Clinical Outcome of Endovascular Coil Embolization For Cerebral Aneurysms In Asian Population In Relation To Risk Factors: A 3-Year Retrospective Analysis

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Research article

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Abstract

Background: This study reviews the impact of comorbidities on the success of endovascular coiling of both ruptured and unruptured intracranial aneurysms. Independent risk factors reviewed were age, sex, smoking and hypertension. Methods A 3-year retrospective analysis, performed to assess the clinical outcomes of patients with cerebral aneurysms treated endovascularly in Asian population. A total of 297 patients treated at a single center were included. Clinical outcomes were evaluated by regular follow-ups. A modified Rankin Scale was used to measure the clinical outcomes in patients. Results Study showed smoking had an adverse effect on clinical outcome, with smokers 35% less likely to recover, while hypertension played a minimal role with only 15%. It was found that aneurysms are more prevalent in women but women have a better chance of recovery. Men in their 20s and 30s have the best recovery, with comorbidities playing a negligible role. Similarly, patients who were above 40 had a lower chance of recovery compared to younger patients due to comorbidities irrespective of gender. Conclusions: Asian sub-continent has different genetic marker that lead to poorer outcomes of aneurysms in women, while outcomes are similar in men and women in developed nations. Smoking does not play a major role in women’s recovery. Men with comorbidity of smoking and hypertension were seen to be at higher risk and age played a major role in recovery.

Background

Subarachnoid hemorrhage secondary to ruptured intracranial aneurysms is a life threatening condition with an incidence rate of 6-7 per 100,000 people per year in most ethnic populations (1). Since the inception of endovascular embolization in 1991, direct coiling has become an established technique for the treatment of patients with both ruptured and unruptured intracranial aneurysms (2,3). In 2002, results of the International Subarachnoid Aneurysm Trial (1) demonstrated that there was better clinical outcome of EVT over surgical clipping of ruptured intracranial aneurysms (4). Since then EVT is gaining popularity and is becoming the standard treatment of intracranial aneurysms.

Coiling is performed on 90% patients suffering from aneurysms at our institution. Only a handful of studies have reported the short and midterm results of endovascular coiling but there are few long-term studies. 20% patients report a reopening of coiling on follow-up. (5) The angiographic results of coil occlusion can be classified into a complete near complete or incomplete using a modified Raymond classification scale. When the sac is occluded but the neck remnant remains, occlusion is near complete or subtotal. When an aneurysm has loose packing and there is partial opacification of the aneurysm sac, it is called incomplete occlusion. It is the physician’s discretion to make the distinction between small recurrences and full recanalization. A second treatment and high risk of rupture is seen as a consequence of coil complication due to high arterial blood flow or aneurysm growth. (6)

Smoking is known to increase the risk of SAH and brain infarction, when baseline characteristics of case and control patients was kept constant, smoking status directly and significantly correlated with the onset of the disease and established smoking as an independent risk factor in SAH (4). Smokers also
witness higher rates of thromboembolic events in aneurysms larger than 10 mm. Furthermore, the frequency of intraoperative rupture is also higher in smokers with middle cerebral artery aneurysms. This greatly impacts the need for patient care during endovascular treatment and negatively impacts long term recovery, however long-term recovery impact has not been measured (7).

The last comorbidity measured in this study is hypertension. Patients presenting with SAH who had high grades of HHG and IVH have been associated with poor outcomes with significant statistical significance. (8) This indicates the need for careful consideration when opting for aggressive therapy. However, when looking at elderly patients with UIA's the results of treatment were found to be consistent regardless of treatment modality and aggressive treatment can still be considered in UIA cases. It has been found that high grade HHG, increased age and intra-ventricular hematoma have poor clinical outcomes as compared to patients without these factors. In such cases it is recommended to place an external ventricular drainage prior to aneurysm securing intervention to improve short-term outcomes (8).

Other studies found that patient characteristics such as higher age, female gender have poor outcomes of SAH. (9,10) Primary risk factors are old age, female gender and smoking while hypertension plays a higher role in younger patients but does not have much impact in elderly patients. Literature shows no evidence of greater risk of rupture with an increase in age. This leaves a gap in available literature that can be filled by looking at the population of the Asian sub-continent over an extended period of time and grouping these various risk factors into a singular multivariate analysis.

