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Original Contributions

Multicenter Retrospective Review of Results and Complications of Carotid Endarterectomy in 1981

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SUMMARY A multicenter retrospective audit of carotid endarterectomies performed during 1981 was completed with 46 institutions contributing 3,328 cases. Overall, there was a 2.5% risk of transient neurological dysfunction following surgery and a 6% risk of stroke or death. The intra-institutional combined major morbidity and mortality varied from 21% to 0. Those institutions with greater than 700 beds had a statistically lower incidence of stroke or death than did other institutions. The incidence of stroke or death postoperatively was significantly lower for patients who were operated on for amaurosis fugax or for unspecified reasons. Those patients who were operated on for a progressing stroke had a higher incidence of stroke but this group was at greatest risk for stroke without surgery. The incidence of postoperative stroke or death was related to the type of arterial repair; vein patch grafting was statistically better than both fabric patch grafting and primary closure. When all patients who were not monitored during surgery were compared to all patients who had electroencephalographic (EEG) monitoring, there was found to be a significant statistical difference in favor of the EEG group. Endarterectomy combined with coronary artery bypass or simultaneous bilateral endarterectomies had a statistically significant higher incidence of stroke or death than did unilateral carotid endarterectomy.

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A RETROSPECTIVE multicenter audit of carotid endarterectomies performed in 1981 was proposed, sponsored, and completed by the Cerebrovascular Surgery Section of the American Association of Neurological Surgeons. The purpose of this study was to achieve through a national audit covering a broad spectrum of practices a profile concerning the status of carotid endarterectomy in North America. The need for such a study is self-evident.

Methods

A. Case Material

This retrospective analysis was actually completed during the years of 1982 and 1983. The year 1981 was selected for retrospective analysis as it was felt that records on patients undergoing an endarterectomy during that year should have been completed by the time of the audit and that the time period was recent enough to represent the current state of the art.

A statistical form was designed with 14 questions (see Appendix A) permitting the collection of pertinent data from a minimal amount of effort on the part of the participants. This abbreviated form was used in order to increase the response and participation from the contributing institutions. This was necessary as no special funds were allocated for this study and the costs of the audit were borne individually by the participating centers and the Cerebrovascular Section of the American Association of Neurological Surgeons.

The participation was solicited from members of the Cerebrovascular Section initially, but thereafter letters were sent to all members of the AANS in an effort to increase the number of reporting centers. Participation was entirely voluntary and was without remuneration. It was not necessary to be a member of the AANS to participate in this study and some contributors were neurologists. Although case material is included from vascular and general surgeons, all correspondence was through neurosurgeons and neurologists. There was no pre-selection process as it was our goal to achieve a broadbased view of the spectrum of carotid endarterectomy in North America.

Anonymity of responses from participating institutions was guaranteed. A code number was assigned to each institution and only one person (NF) had access to the code list. The information obtained was key-punched into a computer bank for retrieval and analysis.

Forty-six centers (Appendix B) contributed their cases of carotid endarterectomy for the year 1981 resulting in a total of 3,328 cases for analysis. The size of responding institutions varied from under 200 beds to over 900 beds and included: private, county or city, university, and veteran's hospitals. The number of cases contributed per center ranged from 12 to 243. The geographic distribution was representative of the continental United States (New England, Middle Atlantic, South, Midsouth, Southwest, West Coast, Northwest, Midwest) and Canada (Quebec and Ontario). The patient population included 1,251 women and 2,077 men.

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B. Categorization of Cases

1. Indications for surgery — The following indications for surgery with the numbers of recorded cases reported in each category were recorded: asymptomatic bruit, 396 cases; prelude to surgery elsewhere in the body such as coronary bypass or aortic aneurysm repair, 176; amaurosis fugax, 461; transient ischemic attacks, 1295; dizziness, vertigo or syncope, 336; mild stroke (grade 1 or 2 paresis), 388; severe stroke (grade 3 or 4 paresis), 51; progressing stroke and/or crescendo TIA's, 38; and unspecified or other, 197.

2. Surgical Complications — Complications were coded as either intraoperative or postoperative (occurring during the patient's hospital stay). Days in the hospital ranged from five days to > 99 days. Complications of surgery were divided into transient and permanent neurological deficits; death from stroke or myocardial infarction; and other:

a) Transient

1) Transient ischemic attack (TIA) — A neurological deficit resolving in 24 hours.

