Intracerebral Hemorrhage in a Young Urban Population: Etiologies and Outcomes in Patients 50 and Younger

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Goal: There is limited research on intracerebral hemorrhage in young urban populations. There is reduced access to healthcare and a high prevalence of multiple comorbidities in this vulnerable population. We studied the etiologies and outcomes of spontaneous intracerebral hemorrhage in an urban North Philadelphia cohort aged 50 years old and younger. *Materials and methods:* A retrospective chart review of subjects 50 years old and younger who presented with spontaneous intracerebral hemorrhage at Temple University Hospital was conducted. A novel scoring system was used to classify the cause of each intracerebral hemorrhage. This system was used to assign a degree of likelihood that hypertension, amyloid angiopathy, tumor, oral anticoagulants, vascular malformations, infrequent causes, or cryptogenic etiologies were present. Aneurysmal subarachnoid hemorrhage was excluded. The prevalence of each risk factor and outcomes were analyzed. *Findings:* Of the 110 patients in the study, the most common etiology was hypertension (82.7%). There was no statistically significant difference in mortality between patients with multiple possible etiologies for their hemorrhage. Vascular malformations and cavernomas were rare (5.5%). *Conclusions:* Hypertension was the most common cause of intracerebral hemorrhage in a young urban population. The presence of multiple possible etiologies does not correlate with a worse prognosis of mortality. There is a need for further research into hemorrhagic stroke in young populations.
Key Words: Hemorrhage—stroke—stroke in young populations—populations at risk for stroke—intracerebral hemorrhage

Introduction

Intracerebral hemorrhage (ICH) makes up between 10% and 20% of all strokes and often has a poorer prognosis than an ischemic stroke. In a review by Ikram et al, there was a 40% fatality rate at 1-month posthemorrhage. They also found that there was a 10-fold increase in ICH risk in people aged 85 and older compared to those aged 45-54.[1] While the rate of ICH increases with age, there are also cases of ICH in younger patients, and there have not been many studies investigating the etiologies of ICH in this population group. Sandoval et al described a wide range of risk factors in a study of patients under 40 with ICH with vascular malformation and hypertension being the most common.[2] At the time this study was done there was no unifying classification system for ICH. Since then, 2 novel systems have been created, structural lesions, medications, amyloid angiopathy, systemic/other diseases, hypertension, and undetermined causes (SMASH-U) and hypertension, amyloid angiopathy, tumor, oral anticoagulants, malformations, infrequent causes, cryptogenic (H-ATOMIC).[3,4] The main issue with the first system is that it is difficult to address ICH due to

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multiple causes. This was accounted for with the H-ATOMIC classification system, where etiologies were scored definite, probable, and possible. The H-ATOMIC classification system, while currently not extensively studied, allows for standardization in studying ICH causes.

There has been no study to examine ICHs in young patients specific to a large urban North American population. A recent literature review has been done citing previous studies of ICH in young patients. Within this review, there were two studies cited that were done in the United States, in Iowa and Vermont.[5] While these studies provide valuable data, we would like to examine patients in a large urban setting. In addition, the SMASH-U scale was used and we would like to apply the H-ATOMIC scale due to the previously mentioned reasons. Studying a large urban population is important because risk factors and outcomes for ICH can vary by population. There are many different aspects that contribute to this ranging from access to healthcare, poverty, and diet. Preventive measures and treatments vary by population and it is important to study risk factors and ICH etiologies in individual populations. In North Philadelphia where Temple University Hospital is located, zip code 19140, the median household income is $21,272 and many residents live below the poverty line.[6] In a study conducted by Virginia Commonwealth University, the life expectancy was compared between this region and the wealthiest zip code in Philadelphia, showing a discrepancy; 72 years, compared to 88 years in the latter.[7] It is clear that in North Philadelphia, people get sicker at a younger age and it is vital to examine the specific causes more closely. It is important to further classify ICH risk factors specific to this population so that preventative measures and treatments can be tailored to the needs of this vulnerable population. Such research can also lay the foundations for studying populations with similar demographics across the country to see if such preventative measures can be expanded to other locations.

We propose a retrospective chart review using the H-ATOMIC classification system to study the etiologies of ICH in patients 50 and younger in a North Philadelphia population. Given the prevalence of poverty and decreased life expectancy, we expect there to be a larger presence of stroke risk factors. We hope that this chart review will highlight the most common risk factors. In doing so, preventative measures and even therapies could be more closely designed to fit the needs of this population. In addition, we will determine the severity and prognosis of each ICH event using the ICH, New ICH, Modified ICH, and Secondary ICH scores, all of which have been shown to correlate with prognosis in ICH.[8,9] We hope to gain a better understanding of ICH in patients aged 50 and younger and bring to the forefront a topic not thoroughly studied.