**Methods**

**Patients data**

This study was approved by the hospitals ethical review board and institutional review board. Consent forms for all patients were obtained and in the case of a minor a guardian was asked to sign on their behalf. All patients with ruptured and unruptured intracranial aneurysms initially treated with endovascular coiling with or without remodeling technique between July, 2015 to August 2018 are included in this study. The information was obtained from a neurointerventional procedure log book maintained at the institute. The time period chosen allows an opportunity for retrospection of atleast 3 years of clinical and angiographic follow ups. Prior clipping was set as an exclusion criterion in the study. If multiple aneurysms were present, the ruptured aneurysm was determined from the distribution of subarachnoid hemorrhage and intraventricular blood. If the site of the hemorrhage could not identify the ruptured aneurysm, we treated all aneurysms in single session. Patients age, sex, the presence or absence of smoking and hypertension, number of aneurysms, whether or not it ruptured, the location of aneurysm and any recurrences were recorded. The recovery of patients was gauged clinically with the Modified Rankin scale and radiological outcome was measured through Raymond classification and both were also recorded for analysis.

**Acute Management Paradigm:**
During the time period of this study, the overall management strategy was endovascular coiling as the first treatment option, if feasible. Each case was discussed and consensus reached by members of neurointerventional team. Patients with large intracerebral hemorrhage associated with a ruptured aneurysm generally underwent emergency evacuation prior to coiling. Ruptured intracranial aneurysms were generally treated within 24 to 72 hours of rupture. In all endovascular treated aneurysms detachable coils were used with the goal of occluding as much as of aneurysm as possible in a safe manner. In case of aneurysms with wide necks or unfavorable shapes, we used assisted technique of double catheter, balloon or stent assisted coiling. After the completion of coil embolization, we divided the angiographic findings into three classes using the Modified Raymond Scale: complete occlusion, neck remnant and residual aneurysm.

Clinical Parameters and Long Term Follow Up:

Baseline clinical information was retrospectively abstracted from hospital charts and stratified. Computed tomography scans and digital subtraction angiograms were analyzed prior to deploying the first coil. Aneurysm sac diameter, neck width and dome to neck ratio was analyzed before prior coiling. The use of remodeling techniques (balloon or stent) were also decided on angiography. Clinical outcome was defined as a deterioration of >0 on the mRS and any deaths related to the treatment. Clinical outcome and neurological status were evaluated in detail during every outpatient visit as well as via follow-up over call.

Angiographic Analysis and Long Term Follow Up:

Angiographic follow up is not routinely done for clipped aneurysms, however, coiled aneurysms need follow up, but the recommendable length of follow up has not been established. Age of the patient, comorbidities, size and shape of the aneurysm, location, rupture status and occlusion grade were taken into account when deciding the follow up duration by Sprengers et.al (2008) (3) who suggested that adequately occluded aneurysms at six months after coiling do not need imaging follow up, except aneurysms that are partially thrombosed or larger than 15 mm. The standard operating procedure at our institution is having first follow up angiography (MRA) after 6 months, followed by another at 1 year and then serially for 3 years. In patients with incomplete initial aneurysm occlusion or reopening of the aneurysm over time, different intervals for angiographic follow up were chosen because additional treatment was considered in those patients. In other cases, if post coiling six months MRA showed some residual or recurrent neck, we have a fixed protocol that entails repeating the angiogram to confirm the findings of MRA.

Outcome Measures:

The outcome was assessed by an independent neurosurgeon and neurointerventionalist by using the modified Rankin Scale. The primary outcome measure was functional outcome at discharge and at first follow up after 15 days and then every 6 months until the end of 3-year period.
Methodology of Analysis:

IBM SPSS Version 25 was used for the analysis of data-set collected. A specialist statistician's services were acquired for the tabulation of data, the decision of analysis to be conducted and for the interpretation and analysis of data findings. Multi-variate auto-regressions were run keeping all factors in a single equation. Beta values of 1 and 0 were assigned to people with smoking and hypertension present or absent. Furthermore, smoking, hypertension, age group and sex were all individually tested against clinical outcomes. As well as conducting a chi-square test to see the results of various permutations such as age and hypertension, age and smoking, sex and age etc. Cronbach-Alpha, p and p² values were also determined to ratify the statistical significance of results. A linear regression equations was made and run to find the impact of factors on clinical outcomes and the equations can be seen as follows:

Clinical Outcome= Age + Sex + Hypertension + Smoking + Residual

Clinical outcomes were on the Modified Rankin Scale with rating from 0-6. 0 being perfect recovery and 6 being death. Age was divided into intervals of 10 years as follows <20 21-30 30-40 40-50 50<. Finally, sex, hypertension and smoking were kept as binary variables with sex being male or female and hypertension and smoking being present or absent. The entire raw-data set can be found in (Table 1) and is available online for cross checking and further analysis.