2) Reversible Ischemic Neurological Deficit (RIND) — A neurological deficit resolving in 7 days.

b) Permanent

1) Minor Stroke — This was defined as a patient who was still able to work but had a minor deficit such as an incomplete field cut or clumsiness in one hand or arm.

2) Major Stroke — Unable to work, able to care for self. This category included patients who had a nondominant hemispheric major stroke rendering them unable for gainful employment but yet able to care for self.

3) Major Stroke, Unable to care for self — This category included patients with a major stroke in the dominant hemisphere who, thereafter, required some nursing assistance for self-care and were essentially candidates for a nursing home.

c) Death

Causes for death were coded into two categories: death from stroke and death from myocardial infarction.

d) Other

The form used for compiling information included a code-space for other types of complications. Because of the range of "other" complications from minor (wound hematomas, transient cranial nerve deficits) to major (nonfatal myocardial infarction, death from pulmonary problems), this category was not included in the statistical analysis. However, there was an overall incidence of 9% of "other" complications.

3. Intra-Operative Monitoring — Three major groupings for analysis with two subgroups in each major group were used for analysis. These included: 1) no monitor (shunt and no shunt); 2) electroencephalographic (EEG) monitoring (shunt and no shunt); and 3) stump pressure (shunt and no shunt).

4. Classification of Operative Procedure — The categories for classification of the operation were as follows: single-stage unilateral endarterectomy; simultaneous bilateral endarterectomy; staged bilateral endarterectomy (bilateral procedures one week or more apart); endarterectomy combined with peripheral vascular procedure; and endarterectomy combined with coronary bypass.

5. Type of Procedure — Procedures were coded according to the type of closure used: endarterectomy without patch graft; endarterectomy with vein patch graft; or endarterectomy with fabric patch graft.

6. Type of Surgeon — Operative procedures were coded according to the type of surgeon: cardiovascular, peripheral vascular, general surgeon, and neurosurgeons.

C. Statistical Analysis

Chi square analysis was used for each of the six statistical analyses involving type of complication. Rank sum analysis was performed in looking at clinical indication for surgery versus type of surgeon.

Results

Types of complications were cross tabulated with each of the following six categories: 1) size of institution, 2) clinical indication for surgery, 3) classification of operation, 4) type of procedure, 5) type of intraoperative monitoring, 6) type of surgeon. Clinical indication for surgery was also cross tabulated with type of surgeon.

In the 3,328 cases reported, there were 82 postoperative TIA's or reversible ischemic deficits (2.5%), 44 minor strokes (1.3% incidence), and 96 major strokes (2.9%) giving an overall incidence of transient deficits of 2.5% and permanent deficits of 4%. There were 26 deaths from myocardial infarction (over 1% incidence) and 40 deaths due to stroke (1.2%). Thus there was a 2.5% risk of transient neurological dysfunction following surgery and a 6% risk of stroke or death from endarterectomy in the group.

In each of the six categories mentioned above, there was no statistically significant difference found in the frequency of transient or reversible neurological events postoperatively. The incidence of reversible events was 2 to 3% in each category of analysis.

A. Size of Institution

Institutional morbidity and mortality ranged from a high of 16% major stroke and 5% mortality to a low of 1.5% minor stroke with no deaths. When data were analyzed according to the size of the institution, there were no major or striking differences among any institutions except for those greater than 700 beds. Those institutions with greater than 700 beds had a statistically lower incidence of stroke or death than did other institutions (table 1) ($p < 0.005$).

B. Indication for Surgery

The incidence of stroke or death postoperatively was significantly ($p < 0.01$) lower for those patients who

