IV-PA</td>
<td>1</td>
<td>1</td>
<td>8.73</td>
<td>0.003</td>
</tr>
</tbody>
</table>

DF indicates degrees of freedom; IV-PA, intravenous tissue-type plasminogen activator; NIHSS, National Institutes of Health Stroke Scale initial; and TICI, Treatment in Cerebral Ischemia.

배경과 목적


방법

NASA 레지스트리는 Solitaire–FR로 치료받은 일련의 환자들 자료를 제출한 기관들을 모집하였다. 임상 및 혈관조영 결과에 대한 나이의 영향은 코호트를 80세 이하와 80세 초과로 이분화하여 평가되었다.

결과

24개 센터에서 354명의 환자들이 치료를 받았다; 276명의 환자는 80세 이하였고 78명은 80세를 넘었다. 80세 이하와 80세 초과 코호트에서의 평균 연령은 각각 62.2 ± 13.2세 및 85.2 ± 3.8세 었다. 80세 초과 환자 중 27.3%는 90일째 수정생활적도 2점 이하로 80세 이하에서는 45.4%이었다(P=0.02), 사망률은 80세 초과 및 80세 이하 코호트에서 각각 43.9%와 27.3%이었다(P=0.01). 혈관재개통까지의 시간, 재개통 성공률, 또는 증상성 두개내출혈은 군간에 유의한 차이가 없었다. 다변량 분석은 80세 초과 임상 결과 및 사망률의 독립적인 예측 인자를 보여주었다. 80세 초과 코호트 내에서, NIHSS, 재개통 비율, 구조 치료(rescue therapy) 여부, 및 증상성 두개내 출혈은 사망의 독립적인 예측인자였다.

결론

80세 이상의 연령은 NASA 레지스트리에서 젊은 환자들에 비해 불량한 임상 결과 및 사망률 증가를 예측한다. 그러나, 정맥 조영 형 플러스미노겐 활성체의 사용, 낮은 NIHSS, 짧은 재관류 시간은 좋은 결과와 연관된다. 이 코호트에서 약물치료와 비교하여 혈관내 치료의 역할을 이해하기 위하여 추가적인 연구가 필요하다.

Table 3. Multivariate Analysis: Independent Predictors of Clinical Outcome and Mortality in the <80 and >80 Group

<table>
<thead>
<tr>
<th>Variable</th>
<th>N Parm</th>
<th>DF</th>
<th>χ²</th>
<th>P &gt; χ²</th>
<th>χ²</th>
<th>P &gt; χ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 80</td>
<td>1</td>
<td>1</td>
<td>7.97</td>
<td>0.005</td>
<td>5.63</td>
<td>0.018</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>1</td>
<td>0.17</td>
<td>0.68</td>
<td>0.011</td>
<td>0.92</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1</td>
<td>1</td>
<td>2.06</td>
<td>0.15</td>
<td>0.43</td>
<td>0.51</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>1</td>
<td>1</td>
<td>0.053</td>
<td>0.82</td>
<td>0.57</td>
<td>0.45</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>1</td>
<td>1</td>
<td>0.056</td>
<td>0.81</td>
<td>0.63</td>
<td>0.43</td>
</tr>
<tr>
<td>Smoking</td>
<td>1</td>
<td>1</td>
<td>0.036</td>
<td>0.85</td>
<td>0.88</td>
<td>0.35</td>
</tr>
<tr>
<td>CAD</td>
<td>1</td>
<td>1</td>
<td>0.0011</td>
<td>0.97</td>
<td>2.47</td>
<td>0.12</td>
</tr>
<tr>
<td>General anesthesia</td>
<td>1</td>
<td>1</td>
<td>9.38</td>
<td>0.002</td>
<td>3.92</td>
<td>0.048</td>
</tr>
<tr>
<td>IV-PA</td>
<td>1</td>
<td>1</td>
<td>0.027</td>
<td>0.87</td>
<td>0.38</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Table 4. Multivariate Analysis: Independent Predictors of Clinical Outcome in >80 Cohort

<table>
<thead>
<tr>
<th>Variable</th>
<th>N Parm</th>
<th>DF</th>
<th>χ²</th>
<th>P &gt; χ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIHSSi</td>
<td>1</td>
<td>1</td>
<td>4.10</td>
<td>0.04</td>
</tr>
<tr>
<td>Time to revascularization</td>
<td>1</td>
<td>1</td>
<td>5.65</td>
<td>0.02</td>
</tr>
<tr>
<td>Number of passes</td>
<td>1</td>
<td>1</td>
<td>1.48</td>
<td>0.22</td>
</tr>
<tr>
<td>Rescue therapy</td>
<td>1</td>
<td>1</td>
<td>2.35</td>
<td>0.13</td>
</tr>
<tr>
<td>TICI success (≥ 2B)</td>
<td>1</td>
<td>1</td>
<td>0.233</td>
<td>0.63</td>
</tr>
<tr>
<td>IV-PA</td>
<td>1</td>
<td>1</td>
<td>8.73</td>
<td>0.003</td>
</tr>
</tbody>
</table>

DF indicates degrees of freedom; IV-PA, intravenous tissue-type plasminogen activator; NIHSS, National Institutes of Health Stroke Scale initial; and TICI, Treatment in Cerebral Ischemia.

CAD indicates coronary artery disease; DF, degrees of freedom; and IA-PA, intra-arterial tissue-type plasminogen activator.