Materials and Methods

A retrospective chart review of patients aged 50 years and younger presenting with ICH at Temple University Hospital was performed. Patients were selected from the Temple Get with the Guidelines (GWTG) stroke database, which documented all patients who presented to the hospital with ICH between December 28, 2010 and September 19, 2018. Patients who were 51 years or older at the time of presentation to the hospital were excluded from the study. On initial review of the GWTG database, 117 hemorrhage cases fit the age criteria. Of these cases, 1 was excluded due to a duplicate record in the database. Three patients were excluded because even though the diagnosis listed in the database was ICH, their initial computed tomography scan showed no acute hemorrhage and no further testing suggested otherwise. This was confirmed through further review of their medical records. Of the 113 remaining cases, there was a patient with 3 repeat ICH's listed in the database. From 113 eligible cases, 110

Table 1. *Baseline categorical characteristics and stroke outcomes by hypertension/H-ATOMIC subgroups*

Variable (# missing)	*Total*	*No H*	*H1*	*H2 or H3*	*Any H*
Overall	110	19 (17.3%)	40 (36.4%)	51 (46.4%)	91 (82.7%)
Sex					
F	41 (37.3%)	5 (26.3%)	12 (30.0%)	24 (47.1%)	36 (39.6%)
M	69 (62.7%)	14 (73.7%)	28 (70.0%)	27 (52.9%)	55 (60.4%)
Race					
Black	52 (47.3%)	6 (31.6%)	23 (57.5%)	23 (45.1%)	46 (50.5%)
Other	18 (16.4%)	4 (21.1%)	5 (12.5%)	9 (17.6%)	14 (15.4%)
White	40 (36.4%)	9 (47.4%)	12 (30.0%)	19 (37.3%)	31 (34.1%)
Smoking history (8)					
Current use	29 (28.4%)	4 (25.0%)	11 (28.2%)	14 (29.8%)	25 (29.1%)
No previous use	60 (58.8%)	9 (56.3%)	21 (53.8%)	30 (63.8%)	51 (59.3%)
Previous use	13 (12.7%)	3 (18.8%)	7 (17.9%)	3 (6.4%)	10 (11.6%)

Abbreviations: Angio, angiography; CTA/CTV, CT angiography/venography; MRA/MRV, magnetic resonance angiography/venography; Patient Alive, patient alive at time of hospital discharge.

Table entry, N(%).

Table 2. *Association between categorical baseline characteristics of interest and hypertension/H-ATOMIC subgroups*

Variable (# missing)	*Total*†	*No H*†	*H1*†	*H2 or H3*†	*P value**	*Any H*†	*Raw odds ratio of any H (95% CI)*	*P value**
Overall	110	19 (17.3%)	40 (36.4%)	51 (46.4%)		91 (82.7%)	-	
Angio					**0.026**			**0.065**
Done	14 (12.7%)	5 (26.3%)	1 (2.5%)	8 (15.7%)		9 (9.9%)	Reference	
Not done	96 (87.3%)	14 (73.7%)	39 (97.5%)	43 (84.3%)		82 (90.1%)	3.25 (0.95, 11.15)	
Patient Alive					0.24			0.35
No	23 (20.9%)	2 (10.5%)	7 (17.5%)	14 (27.5%)		21 (23.1%)	2.55 (0.54, 11.94)	
Yes	87 (79.1%)	17 (89.5%)	33 (82.5%)	37 (72.5%)		70 (76.9%)	Reference	
MRA MRV CTA CTV					**0.0005**			**0.0004**
Done	22 (20.0%)	10 (52.6%)	5 (12.5%)	7 (13.7%)		12 (13.2%)	Reference	
Not done	88 (80.0%)	9 (47.4%)	35 (87.5%)	44 (86.3%)		79 (86.8%)	7.31 (2.47, 21.67)	

Abbreviations: Angio, angiography; CTA/CTV, CT angiography/venography; MRA/MRV, magnetic resonance angiography/venography; Patient Alive, patient alive at time of hospital discharge.
P value of less than .05 are significant.
†Table entry = n (%).
*Chi-square for comparing 3 groups, Fisher's exact for comparing 2 groups.

cases were included in the study to avoid repeats, for a total of 110 patients. Five patients in the study had a previous ICH that either occurred before the creation of the GWTG database or occurred at an outside hospital. These hemorrhages were not recorded in the GWTG database. The study was reviewed and approved by the Temple University Institutional Review Board. A de-identified database was created using age, race, sex, and stroke risk factors. Based on this information, each ICH was given a score based on the H-ATOMIC classification system. The baseline demographics, infarct volumes, presence of stroke risk factors, and H-ATOMIC scores were included in the study. Infarct volumes were calculated from noncontrast computed tomography scans using the National Institute of Health Medical Image Processing, Analysis, and Visualization application.[10] Outcomes were measured using prognostic indicators such as infarct volume, Glasgow Coma Scale (GCS), National Institute of Health Stroke Scale (NIHSS), and ICH score.