Results

The study had a near equal mix of males and females. With a ratio of 43:57 Male to Females. The average age of patients in the study was 42 with majority of patients falling in the age group of 40-50 years old. The standard deviation in age group was 1.09 meaning approximately 10 years. The average patient had a modified Rankin scale result of 1.2 with a standard deviation of 1.4. meaning that the overall outcome of patients who had coiling done was positive. Smoker to non-smoker ratio in the study was 24:76 meaning that for every 100 patients 24 were smokers. Hypertension on the other hand was highly prevalent with a ratio of 40:60 with every 60 out of 100 recorded patients having a history of hypertension.

When looking at the factors considered the value age group had a factor of 0.150 meaning that higher a patients age the less likely he was to fully recover from the aneurysm as age was broken into groups and higher age groups assigned a higher numerical value. Smoking played a much more critical role with a factor of 0.103 meaning that non-smokers had better recovery than smokers as non-smokers were assigned the numerical value of 0 while smokers had a value of 1. Hypertensions presence had a far more significant impact on recovery with a factor value of 0.457 meaning that those with hypertension were more than 45% more likely to have poorer outcomes. Lastly, the only factor considered in the study to have an inverse negative impact was gender having a factor value of -0.155 meaning that women simply due to their gender had poorer odds of recovery as compared to men.
Finally, when age and gender were fixed against the Rankin Scale and we used hypertension and smoking as covariates we were able to find very interesting patterns. For patients who had optimal recovery smoking played a negative factor of 0.77, hypertension a factor of -1.82 and the most impacted age group was that of patients in the age between 40-50 with a factor of -0.815. Gender was not seen to play a very impactful role when there was complete recovery however, when we reviewed patients who had a Rankin scale rating of 5, gender played a major role with a factor of 1.07 and age group not being very impactful with patients in the age between 30-50 being similarly impacted. Hypertension and smoking both played equally impactful roles with factors of 12 and 17 respectively.

**Statistical Analysis**

The $R^2$ value of the regression was 0.69 which means that the model was quite highly accurate given that this study utilized real world data from the only possible authority on the subject in the country. The ANOVA residual value factor was found to be quite high nearly 3 times as high as the regression values which leads us to believe that greater exploration into the subject matter is required and there are other factors that were not considered in this study and must be done so in order to find a more accurate interpretation of what factors contribute to patient recovery.

**Discussion**

Our institution started coil embolization almost 10 years back. In the early years of endovascular treatment coiling was mainly used for patients with high surgical risk. However, in the recent years coiling has been considered as mainstay treatment for intracranial aneurysm. Our aim was to examine all surviving patients initially treated with coiling for both ruptured and unruptured aneurysm with follow up MRA brain and to discover impact of comorbidities such as hypertension and smoking on a clinical outcome.

There is little information about comorbidities impact on patient’s outcome in long-term. To this end this study was carried out to see the impact of hypertension and smoking on clinical outcome of patients.

It has long been established that smoking is bad for health. However, it has been found that smoking is a factor that contributes to the rupture of aneurysms. Smoking is measured in packs per year; A pack-year is a unit for measuring the amount a person has smoked over a long period of time. The number of packs of cigarettes smoked per day multiplied by the number of years a person has smoked result in pack-years. (8)

They are usually preceded by migraine and excessive smoking. Hypertension does not however impact the probability of a rupture (9). The size of the aneurysm has also been seen in literature to contribute to aneurysm rupture and smokers who have necks larger than 4 mm are 20% more likely to have a thromboembolic event during endovascular coiling procedure.
Similarly, age also plays a role in thromboembolic events with patients above the age of 50 having higher likelihood of rupture (10). Similarly, age groups of patients when younger than 30 or older than 50 have an equal likelihood of poor recovery but patients between the ages of 30-50 have the best recovery rates. Our study was not focused on the rupturing of aneurysms but in fact the recovery and quality of recovery of patients after having an embolic event. We found that endovascular treatment of aneurysms has highly successful results and gender plays the most pivotal role in such cases.

Hypertension is another name for high blood pressure. It can lead to severe complications and increases the risk of heart disease, stroke, and death. Blood pressure is the force exerted by the blood against the walls of the blood vessels. The pressure depends on the work being done by the heart and the resistance of the blood vessels. It is considered to be one of the major risk factors for the development of intracranial aneurysm because pressure in aneurysm is directly proportional to systemic pressure. Incidence of hypertension in the international cooperative study of intracranial aneurysms was 21% (13). In our study this number was seen to be as high as 48% and they were known hypertensives at the time of presentation similar to finding by Lai and Manniven. (14).