TABLE 1 *Size of Institution vs. Major Morbidity and Mortality*

Size of institution	Total # of cases	Minor stroke able to work	Major stroke unable to work: Able to care for self	Major stroke unable to work: Unable to care for self	Death: Stroke	Death: MI	Total death & stroke
100–199	12	0	0	0	0	0	0
200–299	150	4 (2.7%)	2 (1.3%)	1 (0.7%)	1 (0.7%)	5 (3%)	13 (8.7%)
300–399	104	0	1 (1%)	6 (5.8%)	1 (1%)	1 (1%)	9 (8.7%)
400–499	446	4 (1%)	7 (1.6%)	10 (2.2%)	9 (2%)	4 (1%)	34 (7.6%)
500–599	588	10 (1.7%)	8 (1.4%)	8 (1.4%)	6 (1%)	4 (0.7%)	36 (6.1%)
600–699	327	8 (2.4%)	6 (1.8%)	6 (1.8%)	8 (2.4%)	6 (1.8%)	34 (10.4%)
700–799	255	1 (0.4%)	2 (0.8%)	1 (0.4%)	4 (1.6%)	0	8 (3%)
800–899	199	3 (1.5%)	3 (1.5%)	7 (3.5%)	1 (0.5%)	0	14 (7%)
over 900	1242	14 (1.1%)	16 (1.3%)	12 (1%)	10 (0.8%)	6 (0.5%)	58 (4.7%)

were operated on for amaurosis fugax or for unspecified reasons as compared to those patients who had their operations for: asymptomatic bruit; TIA; dizziness; vertigo, or syncope; mild stroke; severe stroke; progressing stroke; or as a prelude to surgery elsewhere in the body (Table 2). However, there were no significant differences between those of amaurosis fugax and asymptomatic bruit. Those patients operated on for progressing stroke had a higher incidence (although not significant) of stroke or death postoperatively than those in the other categories.

C. Classification of Operation

In looking at the incidence of stroke or death postoperatively compared to the classification of operation there was no statistical difference in the incidence among categories in the single-stage unilateral endarterectomy, staged bilateral endarterectomy, or endarterectomy combined with peripheral vascular procedure. When these three classifications were compared to endarterectomy combined with coronary bypass or simultaneous bilateral endarterectomy there was a statistically higher incidence of stroke or death in these latter two categories than in the three aforementioned groups (table 3) ($p < 0.005$).

D. Type of Procedure

There was a statistically significant difference among the complication rate of stroke and death vs. the type of closure with vein patch grafting being the lowest risk group analyzed (table 4). Vein patch grafting was statistically better than both fabric patch grafting and primary closure ($p < 0.01$). This could be skewed data as the technique of vein patch grafting was used as the preferred method of closure at one large center with a low morbidity and mortality. Balanced against this, however, was the use of this technique by other groups only for their complicated cases.

E. Type of Monitoring

When all patients who were monitored with EEG or stump pressures were compared to patients who were not monitored, there was a statistically significant difference in favor of the EEG group (table 5) ($p < 0.005$); but no difference in the group monitored with stump pressures. It was difficult to evaluate the use of a shunt in monitored patients as the shunt was placed when monitoring techniques indicated a need for same.

In nonmonitored patients, cases which were operated without a shunt did significantly better than patients

TABLE 2 *Indication for Surgery vs. Major Morbidity and Mortality*

Indication for surgery	Total # of cases	Minor stroke able to work	Major stroke unable to work: Able to care for self	Major stroke unable to work: Unable to care for self	Death: Stroke	Death: MI	Total death & stroke
Amaurosis fugax	461	0	5 (1.1%)	6 (1.3%)	0	3 (0.7%)	14 (3%)
Asymptomatic bruit	396	3 (0.8%)	3 (0.8%)	4 (1%)	7 (1.8%)	4 (1%)	21 (5.3%)
TIA	1283	25 (1.9%)	16 (1.2%)	20 (1.6%)	10 (0.8%)	11 (0.9%)	82 (6.4%)
Dizziness, vertigo, syncope	336	5 (1.5%)	5 (1.5%)	6 (1.8%)	7 (2%)	1 (0.3%)	24 (7%)
Minor stroke	388	4 (1%)	9 (2.3%)	7 (1.8%)	8 (2.1%)	2 (0.5%)	30 (7.7%)
Major stroke	51	0	0	0	4 (7.8%)	1 (2%)	5 (9.8%)
Progressing stroke	38	2 (5.3%)	2 (5.3%)	2 (5.3%)	2 (5.3%)	0	8 (21.1%)
Prelude to surgery elsewhere	176	4 (2.3%)	3 (1.7%)	3 (1.7%)	1 (0.6%)	3 (1.7%)	14 (8%)
Other or unspecified	195	1 (0.5%)	2 (1%)	3 (1.5%)	1 (0.5%)	1 (0.5%)	8 (4%)