The H-ATOMIC Classification System

In 2016, Martí-Fàbregas et al devised a novel classification system for ICHs which was comprised of 7 categories; hypertension, amyloid angiopathy, tumor, oral anticoagulants, malformations, infrequent causes, and cryptogenic. The modified Boston criteria were used to determine the presence of cerebral angiopathy. In all cases of cerebral amyloid angiopathy (CAA), each patient had to be 55 years of age or older.[11] Given that our study restricted patients to ages 50 and younger, the A category representing amyloid angiopathy was not used. Each variable was assigned a score of 0, 1, 2, or 3, reflecting the degree of certainty of the variable being involved in the cause of the hemorrhage. This classification system achieved the ability to have more than 1 possible cause of ICH. A score of 1 meant that the etiology was the definitive cause of the hemorrhage and that no other category could receive any score. If a score of 1 was given to a certain category, all other categories received a score of 0. A score of 2 meant that the variable was probably one of the causes of the hemorrhage and a score of 3 meant that the variable was possibly involved in causing the ICH. Each variable was required to be given a score of 1, 2, or 3, unless another variable was given a score of 1. The requirements needed to achieve a 1, 2, or 3 in each category were described in detail in the original H-ATOMIC article. We used this classification system to identify degrees of certainty as to the cause of ICH in each of the patients in the study.

Statistical Analysis

Data were expressed as frequencies and percentages for categorical variables and mean ± standard deviation (or median (range or quartile range)) for continuous variables. Associations between potential risk factors of interest and H-ATOMIC Classifications for hemorrhage were evaluated using the Fisher's exact test for 2 groups or a

Table 3. *Association between continuous baseline characteristics and outcomes of interest and hypertension/H-ATOMIC subgroups*

Variable (# missing)	*Total*† (*n = 110*)	*No H*† (*n = 19*)	*H1*† (*n = 40*)	*H2 or H3*† (*n = 51*)	*P value**	*Any H*† (*n = 91*)	*Increment for OR*	*Raw odds ratio of any H (95% CI)*	*P value**
Age at hemorrhage	45.0 (18.0-50.0)	37.0 (19.0-50.0)	46.5 (30.0-50.0)	47.0 (18.0-50.0)	<**.0001**	47.0 (18.0-50.0)	4.0	2.04 (1.48, 2.80)	<**.0001**
BMI (1)	26.5 (13.8-62.1)	27.5 (18.2-50.5)	27.5 (17.4-51.9)	25.2 (13.8-62.1)	0.25	26.4 (13.8-62.1)	5.0	0.91 (0.69, 1.20)	0.58
Admission systolic blood pressure	172.0 (80.0-290.0)	122.0 (83.0-198.0)	194.0 (140.0-290.0)	162.0 (80.0-290.0)	<**.0001**	179.0 (80.0-290.0)	28.0	7.99 (3.09, 20.67)	<**.0001**
Admission diastolic blood pressure	102.5 (51.0-180.0)	73.0 (52.0-97.0)	116.0 (77.0-176.0)	100.0 (51.0-180.0)	<**.0001**	108.0 (51.0-180.0)	18.0	8.46 (3.23, 22.17)	<**.0001**
Hemorrhage volume (2)	11.9 (0.1-105.5)	9.7 (0.4-75.8)	11.0 (0.1-95.4)	19.8 (0.1-105.5)	0.32	12.1 (0.1-105.5)	19.0	1.37	
(0.87,2.16)	0.15								
Glasgow Coma Scale	14.0 (3.0-15.0)	15.0 (3.0-15.0)	15.0 (3.0-15.0)	13.0 (3.0-15.0)	**0.050**	14.0 (3.0-15.0)	5.0	0.66 (0.37, 1.18)	0.12
NIH Stroke Scale (29)	9.0 (0.0-42.0)	2.0 (0.0-38.0)	11.0 (0.0-38.0)	10.0 (0.0-42.0)	**0.059**	10.0 (0.0-42.0)	10.0	2.22 (0.91, 5.42)	**0.020**
ICH score (2)	1.0 (0.0-5.0)	1.0 (0.0-4.0)	1.0 (0.0-4.0)	2.0 (0.0-5.0)	0.12	1.0 (0.0-5.0)	2.0	1.66 (0.75, 3.66)	0.19
Modified ICH score	2.0 (1.0-5.0)	2.0 (1.0-5.0)	2.0 (1.0-4.0)	2.0 (1.0-5.0)	0.36	2.0 (1.0-5.0)	1.0	1.07 (0.70, 1.62)	0.69
Secondary ICH score	2.0 (1.0-6.0)	4.0 (2.0-6.0)	2.0 (1.0-4.0)	2.0 (1.0-5.0)	<**.0001**	2.0 (1.0-5.0)	1.0	0.29 (0.17, 0.49)	<**.0001**
New ICH score (28)	2.0 (1.0-6.0)	2.0 (1.0-4.0)	2.0 (1.0-6.0)	3.0 (1.0-5.0)	0.67	3.0 (1.0-6.0)	1.0	1.31 (0.75, 2.28)	0.44