Hypertension in elderly patients plays a huge role in their recovery from ruptured aneurysms, it was found by our study that hypertension and old age had a greatly negative impact on recovery after coiling and this is in concurrence with the findings of various available literature. That has shown that elderly patients with comorbidity of hypertension have statistically significant poorer outcomes and thus need to be treated more aggressively with greater post procedural care and regular follow ups (11).

Past studies showed that Europeans women over the age of 60 have excellent to good outcomes however our study showed the inverse to be true (10). Asian women are seen to have the poorest recovery and high morbidity rate when compared to various age groups and comorbidities. Another study found that men were independently associated with larger aneurysms and that height and size ratio played a great role in outcome and sex was not a risk factor for patients. Our study did not take into account size and height of aneurysm and perhaps this could be a factor that contributed to the larger residual value. While the study by Lin, Chen et.al showed that ruptured aneurysm were more common in men our study found that it was women who had higher rates of aneurysms (10). Similarly, the study showed that men and women showed similar recoveries when age was held constant again something that our results are in stark contradiction of. This leads us to believe that Asian populations especially the Asian sub-continent have different genetic marker that lead to greater prevalence of aneurysms in women, there is a generally lower life expectancy and weaker life strength of women in the Asian sub-continent and it is perhaps cultural factors that are the reason for poorer outcomes in women.

Conclusions

This study is the first of its kind ever conducted in Pakistan at the only center in the country that is dedicated to NeuroIntervention and has the facility for coiling procedures. Very few studies in general have been conducted on the Asian population in regards to aneurysms. We found that women in the sub-
continent have not only far higher frequency of aneurysms but also poorer outcomes. Poor recovery is compounded by the presence of comorbidity of hypertension. Smoking does not play a major role in women’s recovery. Men with comorbidity of smoking and hypertension were seen to be at higher risk and age played a major role in recovery. Men in their 20s and 30s saw the best recovery rates which is highly encouraging with hypertension and comorbidity only having a minor impact on their recovery. It was seen however that men who were 40+ in age had far more negative impacts of smoking and hypertension in their recovery and showed very poor results.

**Abbreviations**

**EVT:** Endo Vascular Therapy  
**HHG:** Hunt & Hess Grade  
**IVH:** Intra Ventricular Hemorrhage  
**MRA:** Magnetic Resonant Angiography  
**mRS:** Modified Rankin Scale  
**SAH:** Sub Arachnoid Hemorrhage  
**UIA:** Unruptured Intracranial Aneurysm

**Declarations**

- Ethics approval and consent to participate

Ethical approval was taken from the organizations ethical approval committee and all 300 patients whose data was collected signed consent forms. Parental and legal guardian consent was obtained on behalf of underage participants.  
- Consent to publish

The author gives complete consent to BioMed to publish this article  
- Availability of data and materials

All data was gathered at a single institution. The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request. For review by the peer reviewers.  
- Competing interests

N/A  
- Funding
Authors' Contributions

This paper was written completely by the primary author Dr. Saima Ahmad (SA) and no help was gotten from anyone else. We approve the final manuscript and give BMC NeuroScience all rights to publication of this scientific research work.