TABLE 3 *Classification of Operation vs. Major Morbidity and Mortality*

Classification of operation	Total # of cases	Minor stroke able to work	Major stroke unable to work: Able to care for self	Major stroke unable to work: Unable to care for self	Death: Stroke	Death: MI	Total death & stroke
Single stage unilateral endarterectomy	2535	31 (1.2%)	38 (1.5%)	39 (1.5%)	32 (1.3%)	12 (0.5%)	152 (6%)
Simultaneous bilateral endarterectomy	27	0	0	1 (3.7%)	2 (7.4%)	1 (3.7%)	4 (15%)
Staged bilateral one week or more apart	623	8 (1.3%)	6 (1.0%)	5 (0.8%)	6 (1.0%)	8 (1.3%)	33 (5.3%)
Combined with peripheral vascular procedure	39	2 (5.0%)	0	1 (2.6%)	0	1 (2.6%)	4 (10.3%)
Combined with coronary bypass	98	3 (3.1%)	1 (1.0%)	5 (5.1%)	0	4 (4.1%)	13 (13.3%)

who were operated with a shunt ($p < 0.005$). Thus, if no monitoring was used, it appeared to be statistically safer to operate the patient without a shunt than with a shunt.

F. Type of Surgeon

There were statistical differences related to surgical complications and the type of surgeon doing the operation, but this information is probably not valid on a sampling basis. The difficulty in making such an analysis obviously refers to the bias of the sampling group in that neurosurgeons with good results were probably more inclined to pursue this form and report their results than were neurosurgeons with bad results. Furthermore, if they knew that bad results were being obtained in their hospitals by vascular and cardiovascular surgeons and they themselves were not tending to do the surgery, they were still more likely to fill out the form.

An analysis concerning the type of surgeon vs. the indication for surgery is of some interest. The rank-sum type of analysis based on table 6 was used for this examination. Here the indications for surgery were divided into two groups: the "solid" or tangible indications for surgery and "less solid" or disputable indications for surgery. These "solid" or tangible indications for surgery included: amaurosis fugax, TIA, mild stroke, severe stroke (with however important residual function), or progressing stroke. The "less solid" or disputable indications for surgery included: asymptomatic bruit; dizziness, vertigo or syncope; and prelude to surgery elsewhere in the body. The cases with "other or unspecified indications for surgery" were not included in this analysis. Neurosurgeons ranked first in this analysis having more patients in the group considered as having solid indications for surgery.

Discussion

The results of this audit are self-explanatory. The variations concerning: indications for surgery, the type of operation performed, and the use of monitoring procedures indicates that there is as yet no consensus regarding any of these. Conflicting reports in the literature indicating excellent results with no monitoring,[1–5] routine closure of the arteriotomy,[2, 6] electroencephalographic monitoring,[7–10] no monitoring and no shunting,[2, 3] shunting routinely,[6] monitoring without shunting,[4] surgery under local anesthesia[11] and reliance upon stump pressures for the use of shunts[12, 13] leave the discriminating reader bewildered. Experienced surgeons adamantly support their position concerning their methods of arterial repair and thus an evaluation of these differences is difficult to achieve.[2, 6, 14–19] Among the major problems with any multicenter study are the variations in populations treated, the dedication of the correspondents and investigators, and the completeness of hospital records. Recognition of minor neurological deficits is often not the same from institution to institution and several community studies suggest minor complications are not always recorded.[20–23]

The original purpose of this investigation was to define the current state of the art. In that we only

TABLE 4 *Type of Procedure vs. Major Morbidity and Mortality*

Type of procedure	Total # of cases	Minor stroke able to work	Major stroke unable to work: Able to care for self	Major stroke unable to work: Unable to care for self	Death: Stroke	Death: MI	Total death & stroke
Primary closure	2714	37 (1.4%)	41 (1.5%)	44 (1.6%)	35 (1.3%)	22 (0.8%)	179 (6.6%)
Vein patch graft	266	3 (1.1%)	0	2 (0.8%)	0	1 (0.4%)	6 (2.3%)
Fabric patch graft	257	3 (1.2%)	4 (1.6%)	5 (1.9%)	5 (1.9%)	1 (0.4%)	18 (7.0%)
Unknown	84	1 (1.2%)	0	0	0	1 (1.2%)	2 (2.4%)