Abbreviations: BMI, body mass index; ICH, intracerebral hemorrhage; NIH,national institute of health.

Age at hemorrhage in years, BMI in kilograms/meter squared, hemorrhage volume in centimeters cubed, all stroke scales and scores have no units.

P value of less than .05 are significant.

*Kruskal-Wallis test for comparing 3 groups, Wilcoxon test for comparing 2 groups.

chi-square test for 3 groups for a categorical factor or Wilcoxon (for 2 groups) or Kruskal-Wallis test (for 3 groups) for a continuous factor. Odds ratios of being in any H-ATOMIC classification and their 95% confidence intervals were reported whenever appropriate. Multivariable logistic regression analyses were performed on the H-ATOMIC Classifications of ICH to explore its association with other potential risk factors or confounding variables. All the variables were entered into the model a priori without any specific selection, first by introducing age, sex, race, hypertension, and smoking, and second by adding blood pressure measurements and various ICH risk scores. However, variables with nonsignificant predictive abilities for any H-ATOMIC Classification in our study were subsequently dropped from the multivariable logistic regression model to keep the model as much parsimonious as possible. The adjusted odds ratios with their 95% confidence intervals are reported in the text as well as in table. *P* values less than .05 were considered statistically significant. SAS version 9.4 (SAS Institute Inc., Cary, NC) was used for all the data analyses.

Results

One hundred ten patients were included in this study (Table 1). The median age (range) at time of initial ICH was 45.0 (18-50) years. Sixty-nine patients (62.7%) were male. The most common etiology was hypertension, with any degree of hypertension present in 91 patients (82.7%). All values were not statistically significant unless otherwise noted. Forty patients had hypertension as the definitive cause of their ICH, and thus were scored as an H1. There were no patients in which tumor, oral anticoagulants, or malformations were a definitive cause. There were 6 patients where infrequent causes were the definitive cause of the ICH, and thus were scored as I1. There were 4 patients who had no identifiable cause and were labeled as cryptogenic and thus scored as C1. Over half of the cases had multiple possible etiologies and could not be scored as definitive in any category. Characteristics and outcomes regarding infrequent causes were further explored but no statistical testing was performed due to the limited number of patients in these subgroups. These data are included in Table 5 for the readers interest.

No statistically significant difference in mortality was seen between those with and without any degree of hypertension as well as between those with definitive and probably/possible hypertension (P= .35 and .24). There was a statistically significant decrease in the use of noninvasive vessel imaging in patients with hypertension compared to those without hypertension (P= .0004; Table 2).

Patients without hypertension presented at much younger ages than those with any degree of hypertension ($P < .001$) and were more likely to have a higher secondary ICH score ($P < .001$). In addition, patients with hypertension were more likely to have a higher NIHSS than those without hypertension (Table 3).

We also examined other factors on the likelihood of having hypertension as the cause of a hemorrhage. For example, we examined if a patient who was black was more likely to have hypertension as a potential cause of their hemorrhage than white patients in this cohort. A Wald chi-square test was used to interpret this data (Table 4).

As mentioned earlier, there were not that many patients with infrequent or cryptogenic causes of their hemorrhage, we felt it was important to include the preliminary data (Table 5).

Finally, we created a visual representation comparing measurements of stroke outcomes between those with definite hypertension and those with probable/possible hypertension (Figs 1 and 2).

Discussion

The purpose of this retrospective chart review was to determine the etiologies and risk factors for ICH in patients aged 50 and younger in an urban North Philadelphia population. An additional goal was to study the differences in patient outcomes stratified by these risk factors. The novel H-ATOMIC scoring system was used to determine the most common causes of ICH as well as cases where multiple causes were present. By far, the most prevalent risk factor for patients in this study was hypertension, which was consistent with current literature. In comparing those with and without hypertension, the only statistically significant difference was people with hypertension were more likely to have a higher NIHSS than those without hypertension. However, there was no difference in mortality between these 2 groups.