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**Tables**

**Table 1: Patient Demographics, Co-Morbidities, Aneurysms location and Clinical outcome data**
| Age  | Gender | Smoking | Hypertension | Aneurysm Location | Outcome m RS |
|------|--------|---------|--------------|-------------------|-------------|
| 45y  | F      | N       | Y            | MCA               | 1           |
| 75y  | F      | N       | Y            | MCA               | 1           |
| 26Y  | F      | N       | N            | MCA               | 2           |
| 35Y  | F      | N       | Y            | MCA               | 2           |
| 50Y  | M      | Y       | Y            | MCA               | 2           |
| 32Y  | F      | N       | N            | MCA               | 1           |
| 50Y  | M      | Y       | Y            | MCA               | 1           |
| 52Y  | M      | N       | N            | ACOA              | 0           |
| 52Y  | M      | N       | Y            | ACOA              | 0           |
| 37Y  | M      | Y       | N            | ACOA              | 0           |
| 45y  | F      | N       | Y            | ACOA              | 1           |
| 60Y  | M      | Y       | Y            | ACOA              | 4           |
| 45Y  | M      | N       | N            | ACOA              | 0           |
| 25Y  | F      | N       | Y            | ICA               | 0           |
| 26Y  | M      | N       | N            | ICA               | 1           |
| 65Y  | F      | N       | Y            | ICA               | 2           |
| 25Y  | F      | N       | N            | ICA               | 1           |
| 35Y  | M      | Y       | Y            | ACOA + MCA        | 1           |
| 45Y  | F      | N       | Y            | MCA               | 6           |
| 39Y  | F      | N       | Y            | MCA + ICA         | 2           |
| 55Y  | F      | N       | Y            | PCOA              | 1           |
| 65Y  | F      | N       | Y            | PCOA              | 5           |
| 50y  | F      | N       | Y            | PCOA              | 1           |
| 23Y  | F      | N       | N            | PCOA              | 0           |
| 60Y  | F      | N       | Y            | PCOA              | 4           |
| 45Y  | F      | N       | Y            | PCA               | 2           |
| 25Y  | F      | N       | N            | PCA               | 0           |
| 45Y  | F      | N       | Y            | PCA               | 1           |
| 50Y  | F      | N       | Y            | ACOA              | 1           |
| 60Y  | F      | N       | Y            | AOAC              | 5           |
| 48Y  | F      | N       | Y            | ACOA              | 6           |
| 33Y  | F      | N       | Y            | ACOA              | 0           |
| 35Y  | F      | N       | Y            | ACOA              | 0           |
| 55Y  | F      | N       | Y            | ACOA              | 1           |
| 45Y  | F      | N       | Y            | ACoA              | 1           |
| 35Y  | F      | N       | Y            | ACOA              | 1           |
| 60Y  | M      | N       | Y            | ACOA + MCA        | 5           |
| Age | Sex | Status | AOA/Other |
|-----|-----|--------|-----------|
| 60Y | F   | N      | Y         | ACOA      | 1         |
| 15Y | F   | N      | N         | ACOA      | 1         |
| 53Y | F   | N      | Y         | ACOA      | 2         |
| 56Y | M   | Y      | Y         | ACOA      | 1         |
| 40Y | F   | N      | N         | ACOA      | 1         |
| 55Y | F   | N      | N         | ACOA      | 2         |
| 40Y | F   | N      | Y         | ACOA      | 6         |
| 48Y | F   | N      | Y         | MCA       | 2         |
| 14Y | M   | N      | N         | MCA       | 3         |
| 32Y | M   | Y      | Y         | MCA       | 2         |
| 50Y | F   | N      | Y         | MCA       | 1         |
| 50Y | M   | Y      | Y         | MCA       | 1         |
| 76Y | F   | N      | N         | ICA       | 3         |
| 48Y | M   | N      | Y         | ACOA      | 1         |
| 40Y | M   | Y      | Y         | ICA       | 2         |
| 52Y | F   | N      | Y         | ICA       | 1         |