TABLE 5 *Cerebral Protection vs. Major Morbidity and Mortality*

Cerebral protection	Total # of cases	Minor stroke able to work	Major stroke unable to work: Able to care for self	Major stroke unable to work: Unable to care for self	Death: Stroke	Death: MI	Total death & stroke
No monitor							
Shunt	953	19 (2.0%)	19 (2.0%)	10 (1.0%)	20 (2.1%)	13 (1.4%)	81 (8.5%)
No shunt	955	6 (0.6%)	9 (0.9%)	23 (2.4%)	10 (1.0%)	5 (0.5%)	53 (5.5%)
EEG							
Shunt	462	2 (0.4%)	0	2 (0.4%)	2 (0.4%)	2 (0.4%)	8 (1.7%)
No shunt	511	7 (1.4%)	8 (1.6%)	5 (1.0%)	3 (0.6%)	3 (0.6%)	26 (5%)
Stump pressure							
Shunt	41	2 (4.9%)	0	0	1 (2.4%)	0	3 (7.3%)
No shunt	135	0	2 (1.5%)	3 (2.2%)	0	0	5 (3.7%)
Other/unknown	262	8 (3.0%)	7 (2.7%)	7 (2.7%)	4 (1.5%)	3 (1.1%)	29 (11%)

TABLE 6 *Type of Surgeon vs. Indication for Surgery*

Type of surgeon	Total # of cases	Amaurosis fugax	Asymptomatic bruit	TIA	Dizziness, vertigo, syncope	Mild stroke	Severe stroke	Progressing stroke	Prelude to surgery elsewhere	Unspecified or other
Cardiovascular	652	78	105	178	75	34	7	6	77	92
Peripheral vascular	707	102	97	245	87	67	11	6	67	25
General surgeon	245	26	22	96	42	24	3	1	19	12
Neurosurgeon	1720	254	172	764	132	263	30	25	13	67

achieved reports from 46 centers with 3,328 cases we fell far short of our original goal of 100–200 centers and 7,000 cases.

There is an admitted bias in this report in that neurosurgeons were the correspondents. Nevertheless, the above information reported here may serve as a benchmark for further studies and may represent a possible cross-section of carotid endarterectomy in North America today. Parenthetically, it should be noted, that there was considerable variability from institution to institution in the obvious time taken for preparation of the answered computerized form. This was a simplified computer form and only two code numbers required any comment. In those computer forms with more complete information in these areas, indicating possibly a more discriminating analysis, the reported complications were higher. Thus, this retrospective analysis may represent an optimistic report on the current state of the art.

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Appendix A

Current Status Carotid Endarterectomy-In-House Audit

Patient's Initials ______________ (for in-house surveyor's)

Column Item

1–3 ___ ___ ___ Institution code number — For All:

4–9 ___ ___ ___ ___ ___ ___ Case code number (leave blank) — Blank = unknown

10 ___ Size of institution:
- 1 = 100 to 199 beds
- 2 = 200 to 299 beds
- 3 = 300 to 399 beds
- 4 = 400 to 499 beds
- 5 = 500 to 599 beds
- 6 = 600 to 699 beds
- 7 = 700 to 799 beds
- 8 = 800 to 899 beds
- 9 = over 900 beds

11 ___ Regional location:
- 1 = New England/Canada
- 2 = Middle Atlantic
- 3 = South
- 4 = Mid-South
- 5 = Southwest
- 6 = West Coast
- 7 = Northwest
- 8 = Mid-West
- 9 = Hawaii and Alaska

12 ___ Type of institution:
- 1 = Private
- 2 = County-City
- 3 = University
- 4 = University-Affiliated
- 5 = Veteran
- 6 = District

13 ___ Sex of patient:
- 1 = male, 2 = female

14 ___ Clinical indication for surgery:
- 0 = Unspecified
- 1 = Asymptomatic bruit
- 2 = Prelude to surgery elsewhere in body such as coronary bypass, aortic aneurysm, etc.
- 3 = Amaurosis fugax
- 4 = TIA
- 5 = Dizziness, vertigo, light headedness, syncope, etc.
- 6 = Mild stroke (grade 1 or 2 paresis)
- 7 = Severe stroke (grade 3 or 4 paresis)
- 8 = Progressing stroke and/or crescendo TIA's
- 9 = Other (specify __________)

15 ___ Classification of operation:
- 1 = Single stage unilateral endarterectomy
- 2 = Simultaneous bilateral endarterectomy
- 3 = Staged bilateral endarterectomy (bilateral procedures 1 week or more apart)
- 4 = Combined with peripheral vascular procedure
- 5 = Combined with coronary bypass