People with both hypertension and other etiologies, meaning a score of H2 or H3 in addition to other H-ATOMIC etiologies had on average, a higher ICH score infarct volume and a lower GCS on presentation than people with definitive hypertension (Figs 1 and 2). These figures separated definitive and probable/possible

Table 4. *Multiple logistical regression results on any degree of hypertension*

Variable	*Increment for OR*	*Adjusted odds ratio of any H (95% CI)*	*P value**
Admission SBP	28	4.83 (1.70, 13.74)	0.003
Age at hemorrhage	4	1.27 (0.77, 2.10)	0.35
Race	-	-	0.57
Black vs White	-	2.17 (0.20, 23.17)	0.52
Other vs White	-	0.38 (0.02, 7.30)	0.52
Secondary ICH score	1	0.16 (0.04, 0.62)	0.008
Sex: F vs M	-	22.12 (0.98, 500.53)	0.052

Abbreviations: ICH, intracerebral hemorrhage; SBP, systolic blood pressure.

*Wald chi-square test.

Table 5. *Baseline characteristics and stroke outcomes by infrequent causes of cryptogenic subgroups*

Variable (# missing)	*Total*†	*No I*	*I1*	*I2 or I3*	*Any I*	*Any C*	*No C*
Overall	110	65 (59.1%)	6 (5.5%)	39 (35.5%)	45 (40.9%)	4 (3.6%)	106 (96.4%)
Sex							
F	41 (37.3%)	21 (32.3%)	4 (66.7%)	16 (41.0%)	20 (44.4%)	0 (0.0%)	41 (38.7%)
M	69 (62.7%)	44 (67.7%)	2 (33.3%)	23 (59.0%)	25 (55.6%)	4 (100.0%)	65 (61.3%)
Race							
Black	52 (47.3%)	32 (49.2%)	2 (33.3%)	18 (46.2%)	20 (44.4%)	1 (25.0%)	51 (48.1%)
Other	18 (16.4%)	9 (13.8%)	0 (0.0%)	9 (23.1%)	9 (20.0%)	1 (25.0%)	17 (16.0%)
White	40 (36.4%)	24 (36.9%)	4 (66.7%)	12 (30.8%)	16 (35.6%)	2 (50.0%)	38 (35.8%)
Smoking history (8)							
Current use	29 (28.4%)	15 (24.6%)	1 (16.7%)	13 (37.1%)	14 (34.1%)	1 (33.3%)	28 (28.3%)
No previous use	60 (58.8%)	39 (63.9%)	4 (66.7%)	17 (48.6%)	21 (51.2%)	2 (66.7%)	58 (58.6%)
Previous use	13 (12.7%)	7 (11.5%)	1 (16.7%)	5 (14.3%)	6 (14.6%)	0 (0.0%)	13 (13.1%)
Angio							
Done	14 (12.7%)	10 (15.4%)	0 (0.0%)	4 (10.3%)	4 (8.9%)	3 (75.0%)	11 (10.4%)
