Psychiatric Disorders After Childhood Stroke

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ABSTRACT

Objectives: To determine the rate, types, and correlates of psychiatric disorder (PD) following stroke and orthopedic disorders in children and adolescents. **Method:** Children aged 5 to 19 were assessed. The study used a cross-sectional design that compared 29 stroke subjects with 29 congenital clubfoot or scoliosis subjects. Assessments of psychiatric status; cognitive, adaptive, academic, and family functioning; family psychiatric history; neuroimaging; and neurological status were conducted. The main outcome measure was a current PD not present before the stroke or orthopedic disorder. **Results:** Poststroke PD occurred significantly more often than postorthopedic diagnosis PD (17/29 [59%] versus 4/29 [14%], $p \leq .001$). Subjects with ongoing poststroke PD had significantly more impaired intellectual and adaptive functioning, higher intensity family psychiatric history scores, and tended toward higher neurological severity index scores, but they were not different regarding lesion volume or family functioning compared with stroke subjects without PD. Regression analyses showed that neurological severity and family psychiatric history independently contributed significantly to predicting PD. **Conclusions:** The data suggest that there are significant biopsychosocial correlates of PD in children with focal neurological lesions. These include a relatively abnormal neurological exam, lower IQ, and increased family psychopathology. *J. Am. Acad. Child Adolesc. Psychiatry*, 2002, 41(5):555–562. **Key Words:** pediatric, stroke, psychopathology.

Strokes occur during fetal development and at other points in childhood (Riela and Roach, 1993). The resulting focal brain lesions may provide insights regarding psychiatric and cognitive aspects of brain injury and plasticity. Although there is a rich adult psychiatric stroke literature (Robinson and Starkstein, 2000), this is the first psychiatric report of a cohort of children with focal stroke lesions.

Studies of behavioral and emotional features of children with documented unilateral stroke lesions are rare. Trauner et al. (1996), demonstrated that, regardless of hemispheric involvement, children with focal stroke lesions had higher *T* scores (indicating greater abnormality) than controls on scales measuring social competence and emotional, behavioral, cognitive, and academic development. Frontal lesions apparently accounted for the cognitive deficits, whereas posterior lesions were more likely to be associated with social problems.

Several milestones in neuropsychiatric research influenced the present study's design. First, the Isle of Wight epidemiological study (Rutter et al., 1970) documented psychiatric disorder (PD) in 34% of children with a brain disorder and in up to 58% of children who had brain lesions and "fits." The investigators also found PD in 12% of children with chronic "nonbrain" medical conditions, and a population base rate of 7%. None of the seven children with presumed unilateral brain lesions had a PD.

Second, two psychiatric studies directly compared children who had nontraumatic brain disorders with children who had non-CNS chronic disorders (Breslau, 1985; Seidel et al., 1975). Seidel et al. (1975) conducted a blinded epidemiological study of "crippled" children with IQ > 70. They found that children with supratentorial brain

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damage had twice the rate ("just short of significance") of PD compared with a control group of children with musculoskeletal disorders, including some children with cerebellar degeneration (24% versus 12%). Breslau (1985) found that significantly more children with neurological disorders had PD compared with control subjects with cystic fibrosis.

Third, Goodman and Graham (1996) reported on an epidemiological psychiatric study of childhood hemiplegia without neuroimaging data. Childhood hemiplegia is not synonymous with stroke. Some subjects in this study had head trauma and residua of bacterial meningitis (Goodman, 1994), whereas others likely had developmental brain conditions (e.g., congenital malformations). Furthermore, patients with stroke do not present with hemiplegia if the lesioned pathways do not involve the appropriate motor tracts. Nevertheless, in the absence of previous studies on childhood stroke, the findings from this study are relevant. Of 149 individually assessed hemiplegic subjects, aged 6 to 10 years, 61% had a PD. The strongest consistent predictor of PD was IQ, which was highly correlated with an "index of neurological severity" (Goodman and Graham, 1996). "Family adversity," including parental depression, was also significantly associated with PD. Age at assessment, sex, and laterality of lesion had little or no predictive power.