16 ___ Type of procedure:
- 1 = Endarterectomy without patch graft
- 2 = Endarterectomy with vein patch
- 3 = Endarterectomy with fabric patch
- 9 = Unknown

17 ___ Cerebral protection:
- 1 = No shunt, no type of monitor
- 2 = Shunt, no type of monitor
- 3 = Stump pressure, no shunt
- 4 = Stump pressure, shunt
- 5 = EEG monitor, no shunt
- 6 = EEG monitor, shunt
- 7 = Xenon blood flow
- 8 = Other (i.e., stump, eeg; or local anesthetic; or shunt + local
- 9 = Unknown

18 ___ Type of complications:
- 0 = None
- 1 = TIA
- 2 = RIND
- 3 = Minor stroke with minimal residual deficit, employable
- 4 = Major stroke, unable to work; able to care for self
- 5 = Major stroke, unable to work and unable to care for self
- 6 = Intracerebral hemorrhage
- 7 = Death from stroke
- 8 = Death from myocardial infarction
- 9 = Other (specify __________)

19 ___ Time of complications:
- 0 = None
- 1 = Intra-operative
- 2 = Post-operative

20 ___ Neurologic evaluation:
- 1 = Neurologist or neurosurgeon prior to surgery
- 2 = Neurologist pre and post op
- 3 = Neurosurgeon preop
- 4 = Neurosurgeon prior to and following surgery
- 5 = No apparent neurological consultation
- 7 = Neurologist or neurosurgeon postop only
- 9 = Unknown

21 ___ Type of surgeon:
- 1 = Cardiovascular
- 2 = Peripheral vascular
- 3 = General surgeon
- 4 = Neurosurgeon
- 5 = Other
- 9 = Unknown

22–23 ___ ___ Age of patient

24–25 ___ ___ Days in hospital

Appendix B

Carotid Endarterectomy In-House Audit Institutions

Ann Arbor, MI, University of Michigan Hospital & VA Hospital

Augusta, GA, Eugene Talmadge Memorial Hospital & VA Hospital

Baton Rouge, LA, Baton Rouge General Hosp. & Our Lady of the Lake Medical Center

Billings, MT, Billings Deaconess & St. Vincent's Hospital

Birmingham, AL, University Hospital & VA Hospital

Boston, MA

Buffalo, NY, Dent Neurologic Institute of Millard Fillmore Hospital

Chatham, N.J., Morristown Memorial Hospital

Chatham, N.J., Overlook Hospital

Chapel Hill, NC; N.C. Memorial Hospital

Cincinnati, OH, Good Samaritan Hospital

Cleveland, OH, University Hospitals of Cleveland

Columbus, OH

Columbus, OH, Ohio State University Hospital

Concord, NH, Surgical Neurology Professional Association

Dallas, TX, Presbyterian Hospital

Des Moines, IA, Mercy Hospital

Detroit, MI, Henry Ford Hospital

Evansville, IN, Deaconess Hospital

Evansville, IN, St. Mary's Medical Center

Greenville, S.C., Greenville Memorial Hospital

Lexington, KY, University of Kentucky

Little Rock, AR, Baptist Medical Center

Little Rock, AR, St. Vincent's Infirmary

London, Ontario, University Hospital

Louisville, KY

Memphis, TN, Baptist Hospital

Memphis, TN, Methodist Hospital

Memphis, TN, St. Francis Hospital

Memphis, TN, VA Hospital

Minneapolis, MN, University of Minnesota Hospital

Minneapolis, MN, VA Hospital

Montreal, Quebec, Canada, Montreal Neurological Hospital

Norfolk, VA

Pascagoula, MS

Phoenix, AZ

Pittsburgh, PA, University of Pittsburgh

Regina, Saskatchewan, Canada, South Saskatchewan Hospital Centre

Rochester, MN, Mayo Clinic

San Diego, CA, Grossmont District Hospital

St. Cloud, MN

St. Louis, MO, Barnes Hospital & Jewish Hospital

Syracuse, N.Y.

Tulsa, OK, Hillcrest Medical Center

Wilmington, DE, Wilmington Medical Center & Thomas Jefferson University Hospital

Winston-Salem, NC, N.C. Baptist Hospital