| 65Y | F   | N      | Y         | ICA       | 1         |
| 45Y | F   | N      | Y         | ICA       | 2         |
| 62Y | M   | Y      | Y         | ICA       | 2         |
| 60Y | M   | Y      | Y         | ACOA      | 3         |
| 55Y | F   | N      | Y         | ACOA      | 0         |
| 24Y | F   | N      | N         | ACOA      | 3         |
| 58Y | F   | N      | Y         | ACOA      | 0         |
| 35Y | F   | N      | Y         | ACOA      | 2         |
| 33Y | F   | N      | Y         | ACOA      | 0         |
| 48Y | F   | N      | Y         | ACOA      | 6         |
| 68Y | F   | N      | Y         | ACOA      | 0         |
| 45Y | M   | Y      | Y         | ACOA      | 1         |
| 79Y | M   | Y      | Y         | ACOA      | 2         |
| 25Y | F   | N      | Y         | DACA      | 0         |
| 40Y | F   | N      | Y         | BA        | 3         |
| 31Y | F   | N      | N         | PCA       | 0         |
| 45Y | M   | N      | Y         | ACOA      | 1         |
| 40Y | M   | N      | Y         | PCA       | 0         |
| 45Y | M   | Y      | Y         | ACOA      | 0         |
| 55Y | F   | N      | Y         | ACOA      | 0         |
| 53Y | M   | Y      | Y         | ACOA      | 2         |
| 65Y | F   | N      | N         | ACOA      | 1         |
| Age | Gender | Symptom | Location | Side | Score |
|-----|--------|---------|----------|------|-------|
| 50Y | M      | Y       | MCA      |      | 1     |
| 50Y | F      | N       | B/L ICA  |      | 0     |
| 40Y | F      | N       | ICA      |      | 0     |
| 50Y | F      | N       | ICA      |      | 0     |
| 33Y | F      | N       | MCA      |      | 0     |
| 70Y | F      | N       | ICA      |      | 2     |
| 82Y | F      | N       | PCOA     |      | 2     |
| 59Y | M      | Y       | ICA      |      | 3     |
| 40Y | M      | Y       | ACOA     |      | 6     |
| 28Y | M      | Y       | MCA      |      | 0     |
| 30Y | M      | N       | ACOA     |      | 3     |
| 40Y | F      | N       | ACOA     |      | 2     |
| 74y | M      | N       | PCOA     |      | 2     |
| 60Y | M      | Y       | ACOA     |      | 1     |
| 50Y | M      | Y       | MCA      |      | 1     |
| 62Y | F      | N       | MCA      |      | 6     |
| 30Y | F      | N       | ACOA     |      | 0     |
| 52Y | F      | N       | ICA      |      | 1     |
| 50Y | M      | Y       | PCA      |      | 1     |
| 42Y | M      | Y       | MCA      |      | 2     |
| 20Y | M      | N       | PCA      |      | 0     |
| 45Y | F      | N       | ICA      |      | 0     |
| 55Y | F      | N       | ICA      |      | 1     |
| 50Y | F      | N       | ICA      |      | 2     |
| 53Y | M      | Y       | ACOA     |      | 2     |
| 32Y | F      | N       | PCA      |      | 1     |
| 33Y | M      | N       | ACOA     |      | 0     |
| 55Y | M      | Y       | MCA      |      | 1     |
| 35Y | M      | Y       | MCA      |      | 0     |
| 42Y | F      | N       | ACOA     |      | 0     |
| 40Y | F      | N       | ACOA     |      | 0     |
| 13Y | M      | N       | ICA      |      | 0     |
| 62Y | F      | N       | PCOA     |      | 2     |
| 72Y | F      | N       | PCOA     |      | 2     |
| 50Y | F      | N       | MCA      |      | 2     |
| 49Y | M      | Y       | ACOA     |      | 1     |
| 60Y | M      | Y       | BA       |      | 6     |
| 14Y | M      | N       | MCA      |      | 1     |
| Age | Sex | Race | SubSTANCE | ACOA | Score |
|-----|-----|------|-----------|------|-------|
| 50Y | F   | N    | Y         | ACOA | 2     |
| 58Y | M   | Y    | Y         | ACOA | 1     |
| 52Y | M   | Y    | N         | ACOA | 2     |
| 37Y | F   | N    | N         | MCA  | 1     |
| 42Y | M   | N    | N         | PCA  | 2     |
| 44Y | F   | N    | N         | ACOA | 0     |
| 35Y | F   | N    | N         | PCA  | 0     |
| 50Y | F   | N    | Y         | ICA  | 1     |
| 40Y | F   | N    | N         | BA   | 0     |
| 56Y | M   | Y    | Y         | ACOA | 1     |
| 61Y | M   | N    | Y         | MCA  | 2     |
| 55Y | F   | N    | Y         | ACOA | 1     |
| 28Y | M   | N    | N         | ACOA | 0     |
| 72Y | M   | Y    | Y         | PCOA | 1     |
| 45Y | M   | N    | Y         | ACOA | 2     |