Not done	96 (87.3%)	55 (84.6%)	6 (100.0%)	35 (89.7%)	41 (91.1%)	1 (25.0%)	95 (89.6%)
Patient alive							
No	23 (20.9%)	11 (16.9%)	1 (16.7%)	11 (28.2%)	12 (26.7%)	1 (25.0%)	22 (20.8%)
Yes	87 (79.1%)	54 (83.1%)	5 (83.3%)	28 (71.8%)	33 (73.3%)	3 (75.0%)	84 (79.2%)
MRA/MRV/ CTA/CTV							
Done	22 (20.0%)	11 (16.9%)	4 (66.7%)	7 (17.9%)	11 (24.4%)	2 (50.0%)	20 (18.9%)
Not done	88 (80.0%)	54 (83.1%)	2 (33.3%)	32 (82.1%)	34 (75.6%)	2 (50.0%)	86 (81.1%)
Age at hemorrhage	45.0 (18.0-50.0)	45.0 (18.0-50.0)	38.5 (27.0-42.0)	46.0 (19.0-50.0)	45.0 (19.0-50.0)	27.0 (20.0-34.0)	45.0 (18.0-50.0)
BMI (1)	26.5 (13.8-62.1)	27.2 (16.5-51.9)	29.4 (18.2-50.5)	25.2 (13.8-62.1)	25.2 (13.8-62.1)	24.8 (20.0-34.0)	26.5 (13.8-62.1)
Admission systolic blood pressure	172.0 (80.0-290.0)	173.0 (80.0-290.0)	118.5 (83.0-148.0)	177.0 (97.0-290.0)	170.0 (83.0-290.0)	127.5 (116.0-134.0)	174.5 (80.0-290.0)
Admission diastolic blood pressure	102.5 (51.0-180.0)	104.0 (51.0-176.0)	75.5 (52.0-90.0)	107.0 (60.0-180.0)	100.0 (52.0-180.0)	78.5 (68.0-93.0)	104.0 (51.0-180.0)
Stroke volume (2)	11.9 (0.1-105.5)	11.2 (0.1-95.4)	5.1 (0.4-75.8)	19.9 (0.3-105.5)	15.3 (0.3-105.5)	15.7 (3.6-55.5)	11.9 (0.1-105.5)
Glasgow Coma Scale	14.0 (3.0-15.0)	15.0 (3.0-15.0)	12.5 (3.0-15.0)	13.0 (3.0-15.0)	13.0 (3.0-15.0)	15.0 (3.0-15.0)	14.0 (3.0-15.0)
NIH Stroke Scale (29)	9.0 (0.0-42.0)	6.5 (0.0-38.0)	2.0 (1.0-3.0)	12.5 (0.0-42.0)	10.0 (0.0-42.0)	4.0 (0.0-38.0)	9.0 (0.0-42.0)
ICH score (2)	1.0 (0.0-5.0)	1.0 (0.0-5.0)	2.0 (0.0-4.0)	2.0 (0.0-4.0)	2.0 (0.0-4.0)	1.5 (1.0-3.0)	1.0 (0.0-5.0)
Modified ICH score	2.0 (1.0-5.0)	2.0 (1.0-5.0)	3.0 (2.0-5.0)	2.0 (1.0-5.0)	2.0 (1.0-5.0)	2.0 (1.0-4.0)	2.0 (1.0-5.0)
Secondary ICH score	2.0 (1.0-6.0)	2.0 (1.0-5.0)	5.0 (3.0-6.0)	2.0 (1.0-5.0)	2.0 (1.0-6.0)	4.0 (3.0-4.0)	2.0 (1.0-6.0)
New ICH score (28)	2.0 (1.0-6.0)	2.0 (1.0-6.0)	2.0 (2.0-3.0)	3.0 (1.0-5.0)	3.0 (1.0-5.0)	2.0 (2.0-4.0)	2.0 (1.0-6.0)

