Emergence of Recreational Drug Abuse as a Major Risk Factor for Stroke in Young Adults

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Objective: To investigate the clinical and epidemiologic relations between recreational drug abuse and stroke in young persons.

Design: A case-control study based on medical records.

Setting: San Francisco General Hospital, a 400-bed municipal hospital.

Patients: Consecutive sample of 214 patients aged 15 to 44 years, admitted between 1979 and 1988 with a diagnosis of ischemic or hemorrhagic stroke. An equal number of control patients admitted with diagnoses of status asthmaticus, acute appendicitis, or acute cholecystitis were matched to stroke patients by age, sex, and year of hospitalization.

Measurements and Main Results: Seventy-three patients with stroke (34%) were drug abusers compared with 18 (8%) of the controls. In 47 patients with stroke, temporal proximity of drug administration ($n = 34$) or infectious endocarditis ($n = 13$) suggested a direct association between drug abuse and stroke. After controlling for other identifiable stroke risk factors, the estimated relative risk for stroke among drug abusers compared with that among non-drug abusers was 6.5 (95% CI, 3.1 to 13.6), and this increased to 49.4 (CI, 6.4 to 379.0) for those patients whose symptoms began within 6 hours of drug administration. Among patients less than 35 years of age, drug abuse was the most commonly identified potential predisposing condition (47%), and it was the only condition with a significantly elevated relative risk for stroke (11.7; CI, 3.2 to 42.5). Further, a substantial rise in the proportion of drug-related strokes was observed in the last 3 years of the study (31% in 1986 to 1988, compared with 15% in 1979 to 1985, $P = 0.008$). Cocaine, especially recently, was the drug used most frequently in drug-related strokes.

Conclusion: In an urban population such as ours, recreational drug abuse appears to be a prominent and growing risk factor for strokes in young adults.

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There have been many anecdotal reports of strokes in young people provoked by recreational drug abuse (1-15), and our own experience in an urban, public hospital suggests that drug-induced neurologic complications, including stroke, are occurring more frequently (16). However, the epidemiologic role of drug abuse in stroke in young adults has not been examined. To investigate this question, we attempted to identify all the young patients (defined as those between 15 and 44 years of age) with new strokes admitted to our hospital between 1979 and 1988; and compared their risk factors for stroke with those in an age- and sex-matched control group. We then analyzed further those patients whose strokes occurred in temporal proximity to drug abuse in order to characterize the features of drug-related strokes with respect to potential causal mechanisms, outcome, and changes in incidence during the period of study.

Patients and Methods

Identification and Selection of Patients

Eligible patients were those between 15 and 44 years of age admitted to San Francisco General Hospital for either acute ischemic or hemorrhagic stroke, and who were discharged between January 1979 and December 1988. Patients were identified through a computerized admission registry by using International Classification of Disease (ICD) codes (9th revision) pertaining to both ischemic and hemorrhagic stroke: 430, 431, 433, 434, 436, and 437 (17). At the time of data collection, computerized records were not available for the last 2 months of 1988. For these months, patients were identified by reviewing admission and inpatient consultation records of the neurology service.

Using a standardized data-collection form, medical records were reviewed for the symptoms of the stroke, potential predisposing conditions, clinical signs, and the results of laboratory investigations and autopsy studies. Stroke was defined by World Health Organization criteria as "rapidly developing clinical signs of focal, at times global (as in coma or subarachnoid hemorrhage), disturbance of cerebral function, lasting more than 24 hours or leading to death with no apparent cause other than that of vascular origin" (18). Strokes were categorized into cerebral thrombosis, embolism, intracerebral hemorrhage, and subarachnoid hemorrhage according to the discharge diagnosis of the medical staff, as corroborated by clinical evaluation and laboratory testing, including neuroradiologic studies, lumbar puncture, echocardiography, and autopsy. Potential predisposing conditions included cardiac disease with possible embolic consequences, hypertension, hypercholesterolemia, diabetes mellitus, migraine, hematologic disorders, collagen vascular disease, illness related to human immunodeficiency virus, recent pregnancy, oral contraceptive use, head or neck trauma, cigarette smoking, heavy alcohol consumption (a history of six or more drinks per day or a description of current alcohol abuse in the clinical records), and recreational drug abuse.