| 44Y | M   | Y    | Y         | MCA  | 0     |
| 45Y | F   | N    | N         | ACOA | 1     |
| 65Y | M   | N    | Y         | ACOA | 1     |
| 65Y | M   | N    | Y         | MCA  | 6     |
| 45Y | M   | Y    | Y         | ACOA | 3     |
| 45Y | M   | Y    | N         | ACOA | 1     |
| 47Y | M   | Y    | Y         | ICA  | 0     |
| 60Y | M   | Y    | Y         | PCOA | 0     |
| 60Y | F   | N    | Y         | PCOA | 1     |
| 42Y | F   | N    | N         | PICA | 0     |
| 53Y | M   | N    | Y         | MCA  | 0     |
| 50Y | M   | Y    | Y         | MCA  | 2     |
| 40Y | F   | N    | N         | ACOA | 1     |
| 40Y | F   | N    | N         | ACOA | 0     |
| 60Y | F   | N    | Y         | ACOA | 2     |
| 40Y | M   | Y    | N         | ACOA | 0     |
| 40Y | F   | N    | Y         | MCA  | 1     |
| 55Y | F   | N    | Y         | ACOA | 0     |
| 55Y | F   | N    | Y         | ICA  | 2     |
| 35Y | M   | Y    | N         | ACOA | 0     |
| 46Y | F   | N    | Y         | ICA  | 2     |
| 65Y | F   | N    | Y         | PCOA | 1     |
| 15Y | F   | N    | N         | DACA | 0     |
| Age | Gender | SMR | ADR | CA  | Subtype | ICD Code |
|-----|--------|-----|-----|-----|----------|----------|
| 38Y | F      | N   | N   | ACOA| 0        |          |
| 54Y | M      | N   | Y   | BA  | 2        |          |
| 32Y | F      | N   | N   | ACOA| 0        |          |
| 55Y | F      | N   | Y   | ICA | 0        |          |
| 45Y | M      | Y   | N   | PCOA| 2        |          |
| 54Y | M      | Y   | Y   | MCA | 1        |          |
| 56Y | M      | Y   | Y   | ACOA| 0        |          |
| 65Y | M      | N   | N   | ACOA| 0        |          |
| 26Y | M      | N   | N   | PCOA| 1        |          |
| 35Y | M      | N   | N   | BA  | 0        |          |
| 57Y | M      | Y   | Y   | ICA | 0        |          |
| 25Y | F      | N   | N   | ACOA| 0        |          |
| 50Y | F      | N   | N   | MCA | 3        |          |
| 52Y | F      | N   | Y   | ACOA| 1        |          |
| 30Y | M      | N   | N   | MCA | 0        |          |
| 45Y | F      | N   | Y   | ICA , PCOA| 0|          |
| 63Y | F      | N   | Y   | ICA | 1        |          |
| 40Y | F      | N   | N   | MCA | 2        |          |
| 45Y | F      | N   | N   | ACOA| 0        |          |
| 55Y | F      | N   | Y   | MCA | 3        |          |
| 40Y | M      | N   | Y   | PCA | 0        |          |
| 33Y | F      | N   | N   | ACOA| 0        |          |
| 35Y | F      | N   | N   | PCOA| 1        |          |
| 14Y | F      | N   | N   | ICA | 0        |          |
| 40Y | F      | N   | N   | ICA | 1        |          |
| 24Y | M      | N   | N   | ICA | 6        |          |
| 60Y | M      | N   | Y   | ICA (M) | 0|          |
| 55Y | F      | N   | Y   | ACOA| 1        |          |
| 50Y | F      | N   | Y   | ACOA| 1        |          |
| 73Y | M      | Y   | Y   | MCA | 6        |          |
| 50Y | M      | Y   | Y   | ACOA| 1        |          |
| 35Y | F      | N   | N   | PCOA| 0        |          |
| 35Y | F      | N   | N   | AICA| 0        |          |
| 40Y | F      | N   | N   | MCA | 3        |          |
| 60Y | M      | N   | Y   | ACOA| 2        |          |
| 60Y | M      | Y   | Y   | ACOA| 1        |          |
| 40Y | M      | Y   | N   | MCA | 0        |          |
| 60Y | F      | N   | Y   | PCOA| 2        |          |
| Age | Sex | Race | Stroke Site | Diagnosis | Severity |
|-----|-----|------|-------------|-----------|----------|
| 50Y | F   | N    | Y           | ICA       | 2        |
| 40Y | F   | N    | N           | ACOA      | 1        |
| 45Y | F   | N    | N           | ACOA      | 1        |
| 47Y | F   | N    | Y           | ICA       | 0        |
| 13Y | F   | N    | N           | ICA       | 0        |
| 60Y | F   | N    | Y           | PCOA      | 1        |
| 45Y | M   | Y    | N           | BA        | 2        |
| 70Y | F   | N    | Y           | ACOA      | 3        |
| 64Y | F   | N    | Y           | MCA       | 2        |
| 55Y | M   | N    | N           | ACOA      | 0        |
| 45Y | F   | N    | N           | ICA       | 0        |
| 45y | F   | N    | N           | ACOA      | 1        |
