Background and Purpose—Although the National Institutes of Neurological Disorders and Stroke (NINDS) has established time targets for the evaluation of acute stroke patients, little is known about how often these targets are met in the community. To track compliance with NINDS guidelines, Cuyahoga County Operation Stroke implemented a countywide data collection process that provides comparative reporting of hospital performance.

Methods—Data on the emergency department evaluation of stroke patients have been retrospectively collected since January 2000 by hospitals participating in Cuyahoga County Operation Stroke. All hospitals used a 1-page form that includes NINDS time target information.

Results—Median time to emergency department arrival for the 1003 patients in this cohort was 115 minutes; 382 patients (38%) arrived in <3 hours; 506 (50%) arrived in <6 hours. After arrival, median time to physician contact was 12 minutes, time to CT was 65 minutes, and time to imaging results was 105 minutes. Earlier arrival intervals after symptom onset were independently associated with shorter evaluation times. All time targets were met in patients receiving intravenous tissue plasminogen activator.

Conclusions—A countywide data collection system for acute stroke evaluation is feasible. In the Cleveland metropolitan area, time to physician contact is close to the recommended NINDS target. Time to CT and time to imaging results are substantially longer than recommended. However, there was wide variation between hospitals. The association between time to arrival, speed of evaluation, and administration of intravenous tissue plasminogen activator suggests that community physicians selectively accelerate the evaluation and management of potential thrombolysis candidates. (Stroke. 2003;34:994-998.)

Key Words: emergency service, hospital guideline adherence stroke thrombolysis

Intravenous tissue plasminogen activator (tPA), the only approved treatment for acute ischemic stroke, must be administered within 3 hours of symptom onset. The short time window has necessitated institution-wide changes in hospitals throughout the United States so that eligible stroke patients can be evaluated and treated with intravenous tPA.

To assist hospitals in assessing institutional readiness to give intravenous tPA, time targets for the evaluation of acute stroke patients were developed at a National Institutes of Neurological Disorders and Stroke (NINDS) Symposium on the Rapid Identification and Treatment of Acute Stroke. Although widely accepted, little is known about how well community hospitals are able to meet the proposed time targets. The few available studies involved hospitals that participated in thrombolytic clinical trials and may not be representative of other US institutions. Adding impetus to the need to better understand the ability of community hospitals to comply with these targets, the Brain Attack Coalition recently recommended the establishment of primary stroke centers. One proposed criterion for primary stroke center designation is documentation that the NINDS time targets can be met.

Operation Stroke (OS), an initiative of the American Stroke Association, has been a major force in organizing healthcare delivery systems in the United States to better manage acute stroke patients. Cuyahoga County, located in northeastern Ohio and including the Cleveland metropolitan area, has had an OS...
Materials and Methods

Members of the OS medical subcommittee worked with The Stroke Group (Englewood, Colo) to develop a succinct and user-friendly data form for use at all Cuyahoga County hospitals. A 5-page “Stroke Stats” data form, which was used as the initial starting point, underwent significant modifications with extensive community physician input. The final 2-page data form, very similar to Ethos, the Stroke Group’s current Web-based stroke registry data form, was approved by the medical subcommittee. To be a member of Cuyahoga County OS, hospitals are required to participate in data collection, which has been approved by the Institutional Review Board of all OS hospitals. Two pharmaceutical companies provided initial funding support to The Stroke Group to provide comparative hospital reporting to OS hospitals. No funding was provided for initial funding support to The Stroke Group to provide comparative hospital reporting to OS hospitals. Variation in speed of evaluation across hospitals began retrospective data collection on patients with a primary discharge diagnosis of stroke (International Classifications of Diagnosis, ninth revision, clinical modification codes 431 through 436.) in January 2000. To minimize collection on patients arriving at the ED within 6 hours of symptom onset had longer median times, although all other subgroups were fairly similar and near the national time target.

Factors Affecting Speed of Evaluation

Three separate linear regression analyses were performed to evaluate the independent effect of the variables sex, race, time period (divided into 3-month periods), time interval to arrival (≤2, 2 to 3, 3 to 6, >6 hours), and arrival by ambulance on the speed of 3 portions of the evaluation: time to physician contact (MD), time to CT, and time to imaging results. All covariates were entered as 1 block in each regression analysis. Log transformation of the time elements was done to normalize their distributions. All analyses were performed with the SPSS 9.0 statistical package.