Recreational drugs were defined as those drugs used unlawfully for the maintenance of addiction or for their psychic effects (excluding marijuana and abused drugs that are commonly prescribed, such as sedative-hypnotics). Patients who

stated they were abstinent for more than 1 year before admission and those for whom the chart lacked any information on drug abuse were not considered to be drug abusers.

We considered a strong clinical association between drug abuse and stroke to exist if either of the following two conditions was met: temporal proximity existed between drug abuse and subsequent stroke symptoms, either if symptoms began less than 6 hours after drug administration or if toxicologic testing was positive in stroke patients admitted in coma; or diagnosis of cerebral embolism or ruptured mycotic aneurysm was made in the setting of infectious endocarditis provoked by intravenous drug abuse.

Controls were matched to patients with stroke by sex, age within 3 years, and year of discharge. They were patients hospitalized at San Francisco General Hospital for acute medical or surgical conditions for which recreational drug abuse has not been shown to be a risk factor: asthma exacerbation, appendicitis, and cholecystitis. All control subjects were identified by the computerized admission registry using 9th revision ICD codes. Patients were selected sequentially from the computerized listing ordered by date of discharge. Records were requested on the first patient who fit the matching criteria for each stroke patient. Using a standardized data-collection form, we reviewed records for the same conditions predisposing to stroke mentioned above, as well as for drug abuse. Because drug abuse is not regarded as a risk factor for these conditions, physicians may have been less likely to elicit or document in the medical record a history of drug abuse when evaluating such patients compared with patients with stroke. To address this potential source of bias, patients were included in the control group only if their record for the current admission included specific documentation of the presence or absence of drug abuse.

Table 1. *Incidence of Potential Predisposing Conditions in Patients with Stroke and in Control Patients*

Predisposing Condition*	Stroke Group	Control Group
	n (%)	
Cigarette smoking	76 (36)	104 (49)
Drug abuse		
Total	73 (34)	18 (8)
Strongly associated†	47 (22)	
Hypertension	48 (22)	18 (8)
Aneurysm	38 (18)	
Heavy alcohol intake	36 (17)	38 (18)
Diabetes mellitus	16 (7)	4 (2)
Cardiac embolic source‡	16 (7)	5 (2)
Vascular malformation	15 (7)	
Atherosclerosis	5 (2)	
Collagen, vascular	4 (2)	1 (0.5)
Hematologic§	4 (2)	
Oral contraceptives	3 (1)	1 (0.5)
Pregnancy	3 (1)	9 (4)
Hyperlipidemia	3 (1)	
Meningitis	3 (1)	
Drug overdose‖	3 (1)	
Migraine	3 (1)	
Human immunodeficiency virus infection	2 (1)	2 (1)
Others¶	7 (3)	
No identified predisposing condition	16 (7)	79 (37)

* Multiple conditions present in some cases.

† *See* text for definition of "strongly associated."

‡ Includes prosthetic valve, cardiomyopathy, atrial fibrillation, recent myocardial infarction, infectious endocarditis unassociated with intravenous drug abuse, nonbacterial thrombotic endocarditis, and mitral-valve prolapse.

§ Includes hemophilia A, congenital afibrinogenemia, acute lymphoblastic leukemia, and idiopathic aplastic anemia.

‖ Excluding recreational drug abuse. Cerebral embolism in setting of secobarbital overdose; subarachnoid hemorrhage in setting of diazepam, flurazepam, and methaqualone overdose; intracerebral hemorrhage in setting of aspirin overdose.

¶ Other conditions include venous sinus thrombosis, atrial septal defect, fibromuscular dysplasia, monoamine oxidase toxicity, and vertebral dissection.

Statistical Analysis

Clinical features of strokes within the study group and the potential stroke risk factors in both the study and control groups were tabulated. To compare the incidence of specific characteristics between subgroups, the chi-square test with continuity correction was used for comparison between two proportions. The Fisher exact test was used when the count in a category was less than five.