| 60Y | F   | N    | Y           | PCOA      | 1        |
| 45Y | F   | N    | N           | ICA       | 0        |
| 50Y | F   | N    | Y           | distal MCA| 2        |
| 30Y | F   | N    | N           | MCA       | 0        |
| 23Y | F   | N    | N           | ICA       | 0        |
| 40Y | M   | N    | N           | ACOA      | 1        |
| 40Y | M   | N    | Y           | MCA       | 1        |
| 50Y | M   | N    | Y           | ACOA      | 1        |
| 31Y | M   | N    | N           | ACOA      | 0        |
| 60Y | F   | N    | Y           | BA        | 2        |
| 45Y | F   | N    | N           | ACOA      | 1        |
| 46Y | F   | N    | N           | MCA       | 0        |
| 36Y | F   | N    | N           | ACOA      | 0        |
| 40Y | M   | Y    | N           | MCA       | 1        |
| 30Y | F   | N    | N           | ACOA      | 0        |
| 60Y | F   | N    | Y           | ICA       | 1        |
| 60Y | F   | N    | Y           | PCOA      | 1        |
| 60Y | M   | Y    | Y           | DACA      | 1        |
| 36Y | M   | N    | N           | ACOA      | 0        |
| 35Y | F   | N    | Y           | ACOA      | 0        |
| 50Y | F   | N    | Y           | ICA       | 0        |
| 50Y | M   | Y    | Y           | BA        | 2        |
| 39Y | F   | N    | N           | ACOA      | 0        |
| 38Y | F   | N    | N           | DACA      | 0        |
| 50Y | M   | Y    | Y           | ACOA      | 2        |
| 35Y | M   | N    | N           | ACOA      | 1        |
| Age | Sex | History | Diagnosis | Yrs |
|-----|-----|---------|-----------|-----|
| 40Y | M   | Y       | MCA       | 6   |
| 60Y | F   | N       | MCA       | 4   |
| 50Y | F   | N       | ACOA      | 2   |
| 62Y | M   | Y       | PCOA      | 1   |
| 28Y | M   | Y       | ACOA      | 0   |
| 45Y | M   | Y       | MCA       | 1   |
| 33Y | F   | N       | PCA       | 1   |
| 65Y | M   | Y       | ACOA      | 2   |
| 48Y | F   | N       | DACA      | 0   |
| 32Y | F   | N       | MCA       | 1   |
| 45Y | M   | Y       | ACOA      | 0   |
| 46Y | M   | Y       | ACOA      | 1   |
| 45Y | F   | N       | ICA       | 0   |
| 70Y | F   | N       | ICA       | 0   |
| 48Y | M   | Y       | ACOA      | 2   |
| 40Y | M   | N       | ACOA      | 1   |
| 30Y | M   | N       | ICA       | 2   |
| 30Y | M   | N       | ACOA      | 0   |
| 42Y | M   | N       | ACOA      | 1   |
| 28Y | F   | N       | PCOA      | 1   |
| 57Y | M   | Y       | ACOA      | 1   |
| 45Y | M   | Y       | PICA      | 2   |
| 45Y | M   | N       | MCA       | 1   |
| 42Y | F   | N       | ACOA      | 1   |
| 30Y | M   | Y       | ACOA      | 2   |
| 51Y | M   | N       | PCOA      | 1   |
| 32Y | M   | N       | PCA       | 2   |
| 37Y | M   | N       | MCA       | 2   |
| 62Y | F   | N       | MCA       | 3   |
| 42Y | M   | Y       | ACOA      | 0   |
| 60Y | F   | N       | ACOA      | 0   |
| 34Y | M   | Y       | ACOA      | 0   |
| 55Y | M   | Y       | ICA       | 0   |
| 65Y | M   | N       | PCOA      | 2   |
| 26Y | M   | N       | PCA       | 1   |
| 40Y | M   | N       | ACOA,MCA  | 1   |
| 38Y | M   | Y       | ACOA      | 1   |
| 40Y | F   | N       | PCOA      | 1   |
|   |   |   |   |   |   |
|---|---|---|---|---|---|
| 40Y | M | Y | N | BA | 4 |
| 42Y | F | N | N | ACOA | 2 |
| 30Y | F | N | N | ACOA | 0 |
| 52Y | F | N | Y | MCA | 1 |
| 20Y | M | Y | N | ACOA | 0 |
| 54Y | F | N | Y | ACOA | 0 |
| 10Y | F | N | N | ICA | 0 |
| 51Y | F | N | Y | ACOA | 1 |
| 40Y | M | N | Y | ACOA | 1 |
| 40Y | F | N | N | ICA | 0 |
| 58Y | F | N | Y | ACOA | 1 |
| 55Y | F | N | Y | ICA | 2 |
| 50Y | F | N | Y | PCOA | 2 |
| 45Y | F | N | N | ACOA | 0 |
| 50Y | F | N | Y | ICA | 0 |
| 50Y | F | N | Y | MCA | 2 |
| 65Y | F | N | Y | MCA | 1 |
| 60Y | F | N | Y | ICA | 0 |
| 60Y | F | N | Y | ICA | 0 |
| 27Y | F | N | N | B/L MCA | 2 |
| 55Y | F | N | Y | BA | 2 |
| 50Y | F | N | Y | MCA | 0 |
| 30Y | M | Y | N | MCA | 1 |
| 45Y | F | N | N | BA | 0 |
| 65Y | M | Y | Y | ICA | 0 |
| 35Y | F | N | N | ACOA | 0 |
| 43Y | M | N | N | MCA | 1 |
| 35Y | M | N | N | BA | 0 |
| 50Y | F | N | N | MCA | 2 |
| 20Y | M | N | N | ACOA | 0 |
| 25Y | F | N | N | MCA | 3 |
| 26Y | M | N | Y | MCA | 0 |