Against this background, we set out to study PD in children with neuroimaging evidence of focal stroke lesions, controlling for age, gender, ethnicity, socioeconomic status (SES), and the presence and onset of a chronic non-CNS orthopedic condition. We hypothesized, first, that significantly more children with stroke would be affected by ongoing poststroke PD compared with ongoing postorthopedic condition PD in medical controls. Second, we hypothesized that children with post-medical condition (either stroke or orthopedic) PD would be significantly more impaired in intellectual, adaptive, and academic function and show greater family adversity than subjects without PD, when either the entire study population or only subjects with stroke were considered. Finally, we hypothesized that stroke children with PD would have a significantly higher index of neurological severity.

METHOD

The research design is a cross-sectional study of children with a history of a single stroke and a medical control group. The study focus was on psychiatric outcome in children with strokes in addition to neuropsychological, family function, and adaptive function outcomes. Stroke subjects were considered to have "early" lesions if their brain lesion occurred prenatally or up to age 12 months. The "late" lesion group consisted of children who acquired their stroke at age 12 months or later. Subject selection was guided by the need to exclude the risk of recurrent strokes, in order to eliminate the additional anticipatory anxiety such conditions could induce for subjects and their families. A medical control group, used to prevent spurious significant findings, was selected from a sample known to have elevated rates of PD when compared with normal controls (Rutter et al., 1970). We anticipated that many of the subjects with strokes would have physical stigmata such as hemiparesis and/or would have repeated exposure to medical treatments. We therefore selected a medical control group consisting of children with clubfoot or scoliosis who might have had similar experiences. We matched early stroke subjects with children with clubfoot, with the rationale that physical deformity in both groups was an early, and frequently congenital, insult. We matched late stroke subjects with children who had scoliosis because these children were without physical deformity prior to their acquired disorders.

Inclusion criteria for stroke cases were as follows: (1) neuroimaging documentation of a focal, nonrecurrent, and nonprogressive supratentorial brain parenchymal lesion caused by a stroke before age 14; (2) age of 5 to 19 years at the time of the assessment; (3) ≥1 year since stroke; and (4) English as first language. The following exclusions were applied: (1) neonatal bleeds (e.g., intraventricular hemorrhages, germinal matrix hemorrhages) potentially associated with prematurity; (2) neonatal watershed infarcts associated with hypoxia; (3) hemoglobinopathies; (4) progressive neurometabolic disorders; (5) Down syndrome and other chromosomal abnormalities; (6) malignancy; (7) congenital hydrocephalus; (8) shunts; (9) congenital and acquired CNS infections; (10) clotting factor deficiency; (11) stroke in a pregnant minor; (12) transplant status; (13) cerebral cysts; (14) trauma; (15) transient ischemic attack; (16) moya moya; (17) severe and profound mental retardation; (18) quadriplegia, triplegia, or diplegia diagnoses; (19) syndromatic vascular malformations (excluding arteriovenous aneurysm ruptures); (20) systemic lupus erythematosis; and (21) multiple lesions (unless in close proximity).

Inclusion criteria for controls were as follows: Children with congenital clubfoot and children with scoliosis were individually matched to subjects with stroke according to age of onset of stroke (i.e., early versus late). Matching was based on gender, ethnicity, social class, and age within 1 year. Age matching had to be extended to 16 months in three cases. Exclusion criteria for controls: Orthopedic controls were excluded when they had evidence in the chart of acquired or congenital CNS injury that may be part of broader syndromes unrelated to the common idiopathic syndromes. An orthopedic surgeon researcher made final subject eligibility decisions. Matching was possible for all but two children with late stroke lesions. We were unable to find two males with scoliosis to match children aged 3 and 5 years at the time of their stroke and aged 6 and 8 years, respectively, at the time of the assessment. This was because scoliosis present in children this young is often associated with cardiac or neurological disorders in the case of infantile idiopathic scoliosis, and juvenile idiopathic scoliosis is less common than adolescent idiopathic scoliosis (Winter and Lonstein, 1999). Therefore these two late-onset stroke subjects were matched with children with clubfoot. All but one scoliosis subject had an idiopathic subtype, and the other had scoliosis secondary to leg length discrepancy.

A pediatric neurologist (K.M.) supervised a record review guided by the *ICD-9* codes for stroke and congenital cerebral palsy. These procedures yielded 49 apparently eligible subjects. One male with a stroke at age 7 months was found at screening to have severe mental retardation and was therefore ineligible to participate. We were able to locate 32 of the remaining 48 subjects, and we studied 30 subjects.