Because patients with stroke were matched to controls without stroke, we used conditional logistic regression to evaluate the effect of drug abuse, hypertension, cardiac disease, diabetes mellitus, pregnancy, smoking, and alcohol abuse on the occurrence of stroke (19). This approach allows the estimation of odds ratios (and 95% CIs) for a given potential risk factor while adjusting for other confounding variables. Given that strokes in this age population are relatively rare, the calculated odds ratios can be considered an approximation of relative risk (19). Patients who had used drugs beyond 1 year from the occurrence of the stroke, and those who gave a history of drug abuse but provided no further details as to last use, were categorized as nonusers. Similar analyses were done on the subgroups of patients with ages less than 35, ages 35 or older, and admission dates between 1979 and 1985 or 1986 and 1988. To investigate the relation between risk for stroke and recency of drug administration, the same analysis was used on drug abusers who were subclassified according to their stated last use being less than 6 hours, 6 hours to 2 weeks, or 2 weeks to 1 year from the occurrence of stroke. This was done with and without the patients whose strokes were related to infectious endocarditis. Also included in this last analysis was the additional subgroup of patients who gave a history of using drugs, but in whom the exact temporal relation with the stroke could not be specified. All regression analyses were done using the PROC PHGLM program available on SAS (SAS Institute, Inc., Cary, North Carolina).

Results

A total of 321 stroke patients were identified by searching the computerized admission registry and neurology service admission and consultation logbooks. The medical records of 62 of these patients could not be retrieved. Forty-five other patients were not included after review of their records, because the diagnosis of stroke was uncertain (31 patients), or the stroke had occurred in the past and was not related to the current hospitalization (14 patients). To match controls to cases, we requested the records of 385 patients. The records of 87 patients could not be retrieved. Eighty-four patients were not included as controls because they were not hospitalized for acute medical or surgical conditions (38 patients), lack of documentation of the presence or absence of drug abuse (33 patients), or failure to match cases by age or sex after review of records (13 patients).

The study group thus consisted of 214 case-control matched pairs, 141 men and 73 women in each group. The mean age for both cases and controls was 35.4 years, with a range of 17 to 44 years in the stroke patients and 17 to 45 years in the control patients. The control group consisted of 180 patients admitted emergently with exacerbation of asthma, 26 patients with appendicitis, and 8 patients with cholecystitis.

Types of Strokes and Potential Predisposing Conditions

Among the patients with stroke, intracerebral hemorrhage was the most common form of stroke, occurring in 73 (34%) patients. This was followed by cerebral thrombosis (27%), subarachnoid hemorrhage (25%), and cerebral embolism (14%). The various conditions potentially predisposing to stroke in these patients are listed in Table 1 along with the frequencies of these conditions among the control patients. Thirty-eight patients with stroke had no specific information about drug abuse documented in their records and were counted as patients who did not abuse drugs. The most commonly identified conditions potentially related to stroke were cigarette smoking in 76 patients (36%), recreational drug abuse in 73 patients (34%), and hypertension in 48 patients (22%).

Relative Risks for Stroke

Risk ratios were calculated using conditional logistic regression for the six most commonly identified factors potentially predisposing to stroke, as well as drug abuse. Cerebral aneurysm and arteriovenous malformation were not included in this analysis because these conditions are likely to be detected only in the presence of specific neurologic symptoms or signs. Among the entire study group, cardiac conditions predisposing to embolism had the highest relative risk for stroke (7.3; CI, 2.0 to 26.8), followed by drug abuse, diabetes mellitus, and hypertension (Table 2). Alcohol abuse, smoking, or pregnancy showed no significant effect. Analysis of the risk ratios for stroke according to the recency of last drug use showed a temporal gradient: The risk for stroke was highest in the first 6 hours after drug abuse and decreased with time (Table 2). The subgroup of patients with an unknown interval between last use and stroke had a significantly elevated risk ratio that was intermediate between that of the less-than-6-hours and greater-than-6-hours groups. When the 13 patients with strokes related to infectious endocarditis were excluded, the risk for stroke remained elevated only in the less-than-6-hours and unknown-interval subgroups.