Abbreviations: BMI, body mass index; CTA/CTV, CT angiography/venography; MRA/MRV, magnetic resonance angiography/venography; NIH, national institute of health.
Age at hemorrhage in years, BMI in kilograms/meter squared, hemorrhage volume in centimeters cubed, all stroke scales and scores have no units.
Table entry = n (%) for categorical variables or median (range) for continuous variables.

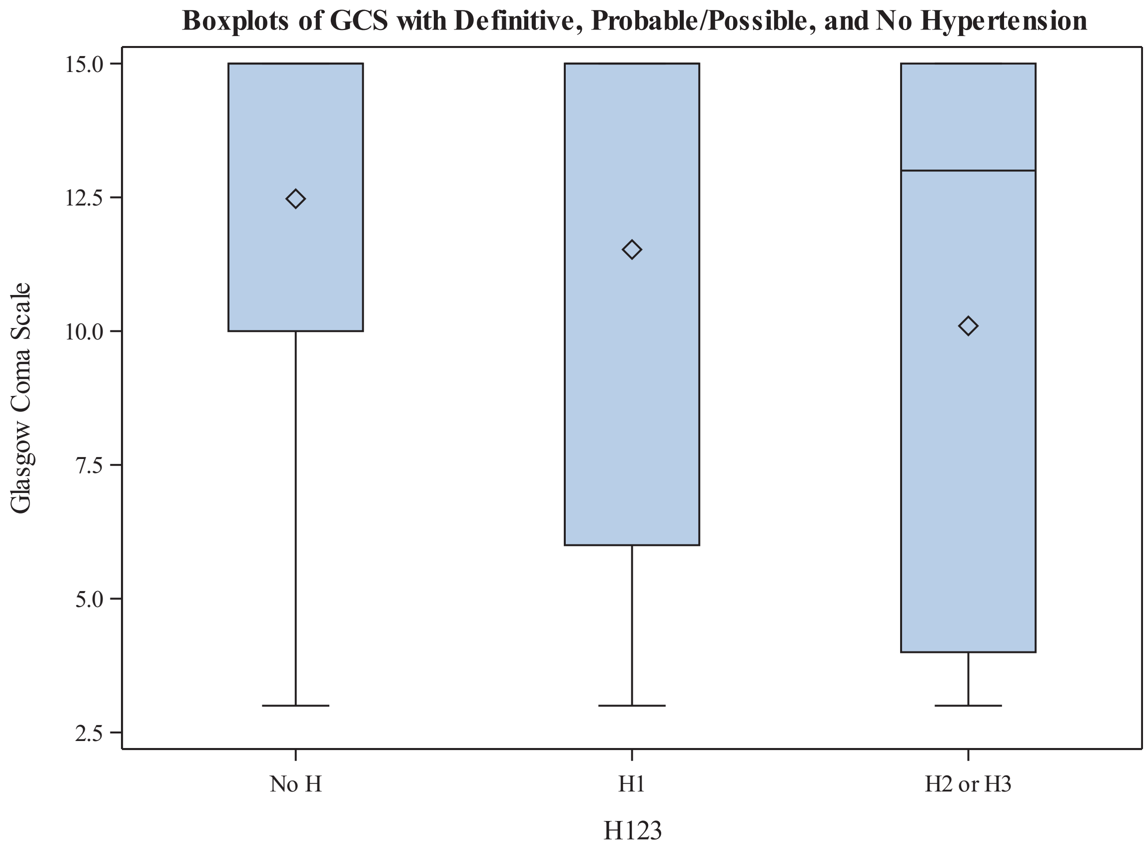

Figure 1. *Boxplots of GCS with definitive, probable/possible, and no hypertension.*

This graph compares the GCS in patients with and without hypertension. On the x axis are 3 separate variables. No H signifies the absence of any degree of hypertension. H1 means definitive hypertension is present and H2 or H3 means that there is probable or possible hypertension present, respectively. On the y axis is the GCS. The minimum and maximum value for the GCS is 3 and 15, respectively. Number in parenthesis in figure title are number of patients in the subgroup. Abbreviation: GCS, Glasgow Coma Scale.

hypertension because our hypothesis included examining outcome measurements in those with multiple potential etiologies. However, these results were not statistically significant. This was an unexpected result because all of the stroke outcome indicators that were studied (GCS, NIHSS, ICH score, infarct volume) were higher in the H2/H3 categories compared to H1. It was surprising that none of these results were significant. There was also no significant difference in mortality between any of these subgroups, keeping in line with the strong correlation between ICH score and 30-day mortality.

We also analyzed the relationship between hypertension and other variables such as sex and race using multiple logistical regression. This was used to add potential links in a causal pathway of ICH in the young. Even though there were no statistically significant results in these specific variables, it was still important to refute or support these connections. There was a significant relationship between admission systolic blood pressure and the presence of hypertension as well as a significant relationship between the absence of hypertension and secondary ICH score. These were not surprising but were beneficial results. It was also interesting to note that there was a significant decrease in the use of vessel imaging in patients without hypertension. This could be seen as a case of diagnostic bias. If a younger person presents to the hospital with hypertension and an ICH, there could still be other factors present. A case could be made to utilize more vessel imaging to avoid potential self-fulfilling diagnoses and the possibility of discovering underlying causes of ICH that may not be obvious upon initial presentation.

Also interesting was the significant difference in the secondary ICH score between those with and without hypertension as the definitive cause. This was to be expected, in that patients who present with a hemorrhage where hypertension is not the definitive cause are more likely to have the potential for a vascular etiology.

An important takeaway from this is that while hypertension remains the most common cause of ICH, it is important to intervene early and address other risk factors for ICH, even if a patient's blood pressure is only mildly elevated. It seems that prevention of ICH at a younger age requires an approach that does not just address hypertension, the most common ICH risk factor, but also takes on other risk factors, such as drug use, smoking, and others. It seems that the more risk factors present, the