The research magnetic resonance imaging (MRI) revealed subtle bilateral lesions in 1 subject, who had to be excluded. Data from his matched control were excluded from analyses in this manuscript. The parents of 2 prenatal stroke female subjects aged 9 and 11 years declined participation. The 16 children not located were demographically comparable to the sample (e.g., age, race, gender, timing of stroke).

Twenty-nine subjects with stroke, including 17 with early lesions and 12 with late lesions, were evaluated. The mechanisms of stroke were occlusive in 21 cases and hemorrhagic in 8 cases. Etiology included 15 idiopathic occlusive cases, 1 idiopathic hemorrhagic case, 4 cases related to congenital heart disease (3 after cardiac surgery or catheterization and 1 after varicella zoster infection), 7 cases of arteriovenous malformation rupture, 1 case possibly linked to comorbid ulcerative colitis, and 1 case following a varicella infection. The distribution of the brain lesions included 7 cases of predominantly putamen lesions, 9 large middle cerebral artery (MCA) distribution infarcts including deep gray structures, 10 smaller MCA distribution frontotemporal or temporoparietal lesions sparing the deep gray, and 3 cases of parietal or parieto-occipital strokes. Fifteen of 19 subjects with clubfoot had surgical correction of their deformity, and all had extensive periods of castings. Three of 10 subjects with scoliosis required surgical intervention, 3/10 required treatment with braces up to 18 hours/day (although 1 was noncompliant), and 4/10 received either brief periods of castings or only monitoring of their curvatures. Forty-eight subjects (including all stroke subjects) were recruited from one university hospital, and 10 subjects were recruited from a second university hospital due to the relocation of the first author.

The stroke and orthopedic groups were not significantly different on matching variables of age and SES. Respective age means (SD) of stroke and orthopedic subjects were 12.1 (3.9) and 11.9 (3.9) (t_{56} = –0.135, $p > .8$). Respective SES means (SD) of stroke and orthopedic subjects were 2.45 (0.95) and 2.45 (1.06) ($t_{56} = 0$, $p = 1.0$). There were 18 males and 27 white and 2 biracial children in each of the stroke and orthopedic groups.

Measures

Psychiatric Measures. DSM-IV psychiatric diagnoses were derived by conducting the Schedule for Affective Disorders and Schizophrenia for School-Age Children, Present and Lifetime Version (K-SADS-PL) (Kaufman et al., 1997) semistructured interview. The K-SADS-PL is an integrated parent-child interview that generates diagnoses based on a clinician synthesizing data collected from the parent and child separately, querying present and lifetime symptoms and providing data regarding the timing of symptom onset in relation to the stroke or orthopedic diagnosis.

Also administered was the Neuropsychiatric Rating Schedule (NPRS) (Max et al., 1998a), which is a reliable and valid semistructured interview designed to identify symptoms and subtypes (labile, aggressive, disinhibited, apathetic, paranoid) of personality change due to a general medical condition (PC). The NPRS is appropriate for use with children with prenatal strokes because PC in children can be a marked deviation from normal development rather than change per se. Both parents and children served as informants, and the clinician integrated the information to determine diagnoses.

Fifty-seven of 58 interviews were administered by J.E.M, who is a board-certified child and adolescent psychiatrist, and all were videotaped. A.L., a trained Ph.D.-level researcher, administered one interview. Eleven interviews were selected randomly to be rated by a second child and adolescent psychiatrist (B.A.R.) to ascertain interrater reliability. The agreement regarding pre- and post-medical condition PD was 11/11 (100%) and was perfect in 9/11 (82%) subjects for specific diagnoses.

Family Psychiatric History. The Family History Research Diagnostic Criteria (Andreasen et al., 1977) interview was conducted in most cases by a trained research assistant and in other cases by J.E.M. Criteria were modified to conform with *DSM-III-R* criteria. At least one parent acted as the informant. Family ratings were summarized for first-degree relatives on a 4-point scale (Max et al., 1998b) of increasing severity: 0 = no family PD, 1 = at least one member of the family met criteria for a PD but no treatment was received, 2 = a family member met criteria for a PD and received outpatient treatment or was arrested for antisocial behavior, 3 = a family member met criteria for a PD and had inpatient psychiatric treatment or was incarcerated.