Results

Of the 20 hospitals in Cuyahoga County, 14 collected data during the period of January 2000 to March 2001. Information was collected on 1003 patients, 50.4% of whom (506 of 1003) arrived within 6 hours of symptom onset (Table 1). The mean age of patients was 72.7 years, and 79.5% were white.

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Speed of Evaluation

Median time to MD was 12 minutes, close to the NINDS time target of 10 minutes (Table 2). Patients arriving >6 hours after symptom onset had longer median times, although all other subgroups were fairly similar and near the national time target. There were differences in the median time to MD across hospitals (P=0.001), which ranged from 0 to 32 minutes. Data on time to MD were documented in 67% of cases. Overall median time to CT was 65 minutes, with significantly longer times in patients arriving >6 hours from symptom onset. The only identified patient subgroup that met the NINDS time target were patients receiving intravenous thrombolysis. Median time to CT across hospitals ranged from 28 to 122 minutes (P=0.001). Data on time to CT were documented in 67% of cases. Median time to imaging results was 102 minutes, much longer than the recommended 45-minute goal. Patients receiving intravenous tPA were the only subgroup that met the
national time target. As with the other time measures, patients arriving >6 hours from symptom onset had longer median times to imaging results. There was wide variability in the median time to imaging results across hospitals, ranging from 43 to 193 minutes. Data were available in only 37.8% of patients.

Time to CT and time to imaging results were nonsignificantly longer for patients arriving within 2 hours of symptom onset who came to the ED between midnight and 4 AM (Table 3). There was no change in any of the evaluation times over the 15-month period (data not shown).

Method of Arrival
Stroke patients arrived by ambulance in 63.9% of cases. Ambulance use was inversely associated with time to arrival \((P=0.001)\). There was no significant difference in ambulance use according to race among any of the arrival intervals examined \((<2, 2 \text{ to } 3, 3 \text{ to } 6, >6 \text{ hours}; \text{ data not shown})\). Women had higher rates of ambulance use only among the 3-to-6-hour arrival interval \((67.2\% \text{ versus } 48.9\%, \text{ } P=0.043)\). There was no change in the use of ambulance over time \((P=0.476)\) with and without adjustment for time from symptom onset to arrival. Patients arriving by ambulance were evaluated more quickly, with significantly shorter unadjusted time to MD, time to CT, and time to imaging results (Figure 1).

Factors Affecting Speed of Evaluation
In regression analyses, factors independently associated with time to MD were arrival by ambulance \((P=0.007)\) and time from symptom onset to arrival \((\text{inverse relationship, } P=0.004)\). The only factor independently associated with time to CT and time to imaging results was initial time to arrival \((P=0.001)\). Sex, race, and date of arrival (divided into 3-month periods) had no significant independent effect on speed of evaluation.

Intravenous tPA Use
The rate of intravenous tPA use was 6.8% in this select population of patients and 18.9% in patients arriving within 3 hours of symptom onset. The mean\(\pm SD\) age of patients receiving intravenous tPA was \(69.1\pm13.4\) years, 78% were white, and 66% were women, similar to the overall sample. There was no difference in rates of intravenous tPA use among patients according to sex \((P=0.99)\) or race \((P=0.18)\). However, there was wide variability across hospitals in the rates of intravenous tPA use for patients with no documented exclusions, ranging from 6.8% to 100% \((P<0.001)\) for the 8 hospitals for which data were available (Figure 2). Notably, all evaluation times fell within the NINDS recommended time targets for patients receiving intravenous tPA.