Among stroke patients under 35 years of age (n = 87), drug abuse was the most common predisposing condition, and was seen in 41 (47%) patients. The relative risk for stroke from drug abuse in this age group was 11.7 (CI, 3.2 to 42.5), compared with 3.6 (CI, 1.3 to 10.4) for patients 35 years of age or older. No other predisposing condition was associated with a significantly elevated relative risk in the younger age group.

Features of Drug Abuse

Of the 73 patients who were recreational drug abusers, 47 (22% of the entire stroke group) had a strong clinical association between drug abuse and stroke, as defined by temporal proximity (stroke within 6 hours of drug administration in 32 patients and admission in coma with a positive toxicologic test in 2 patients), or by stroke in the setting of infectious endocarditis (leading to cerebral embolism in 12 patients and rupture of a mycotic aneurysm in 1 patient). The substances used, types of strokes, and causal mechanisms identified in this group of 47 patients are shown in Table 3. Cocaine was used most frequently (57%), followed by heroin, amphetamine, methylphenidate, and phencyclidine. Of the patients in this group, 30% abused more than one substance before their stroke. All forms of stroke were identified in cocaine and amphetamine abusers and in those patients using heroin in combination with other drugs. However, patients using heroin exclusively only had strokes related to infectious endocarditis. When patients with stroke and control patients who were drug abusers were compared, we found no significant differences in the proportions of specific recreational drugs used.

Table 2. *Risk Ratios for the Seven Most Common Conditions Potentially Predisposing to Stroke*

Condition	Risk Ratio	95% CI	Discordant Pairs	
			case+/ control−	case−/ control+
Cardiac disease*	7.3	2.0–26.8	16	5
Diabetes mellitus	4.5	1.1–18.9	15	3
Hypertension	2.8	1.3–5.9	42	12
Alcohol abuse	1.1	0.4–1.8	29	31
Smoking	0.5	0.3–0.9	45	73
Pregnancy	0.4	0.1–1.7	3	9
Drug abuse (all users)†	6.5	3.1–13.6	52	12
Temporal subgroups‡				
< 6 h	49.4 (46.5)	6.4–379.0 (6.1–354.0)		
> 6 h < 2 wk	2.7 (1.8)	1.1–6.9 (0.7–5.1)		
> 2 wk < 1 y	1.8 (0.7)	0.2–19.3 (0.0–13.7)		
Unknown	7.4 (5.0)	2.1–19.3 (1.4–18.1)		

* Includes prosthetic valve, cardiomyopathy, atrial fibrillation, recent myocardial infarction, infectious endocarditis unassociated with intravenous drug abuse, nonbacterial thrombotic endocarditis, and mitral-valve prolapse.

† Includes all patients with a history of drug abuse within 1 year of admission for stroke. Drug users with an unknown interval between drug abuse and stroke were coded as nonusers for the main analysis and were considered as a separate subgroup in the subsequent analysis looking at the effect of recency of use.

‡ Numbers in parentheses refer to risk ratios and 95% CIs after excluding the 13 patients with strokes related to infectious endocarditis.

Features of Strokes Occurring Acutely after Drug Abuse

Among the 34 patients who had stroke in temporal proximity to drug administration, 31 had used either cocaine or amphetamine, and 59% used an intravenous route of administration. Of the 32 patients in whom the interval was known, stroke symptoms started immediately after drug use in 13 patients, within 3 hours in 11, and within 6 hours in 8. Most (71%) strokes in this group of patients were hemorrhagic, and 73% of these had a peripheral (lobar) location. In contrast, only 37% of intracerebral hemorrhages unassociated with drug abuse were lobar (P = 0.04). Ten patients with drug-related lobar hemorrhage had angiography, revealing an arteriovenous malformation in only two patients and

Table 3. *Drugs Used, Stroke Types, and Etiology of Strokes Occurring in 73 Recreational Drug Abusers*