Family Assessments. Global family functioning was assessed by using the McMaster Structured Interview of Family Functioning. The interview is used to derive scores on the Clinical Rating Scale (CRS) (Miller et al., 1994). The CRS comprises seven domains, including global family functioning, which are rated from 1 to 7 on a Likert scale. Scores of 5 to 7 indicate healthy family function, and lower scores indicate unhealthy family functioning. Two trained research assistants, who remained blind to the psychiatric findings, conducted the interviews.

Socioeconomic Status. Assessment of SES was accomplished with the Four Factor Index (Hollingshead, 1975). Classification depends on scores derived from a formula involving both mother's and father's educational levels and occupational levels. Level I (scores 55–66) refers to the major business and professional class; level II (scores 40–54) refers to the medium business, minor professional, and technical class; level III (scores 30–39) refers to the skilled craftsmen, clerical, and sales workers class; level IV (scores 20–29) refers to the machine operators and semiskilled workers; and level V (scores 8–19) refers to the unskilled laborers, and menial service workers class. Roman numeral classes were recoded to corresponding whole numbers. Controls were matched within two levels of the relevant stroke subject.

Adaptive Functioning Measure. Adaptive functioning assessment was completed by trained research assistants using the Vineland Adaptive Behavior Scale interview (Sparrow et al., 1984), through a nondirective interview with the primary caretaker. The Vineland scales survey activities that the child habitually demonstrates in the environment, yielding an overall composite score and separate standard scores for Socialization, Daily Living, and Communication domains.

Intellectual Function. The WISC-III (Wechsler, 1991) was used. Prorated Full Scale IQ (FSIQ) was derived from a prorated Performance IQ (PIQ; Picture Arrangement, Block Design, and Coding subtests) and a prorated Verbal IQ (VIQ: Information and Similarities subtests). We applied the upper age limit norms for this test to the few subjects who were above the age range for published norms.

Academic Function. The Wide Range Achievement Test-Revised (WRAT-R) (Jastak and Wilkinson, 1984) was administered to assess achievement in reading, spelling, and mathematics. The WRAT-R consists of two alternate forms with two levels (level 1 for children ages 5.0 to 11.11; level 2 for persons over 12 years of age).

Neuroimaging. Protocol MRI scans were obtained (T1-weighted volumetric mode, SPGR/40°, TR = 26, TE = 7, matrix 256 × 192, NEX = 2, 1.5-mm thickness with no skip; T2-weighted multiecho, FSE/V, TR = 2,350, TE = 17/102, matrix 256 × 192, NEX = 1.5 mm, skip = 1 mm). Twenty-six of 29 stroke subjects underwent research scans that were the basis of their lesion location analyses. The other 3 subjects who could not have a research MRI (due to refusal, concern about intracerebral metallic clips, and equipment failure, respectively) had lesion location determined from previous clinical computed tomography scans (2) or MRI scan (1).

Guided by the lesion markings performed by F.F.M., an experienced neuroanatomist supervised by P.F. and J.L. "painted" each lesion

using a three-dimensional brain-morphometrics package (Display, Montreal Neurological Institute). Lesion size was computed in absolute units (cubic millimeters) before and after normalization for intersubject differences in brain size (Lancaster et al., 1997). Size normalization was performed with the spatial normalization software, which has the user mark the front, back, left, right, top, and bottom of the brain following anterior commissure/posterior commissure (AC-PC) alignment. Spatial normalization was then used to size the brain along each axis to the template size, thus correcting for brain volume.

Neurological Examination. A standard history and examination was administered by K.M. or J.E.M. Scores on a neurological severity index were rated. Scoring was adapted from a post hoc derived scale constructed by Goodman and Yude (1996) to account for PD in a population of childhood hemiplegic subjects. The rating is based on the following measures: (1) head circumference: >10th percentile = 0, 3rd to 10th percentile = 1, <3rd percentile = 2; (2) degree of hemiparesis: no hemiparesis = 0, mild hemiparesis = 1, usual or typical hemiparesis = 2, worst hemiparesis (hemiparesis plus contractures or dystonias) = 3; (3) function of "good" side: no dysfunction = 0, slight discoordination = 1, poor coordination = 2; (4) history of seizures: negative = 0, positive = 1.