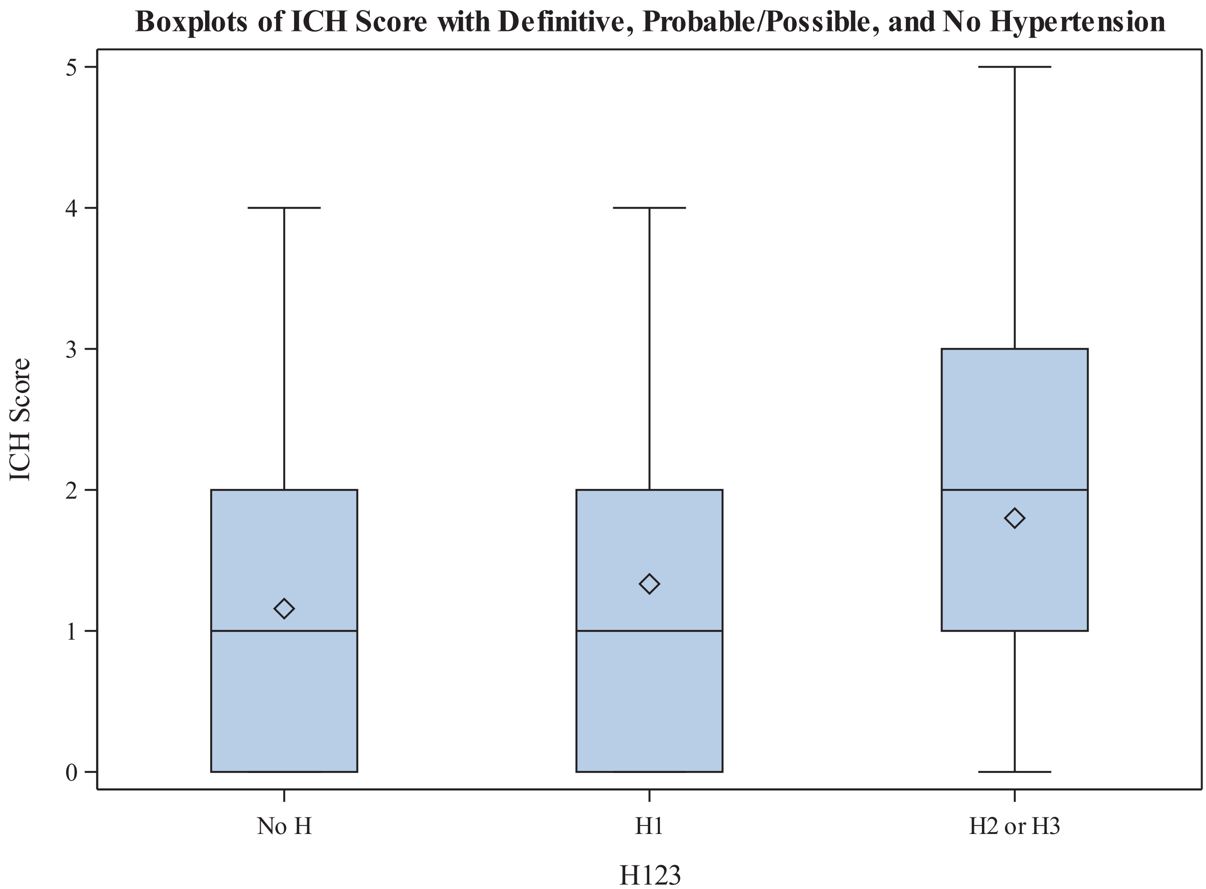

Figure 2. *Boxplots of ICH score with definitive, probable/possible, and no hypertension.*

This graph compares the ICH score in patients with and without hypertension. On the x axis are 3 separate variables. No H signifies the absence of any degree of hypertension. H1 means definitive hypertension is present and H2 or H3 means that there is probable or possible hypertension present, respectively. On the y axis is the ICH score. The ICH score ranges from a minimum of 0 to a maximum of 6, with a higher score indicating a higher risk of 30-day mortality. Number in parenthesis in figure title are number of patients in the subgroup. Abbreviation: ICH, intracerebral hemorrhage.

threshold for an elevated blood pressure to contribute to an ICH in people 50 and younger becomes lower. This is especially important in North Philadelphia where widespread poverty and decreased access to healthcare create situations where it is not very difficult for even mild hypertension to occur.

There were some limitations to this study. There may have been cases of CAA in patients under 55 but given the H-ATOMIC criteria, they were unable to be included. Even though CAA is rare in younger patients, there are case reports of ICH in younger patients attributed to CAA.[12,13] This could be a consideration in younger patients with unexplained lobar hemorrhages and could be included as a possible ICH etiology in future studies. In addition, long-term follow-up results are not included. This would have added valuable long-term outcome data. Additional studies need to be conducted where patients with ICH at 50 years old and under are followed, possibly prospectively, for a longer period of time to see if there are any differences between outcomes when comparing ICH risk factors. Another limitation of this study is that we do not know to what extent individual risk factors played a role in hemorrhages where multiple etiologies were present. For example, cocaine use was one of the infrequent causes of ICH. This is important specifically from an epidemiology and public health standpoint in North Philadelphia where drug use and hypertension are both more common. In patients with both of these risk factors, we were unable to tell if the patient had hypertension at baseline with occasional cocaine use or if the drug use was the cause of the hypertension and ICH. This would require long-term follow-up as well.

Despite the limitations of this study, we feel that this effort is important in bringing light to a topic that needs more attention and hopefully will help to jumpstart more efforts in studying ICH in young populations, especially urban populations that have many healthcare barriers to overcome.

In conclusion, there are many ICH risk factors present in the studied vulnerable young urban population. It is important to further elucidate which risk factors put these patients at greatest liability for ICH. Such data and associations could likely be extrapolated to other patient populations in areas where reduced access to healthcare is common. We hope that this will further highlight the need for improved preventive measures in the most vulnerable populations.

Conflict of Interest

No conflict of interest.

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