All Drug Abusers	Patients	Drugs Used*				
		Cocaine (n = 33)	Heroin (n = 28)	Amphetamine (n = 21)	Methylphenidate (n = 7)	Phencyclidine (n = 1)
	n	n (n)†				
"Strong clinical association"‡	47	27 (17)	17 (6)	12 (7)	5 (2)	1 (1)
Stroke type (mechanism)						
Thrombosis	10	7 (4)	3 (0)	2 (2)	1 (1)	
Vasculitis	1			1		
Vasospasm	2	2				
Embolism	12	4 (2)	9 (5)	2 (1)	2 (0)	
Endocarditis	12	,4	9	2	1	
Subarachnoid hemorrhage	10	6 (4)	3 (0)	2 (1)	1 (1)	1 (1)
Aneurysm	6	5	2	1	1	
Intracerebral hemorrhage	15	10 (7)	2 (1)	6 (3)	1 (0)	
Vasculitis	2			2		
Vascular malformation	2	1		1		
Mycotic aneurysm	1		1			

* More than one drug was used by some patients.
† Numbers in parentheses indicate patients exclusively using a given drug.
‡ *See* text for definition of "strong clinical association" between drug abuse and stroke.

irregular, segmental arterial constriction ("beading") suggestive of vasculitis in one patient. Among eight patients with subarachnoid hemorrhage who had angiography, a cerebral aneurysm was identified in six, including five of six cases of cocaine-induced subarachnoid hemorrhage. Angiographic evidence of vasculitis was seen in three patients with hemorrhagic or ischemic strokes; all used intravenous amphetamine exclusively. Two cocaine abusers with cerebral thrombosis had localized arterial narrowing suggestive of vasospasm, but in neither were there other convincing findings of vasculitis. Cerebral thrombosis in exclusive users of cocaine involved the vertebrobasilar system in all four instances.

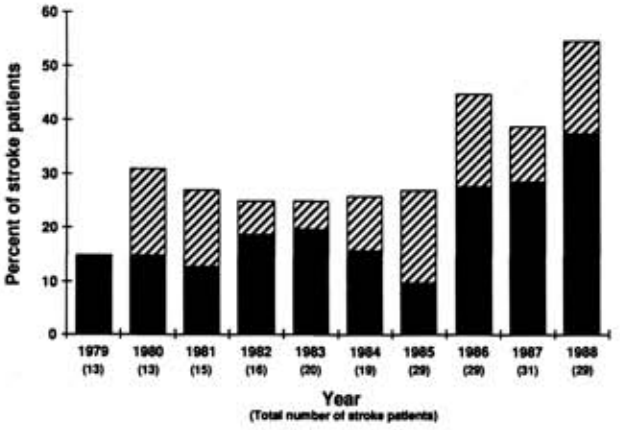

Figure 1. Percentage of patients with stroke involving drug abuse, 1979 to 1988. The black portion of the bars represents patients with stroke that had a strong clinical association with drug abuse, as defined in the text. The entire height of the bars represents all drug abusers, and the annual number of patients with stroke is indicated in parentheses below each year. There were significant differences between study periods 1979 to 1985 and 1986 to 1988 in the overall proportion of strokes related to drug abuse (P = 0.003), and in the proportion of strokes having a strong clinical association with drug abuse (P = 0.008).

Mortality

Fifty-six (26%) patients with stroke died during the acute admission; 48 (86%) of these had hemorrhagic strokes (16 subarachnoid hemorrhage, 32 intracerebral hemorrhage). Mortality was higher among the 47 patients whose strokes were strongly linked to drug abuse (36%) than among non-drug users (23%) (P = 0.1).