Microcephaly (<3rd percentile) was present in 5/25 (25%) cases in which head circumference was measured. There was no hemiparesis in 12/29 (41%) cases, mild hemiparesis in 4/29 (14%) cases, typical hemiparesis in 11/29 (38%) cases, and worst hemiparesis in 2/29 (7%) cases. The side of the body ipsilateral to the brain lesion was normal in 27/29 (93%) cases, had slightly decreased coordination in 1/29 (3%) cases, and was poorly coordinated in 1/29 (3%) cases. The possibility of bilateral physical signs with unilateral lesions is a well-known phenomenon (Goodman and Yude, 1997). Eleven of 29 (38%) subjects had a history of seizures, but only 5 were receiving anticonvulsant medication (carbamazepine monotherapy in 3, carbamazepine plus primidone in 1, phenytoin in 1) at the time of assessment, and all were in good control.

Statistical Analysis

Group differences were tested with independent sample *t* tests and χ^2 analyses when the variables of interest were continuous or categorical, respectively. Logistic regression was used to test variables predictive of poststroke PD.

RESULTS

Comparison Between Stroke and Control Group

Stroke and control subjects were not significantly different with regard to family function and family psychiatric history. Respective family function means (SD) of stroke and orthopedic subjects were 4.81 (1.04) ($n = 27$) and 5.07 (1.05) ($n = 28$) ($t_{53} = -0.910$, $p > .3$). Respective family psychiatric history means (SD) of stroke and orthopedic subjects were 1.46 (1.17) ($n = 26$) and 1.24 (1.02) ($t_{53} = 0.743$, $p > .4$).

Table 1 shows the frequency counts of post-medical condition PD for the entire cohort. Post-medical condition PD, at the time of assessment, occurred in 17/29 (59%) of children with stroke compared with 4/29 (14%) of their orthopedic counterparts (Fisher exact test ≤ .001). Twelve (41%) stroke subjects, compared with 8 (28%) orthopedic subjects, had a resolved post-medical condition PD ($p > .4$).

Among the lifetime post-medical condition PD, attention deficit/hyperactivity disorder (ADHD) was the most common disorder (46% poststroke or 13/28 subjects without prestroke ADHD, 17% postorthopedic). For the entire sample, anxiety disorders were the next most common PD (31% poststroke, 7% postorthopedic). Mood disorders were the third most common PD (21% poststroke, 7% postorthopedic). Only stroke subjects exhibited PC (17%). Comorbidity did not occur in orthopedic subjects but was common among those stroke subjects with current psychiatric symptoms (poststroke PD diagnoses mean = 2.2, SD = 1.2).

A current PD, irrespective of onset timing, occurred in 18 stroke children compared with 4 orthopedic children ($p \leq .0005$). Twenty-one stroke children, compared with 13 orthopedic children, had a lifetime history of PD ($p < .07$). Prestroke PD consisted of ADHD (1); transient tic disorder (1); oppositional defiant disorder (2); and depressive disorder, not otherwise specified (1); and one child had both a social phobia and an anxiety disorder, not otherwise specified. Preorthopedic psychiatric diagnoses consisted of specific phobia (1) and social phobia (1).

Table 2 shows the pattern of intellectual, academic, and adaptive function in stroke subjects and controls, indicating significant deficits in the former group.

Characteristics of Children With Post-Medical Condition PD

Entire Cohort. Stroke and control children with post-medical condition PD were significantly more impaired than stroke and control children without these disorders with regard to intellectual, academic, and adaptive function and family psychiatric history, and they tended toward increased family dysfunction (Table 3). The post-medical condition PD group was not significantly different regarding age, SES, and gender (13/36 males versus 8/22 females).

Stroke Subjects Only. We also limited our analyses to stroke subjects and compared stroke subjects with poststroke PD to stroke subjects without these disorders (Table 3). Stroke children with poststroke PD demonstrated significantly more impairment in FSIQ and VIQ; adaptive function, particularly in the socialization domain; and family psychiatric history. The stroke children with poststroke PD tended toward significance regarding higher neurological severity summary scores and seizure activity history (9/17 subjects with poststroke PD compared with 2/12 subjects without PD; Fisher exact test < .07). All 5 sub-