Trends in Drug-related Strokes over the Study Period

The proportion of patients with strokes involving drug abuse increased over the 10-year study period (Figure 1). Over this period we also identified a gradual increase in the total number of young stroke patients each year, but this was due, in part, to better recovery of records in more recent years. In the last 3 years, a significant increase was observed both in the overall proportion of drug abusers (46% of stroke patients in 1986 to 1988, compared with 26% in 1979 to 1985, P = 0.003), as well as in the proportion of the cases showing a strong clinical association between drug abuse and stroke (31% compared with 15%, P = 0.008). The relative risk for stroke from drug abuse was similar in these two periods; for 1979 to 1985 it was 7.9 (CI, 2.8 to 22.4), and for 1986 to 1988 it was 5.8 (CI, 1.9 to 17.2). The contribution of cocaine use to drug-related strokes also increased during the study period. From 1984 to 1988, cocaine was used in 83% of cases of stroke occurring in temporal proximity to drug abuse, but in only 30% of such cases from 1979 to 1983 (P = 0.005, Fisher exact test). Similar increases in cocaine use were observed among patients with stroke strongly associated with drug abuse (68% in 1984 to 1988, compared with 31% in 1979 to 1983, P = 0.05) and among all drug abusers (52% compared with 26%, P = 0.1).

Discussion

Although stroke occurring in persons under 45 years of age accounts for only 4% of all strokes, such events

strike more than 10 000 young persons per year in the United States (20). Approximately 25% of these patients die during their initial hospitalization (21), and many of those who survive are left with permanent neurologic handicaps. Thus, stroke in this age group exacts an enormous toll in personal suffering, lost productivity, and health care costs.

Many epidemiologic surveys have shown various potential causal factors for strokes in young persons. However, among the 11 surveys in the United States of stroke in young adults (22-32), only 2 identified drug abuse in association with stroke, and in neither study was drug abuse a prominent factor (Table 4). Toffol and colleagues (31) noted abuse of amphetamine or phenylpropanolamine in 5 of 72 patients 45 years of age or younger with hemorrhagic strokes. Lacy and colleagues (29) attributed only 2 of 131 cases of stroke to intravenous drug abuse, including one case of cerebral thrombosis from amphetamine vasculitis. Most of these surveys did not include hemorrhagic strokes, whereas hemorrhages accounted for most drug-related strokes in this study, as well as in previous reports of stroke associated with cocaine and amphetamine use (2, 3, 5, 10, 11, 13, 14, 16, 33-36). However, a review of major epidemiologic studies of both subarachnoid hemorrhage and intracerebral hemorrhage, including patients of all ages, shows that none has cited drug abuse as a predisposing factor (37-48). Thus, despite the growing number of anecdotal reports linking drug abuse to stroke, the epidemiologic role of recreational drug abuse as a potential cause of stroke in young people has not been emphasized.

Our study is the first case-control analysis of this issue. Our results differ distinctly from those of earlier reports in that 34% of our patients abused recreational drugs, and in 22% there was a strong clinical association between drug abuse and subsequent stroke. Further, drug abuse emerged as a substantial risk factor for stroke when comparing cases with controls, ranking second among the seven most commonly identified potential risk factors. This observation was even more striking in the subgroup of patients less than 35 years of age, where drug abuse was the only identified potential predisposing condition with a significantly elevated risk ratio. The reason for this increased risk in younger patients is unclear, but may reflect differences in the frequency, quantity, quality, or method of administration of drugs in younger drug abusers.

Several factors may account for the marked disparity between our findings and those of earlier studies. The prevalence of recreational drug abuse, especially of cocaine (49), has increased over the past 10 years, and a similar trend was observed in our study group. Many of the previous surveys of stroke in young people included small numbers of patients and were conducted before this rise in drug abuse (Table 4). Further, recent surveys of stroke in young persons have not been based in large metropolitan areas where drug abuse is relatively common. We therefore suspect that our findings may be representative of the recent experience of many medical centers serving inner-city populations nationally.

Certain characteristics of the drug-related strokes identified in our study are of potential clinical interest and may eventually provide insight into the mechanisms underlying these events. The greatest risk for stroke was within hours of drug use. This point became especially clear after we excluded patients with strokes related to infectious endocarditis, where an embolic event would not necessarily occur acutely after drug administration. There have been many previous reports of