TABLE 1
Psychiatric Disorders After Stroke and Orthopedic Condition Onset

Poststroke or Orthopedic Disorders	Stroke Subjects		Orthopedic Subjects	
	No. of Current Disorders	No. of Resolved Disorders	No. of Current Disorders	No. of Resolved Disorders
Disruptive behavior disorders				
Attention-deficit/hyperactivity disorder	12	1	3	2
Inattentive	6		2	
Not otherwise specified	4	1		2
Hyperactive/impulsive	1			
Combined type	1		1	
Oppositional defiant disorder	5	2		
Disruptive behavior disorder, NOS		1		
Personality change disorder	5			
Anxiety disorders				
Social phobia	3		1	
Specific phobia	2	1		1
Agoraphobia without panic	2			
Panic disorder with agoraphobia	1			
Obsessive-compulsive disorder	1			
Separation anxiety disorder	1	2		
Posttraumatic stress disorder		1		
Anxiety disorder, NOS	1			
Mood disorders				
Major depressive disorder		2		1
Depressive disorder, NOS	2	2		
Dysthymic disorder		1		1
Adjustment disorders				
Adjustment disorder, depressed mood		1		1
Adjustment disorder, mixed emotions/conduct				2
Adjustment disorder, NOS				1
Other disorders				
Encopresis		1		1
Chronic motor tic disorder	1			
Chronic vocal tic disorder	1			
Stereotypic movement disorder	1			
Marijuana abuse		1		
Pain disorder		1		

Note: Frequency totals are not equivalent to sample size, as subjects may have multiple current and resolved disorders. Disorders in partial remission (but not impairing) were classified as "Resolved." NOS = not otherwise specified.

jects with seizure disorders that were well controlled by anticonvulsants had a poststroke PD. The groups were not significantly different regarding age, SES, gender (9/18 males versus 8/11 females), early/late lesion (10/17 versus 7/12), lesion laterality (9/13 left; 8/16 right), lesion volume, PIQ, academic function, and family function. A logistic regression analysis (–2 log likelihood = 24.30, χ^2_2 = 11.12, $p < .004$) was performed to examine two potential predisposing factors for poststroke PD. The analysis revealed that family psychiatric history (Wald $\chi^2_1 = 5.50$, $p = .019$) and the neurological severity summary score (Wald χ^2_1 = 4.43, $p = .035$) both independently and significantly contributed to and correctly accounted for 89% of cases.

DISCUSSION

Our main finding from this study was that persistent poststroke PD occurred at a rate that was significantly higher than persistent PD that occurred after an orthopedic diagnosis in controls. This increased PD rate could not be explained by differences in age, gender, SES, race, family function, family psychiatric history, or the presence of a chronic medical condition. Therefore, although it may be difficult to attribute a specific PD of any individual to their medical condition, the group difference was likely related to the brain lesion and/or its complications.

The second finding was that psychiatric comorbidity was common only for the childhood stroke cohort, with

TABLE 2
Intellectual, Academic, and Adaptive Function in Stroke and Control Subjects

	Stroke (n = 29)		Orthopedic (n = 29)				
	Mean	(SD)	Mean	(SD)	*df*	*t*	*p*
IQ variables[a]							
Performance IQ	84.5	(20.4)	100.4	(15.2)	56	–3.38	.001
Verbal IQ	90.9	(16.5)	105.8	(13.9)	56	–3.74	.0005
Full Scale IQ	86.6	(18.0)	103.5	(13.1)	56	–4.08	.0005
Academic function[b]							
Reading	80.8	(17.7)	101.0	(14.0)	56	–4.82	.0005
Spelling	84.5	(17.3)	101.5	(16.2)	56	–3.86	.0005
Arithmetic	81.6	(19.0)	98.4	(19.3)	56	–3.33	.002
Adaptive function[c]							
Communication	80.5	(15.8)	97.1	(13.6)	56	–4.30	.0005
Daily Living Skills	80.1	(15.3)	99.5	(18.5)	56	–4.35	.0005
Socialization	84.5	(16.3)	94.7	(13.7)	56	–2.58	.013
Adaptive Behavior Composite	77.3	(14.7)	96.3	(17.9)	56	–4.41	.0005

Note: Means (SD) of standard scores on the [a] WISC-III; [b] Wide Range Achievement Test-Revised; [c] Vineland Adaptive Behavior Scales.

a notable heterogeneity of poststroke PD. Such heterogeneity is common after brain injury (Goodman and Graham, 1996; Max et al., 1998b). It is possible that some heterogeneity within categories such as ADHD and anxiety disorder may be an artifact of applying detailed *DSM-IV* descriptors. For example, we found evidence of progression from separation anxiety disorder/symptoms to agoraphobia without panic, or panic disorder with agoraphobia, suggesting common underlying etiological factors. Thus when the disorders are considered in general categories, there were particularly high rates of poststroke ADHD (46%), anxiety disorder (31%), mood disorders (21%), and PC (17%).

Next we predicted and found several significant correlates of post-medical condition PD. When all stroke and control subjects were included, children with post-medical condition PD functioned significantly worse than the group without PD in terms of IQ, academic function, and adaptive function. These findings reflected the fact that PD affected the stroke group disproportionately and that children with stroke were more impaired than controls. The same analyses on the stroke group alone were more revealing. Stroke children with poststroke PD had significantly lower adaptive function, mostly explained by decrements in socialization. They also had significantly worse FSIQ and VIQ scores. This is particularly important given that VIQ has been regarded as a more reliable index of intelligence in children with hemiplegia or motor impairment after brain injury (Goodman and Yude, 1996).

We then asked a question similar to that posed by others (Breslau, 1985; Goodman and Graham, 1996), namely, "When IQ is controlled, does the presence of a brain lesion contribute significantly to post-medical condition PD?" The logistic regression analysis with post-medical condition PD as the dependent grouping variable and FSIQ and group membership (stroke versus control) as independent variables was significant (–2 log likelihood = 54.26, $\chi^2 = 21.67$, $p < .00005$). FSIQ independently and significantly predicted post-medical condition PD (Wald $\chi^2_1 = 6.22$, $p < .02$), and the presence of a brain lesion showed a trend in this regard (Wald $\chi^2_1 = 3.75$, $p < .06$). This finding is consistent with the previous studies (Breslau, 1985; Goodman and Graham, 1996). Goodman and Graham (1996) suggested that IQ may be a marker for underlying neurobiological factors that influence psychopathology rather than being the main risk factor itself.

The index of neurological severity was an additional interesting neurobiological variable that fell just short of significance as a correlate of poststroke PD. The assessment of neurological severity comprised seizure history, head circumference, degree of hemiplegia, and function of the "good" side. This may have important implications for child neurologists, child and adolescent psychiatrists, and pediatricians in identifying cases of PD in this population. A neurological severity score is a simple measure that requires virtually no extra examination time in a busy clinical practice. From a theoretical point of view, this implies that the diverse neurological damage variables listed above capture an important construct related to PD.

Another potential influence on child psychopathology included family characteristics. We found that children with persistent PD had a significantly higher intensity of

TABLE 3
Characteristics of Post-Medical Condition Psychiatric Disorder (PD)

	Post-Medical Condition PD: Mean (SD)	No Post-Medical Condition PD: Mean (SD)	*df*	*t*	*p*
Entire cohort	*n* = 21	*n* = 37			
Age	11.5 (4.1)	12.3 (3.8)	56	0.71	NS
Socioeconomic status	2.62 (0.92)	2.35 (1.03)	56	–0.99	NS
Family function	4.58 (0.96) *n* = 19	5.14 (1.05) *n* = 36	53	1.94	.058
Family psychiatric history	1.86 (1.01) *n* = 21	1.11 (1.06) *n* = 36	55	–2.60	.012
IQ variables[a]					
Performance IQ	82.5 (20.3)	98.1 (16.9)	56	3.15	.003
Verbal IQ	86.4 (14.8)	105.1 (14.1)	56	4.78	.0005
Full Scale IQ	83.0 (16.8)	101.9 (14.5)	56	4.50	.0005
Academic function[b]					
Reading	80.0 (19.8)	96.5 (16.4)	56	3.50	.001
Spelling	82.7 (19.0)	98.5 (16.9)	56	3.35	.001
Arithmetic	82.0 (21.4)	94.1 (20.0)	56	2.23	.030
Adaptive function[c]					
Communication	79.6 (17.2)	94.0 (14.4)	56	3.43	.001
Daily Living Skills	78.9 (16.1)	96.0 (18.6)	56	3.53	.001
Socialization	79.5 (16.8)	95.4 (12.0)	56	4.18	.0005
Adaptive Behavior Composite	74.8 (15.8)	93.7 (17.1)	56	4.15	.0005
Stroke subjects only	*n* = 17	*n* = 12			
Age	12.2 (4.1)	11.5 (3.6)	27	–0.50	NS
Socioeconomic status	2.65 (0.93)	2.17 (1.19)	27	–1.22	NS
Family function	4.60 (0.99) *n* = 15	5.08 (1.08)	25	1.21	NS
Family psychiatric history	1.87 (0.99) *n* = 15	0.91 (1.22)	24	–2.21	.037
IQ variables[a]					
Performance IQ	79.7 (21.1)	91.3 (17.9)	27	1.54	NS
Verbal IQ	84.9 (15.9)	99.3 (13.8)	27	2.54	.017
Full Scale IQ	80.7 (17.6)	95.0 (15.7)	27	2.25	.033
Academic function[b]					
Reading	78.5 (18.6)	84.1 (16.5)	27	0.84	NS
Spelling	81.8 (17.2)	88.3 (17.4)	27	1.01	NS
Arithmetic	79.7 (21.6)	84.4 (14.9)	27	0.66	NS
Adaptive function[c]					
Communication	76.5 (16.0)	86.2 (14.3)	27	1.68	NS
Daily Living Skills	77.6 (16.9)	83.8 (12.3)	27	1.07	NS
Socialization	77.3 (16.5)	94.8 (9.3)	27	3.30	.003
Adaptive Behavior Composite	72.2 (14.5)	84.6 (12.1)	27	2.41	.023
Lesion volume (mm^3)	42,797 (55,164) *n* = 15	33,980 (74,990) *n* = 11	24	–0.35	NS
Neurological severity	2.53 (1.87)	1.33 (1.15)	27	–1.96	.061