Table 4. *Surveys of Stroke in Young Adults in the United States*

Study (Year) [Reference]	Period Surveyed	Location	Total Patients, *n*	Age, y	Type of Stroke	Drug Abuse
Berlin et al. (1955) [22]	1948-1953	Bellevue Hospital, Bronx VA Hospital, New York	13	18-37	Thr	Not cited
Sprofkin and Blakey (1956) [23]	1938-1955	Vanderbilt University Hospital, Nashville	18	23-41	Thr, Emb, SAH, ICH	Not cited
Wells and Timberger (1961) [24]	1932-1959	New York Hospital, New York	77	6-49	Thr	Not cited
Louis and McDowell (1967) [25]	1956-1966	Bellevue Hospital, New York	56	34-50	Thr	Not cited
Grindal et al. (1978) [26]	1970-1975	Medical College of Virginia Hospital, Richmond	58	15-40	Thr, Emb	Not cited
Snyder and Ramirez-Lassepas (1980) [27]	1970-1975	University of Minnesota St. Paul-Ramsey Hospital	61	16-49	Thr, Emb	Not cited
Hart and Miller (1983) [28]	Not stated	Oregon Health Science University, Portland	100	< 40	Thr, Emb	Not cited
Lacy et al. (1984) [29]	1971-1981	Denver General Hospital	131	17-55	Thr, Emb, ICH	Two patients (amphetamine)
Adams et al. (1986) [30]	1977-1986	University of Iowa Hospitals, Iowa City	144	15-45	Thr, Emb	Not cited
Toffol et al. (1987) [31]	1978-1985	University of Iowa Hospitals, Iowa City	72	15-45	ICH	Five patients (amphetamine, phenylpropanolamine)
Brick and Riggs (1989) [32]	1982-1984	West Virginia University Hospital, Morgantown	28	15-30	Thr, Emb, SAH, ICH	Not cited
Present study	1979-1988	San Francisco General Hospital	214	17-44	Thr, Emb, SAH, ICH	73 patients

* Thr = thrombotic; Emb = embolic; SAH = subarachnoid hemorrhage; ICH = intracerebral hemorrhage.

stroke arising acutely after drug abuse (1-16, 50), and together with our findings, these observations support a causal association between stroke and the acute physiologic effects of recreational drugs. The substances involved in acute drug-related strokes were primarily cocaine and amphetamine, with cocaine emerging as the predominant drug associated with strokes in more recent years. This finding parallels an increasing number of reports of cocaine-associated neurologic complications (8, 16, 50, 51). It is not known whether these trends reflect the increasing popularity of cocaine, changes in the type or route of administration of cocaine, improved recognition of cocaine-related medical problems, or other factors.

Certain limitations imposed by the retrospective nature of our study should be recognized. It is difficult to obtain an unbiased selection of patients to serve as controls because the retrospective identification of a history of drug abuse, or of any stroke risk factors, is likely to depend highly on the illness for which patients are referred. We addressed this issue by excluding patients from the control group if their record omitted specific history-taking regarding drug abuse. In reviewing medical records, however, it is difficult to be certain whether all potential risk factors have been adequately identified and documented. For instance, we were not able to collect information on socio-economic class. If there were substantial differences in socio-economic class between the two groups, then certain related factors, such as drug abuse, could explain some of the observed differences. The temporal connection between drug abuse and stroke, however, militates against this effect. In addition, the accuracy of the information regarding drug abuse obtained by chart review is inexact, because patients may deny drug abuse or minimize its recency, and because the recording of details is often less than optimal. We therefore chose a liberal time constraint (a history of use within 1 year of admission) for identifying drug abusers in the case and control groups. However, we limited our analysis of the features of drug-related strokes to those with stricter temporal or causal association.

We conclude that in an urban population such as ours, recreational drug abuse is a prominent and growing risk factor for strokes in young adults. Our findings provide the basis for further study, and they permit certain recommendations concerning the clinical approach to stroke in young persons. A history of drug abuse should be sought and toxicologic tests done in all cases of stroke, particularly in young adults. Evaluation should include appropriate investigation for potentially treatable mechanisms commonly associated with drug-related strokes, including cerebral aneurysms, arteriovenous malformations, endocarditis, and vasculitis. Finally, education of the public, patients, and health care workers about the relation between recreational drug abuse and cerebrovascular disease should be a prime objective in addressing this very prominent and preventable problem.

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