Note: Means (SD) of standard scores on the [a] WISC-III; [b] Wide Range Achievement Test-Revised; [c] Vineland Adaptive Behavior Scales. NS = not significant.

family psychiatric history in first-degree relatives than did children without PD. This finding was present even when the children with stroke were analyzed separately. Therefore the deleterious effect of the brain lesion was not so overwhelming as to obliterate the significant influence of family psychiatric history on PD. In fact, family psychiatric history and neurological severity were independently significant in accounting for persistent PD in the stroke children. The same relationship did not hold true for a sensitive measure of family functioning involving a family assessment interview.

Limitations

First, the sample is small, and findings on larger samples are needed. Nevertheless, this represents one of the largest reports of childhood stroke. Second, the stroke sample is heterogeneous in etiology, and developmental level of the children was broadly distributed at time of

insult and assessment. The control group was designed to minimize this problem. Third, about one third of the orthopedic control children were recruited from a different site than the children with stroke. Unknown biases may be operative as a result of this. However, all controls were carefully selected to match the subjects in age, gender, ethnicity, SES, and the presence of a chronic medical condition. Furthermore, the groups did not differ on family function or family psychiatric history. Fourth, the psychiatric interviewer was not blind to the group affiliation of the subjects. However, excellent interrater reliability was recorded with another child and adolescent psychiatrist who watched randomly selected videotaped psychiatric interviews and who was blind to group affiliation of the subjects. Fifth, the interviewers who conducted the family psychiatric history, family functioning, and adaptive functioning assessments were not blind to stroke versus control status. Sixth, the stroke sample is not an epidemiological sample but rather represents the results of a case-finding strategy of children diagnosed with stroke at a university teaching hospital. The children were not referred for their PD but rather for neurological diagnosis, treatment for cardiac problems, or orthopedic procedures for residual neurologically based musculoskeletal problems. The validity of the differences between subjects and controls is strengthened because the control subjects were subject to similar referral biases. The fact that our findings are so similar to those of a previously published epidemiological study of childhood hemiplegia (Goodman and Graham, 1996) suggests that referral bias may not be of overwhelming significance in this study. Seventh, the psychiatrist did not have the benefit of a teacher's report in reaching diagnostic decisions. Eighth, the absence of CNS involvement in orthopedic subjects was determined by clinical workups in active orthopedic research settings rather than by protocol MRI scans.

Clinical Implications

A careful screening of PD, combined with a thorough neurological history and exam and the recording of a family psychiatric history among patients with neurological disorders, including stroke, is critical. These will lead to the identification and, it is hoped, treatment of most cases with PD. Our findings are correlational, and causality cannot be inferred; however, they may suggest that factors protective against PD even in children with focal neurological lesions include an average IQ, relatively normal neurological examination, and limited family psychopathology.

Having established that unilateral stroke in children is associated with increased PD, we present further analyses, in a companion paper, to determine possible lesion correlates of ADHD, which was the most common PD.

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