Discussion
Since the approval of intravenous tPA, the evaluation of acute stroke patients has become a priority nationwide.\(^2,6–8\) However, most metropolitan areas or regional health systems do not systematically collect performance data on patients with acute stroke. The Cuyahoga County OS initiative demonstrates that a voluntary countywide stroke data collection

### TABLE 1. Patient Demographics, January 2000 to March 2001

| Patients, n | 1003 |
| Age, y | 72.7 |
| Mean | 72.7 |
| Median | 75 |
| Men, % | 44 |
| Race, % | 18.7 |
| Black | 79.5 |
| White | 100%
| Stroke subtypes, % | 84% |
| Ischemic | 6% |
| Hemorrhagic | 7% |
| Transient ischemic attack | 3% |
| Other or undefined | 70.1% |
| Imaging, % abnormal | 0.0%
| Time to arrival* | 0.0%
| Median (25th, 75th percentile), min | 115 [59, 238.7] |
| Mean (SD), min | 240 (±438.2) |
| <3 h, n | 396 |
| <6 h, n | 509 |
| *Available for 604 patients.

### TABLE 2. Speed of Evaluation

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Time to MD</th>
<th>Time to CT*</th>
<th>Time to Imaging Results*</th>
</tr>
</thead>
<tbody>
<tr>
<td>NINDS recommended time targets</td>
<td>10</td>
<td>25†</td>
<td>45</td>
</tr>
<tr>
<td>All patients</td>
<td>692</td>
<td>12 (0, 28.7)</td>
<td>671</td>
</tr>
<tr>
<td>Intravenous thrombolysis patients</td>
<td>65</td>
<td>2 (0, 10)</td>
<td>56</td>
</tr>
<tr>
<td>No recorded exclusions‡</td>
<td>224</td>
<td>10 (0, 25)</td>
<td>241</td>
</tr>
<tr>
<td>Arrival &lt;2 hr</td>
<td>253</td>
<td>7 (0, 20)</td>
<td>262</td>
</tr>
<tr>
<td>Arrival 2–3 hr</td>
<td>65</td>
<td>10 (0, 24)</td>
<td>53</td>
</tr>
<tr>
<td>Arrival 3–6 hr</td>
<td>101</td>
<td>10 (0, 25)</td>
<td>78</td>
</tr>
<tr>
<td>Arrival &gt;6 hr</td>
<td>59</td>
<td>20 (5, 40)</td>
<td>58</td>
</tr>
</tbody>
</table>

*Values in parentheses represent 25th and 75th percentiles.
†Excludes patients with an ED diagnosis of transient ischemic attack and ED transfers.
‡NINDS target refers to time to CT completion.
§Includes patients arriving within 3 hours who had no recorded exclusions to intravenous tPA therapy.
process is feasible. We believe important factors in the success of this process included the nonpunitive nature of the project and the ability for anonymous comparative reporting of individual hospital performance with the rest of Cuyahoga County in aggregate. In addition, to participate in OS, hospitals were required to collect data, which resulted in peer pressure among Cleveland hospitals. There was also stakeholder input with extensive community physician input into the data collection process. Finally, there was institutional support for the data collection process.

The NINDS stroke time targets were empirically established on the basis of the “golden hour” and the 1-hour door to needle time for acute myocardial infarction. The time targets were meant to be optimal guidelines for hospitals considering the administration of intravenous tPA for acute stroke; they were not based on any data to suggest that hospitals could in fact comply with the suggested targets. In the Cleveland region, time to initial MD contact is close to the recommended time target of 10 minutes. It took substantially longer, however, to obtain a CT than recommended by the NINDS. Our median time to initiation of a CT (time the patient was transported to CT) among patients arriving within 2 hours was 50 minutes, whereas the NINDS target for CT completion is 25 minutes. Our findings are in keeping with those of Morris et al,5 who found a median time to imaging of 1.1 hours in hospitals participating in a clinical tPA trial. Interestingly, time to CT was longer among patients arriving within 2 hours who came to the ED between midnight and 4 AM, suggesting that speed of obtaining a CT depends on the time of day. The CT time during all periods of the day should be a focus of quality improvement efforts because it is a significant limiting factor in the ability of hospitals to complete acute stroke evaluations and start therapy in a timely manner.

Neurological outcome after intravenous tPA is inversely related to the time from stroke onset to initiation of therapy.9,10 One potential explanation for the prolonged time to CT and time to imaging results, despite the prompt initial evaluation by physicians, is that only patients who may qualify for tPA or another acute intervention are entered into an accelerated stroke evaluation protocol. In fact, all time targets were met in patients who received intravenous tPA. Although we cannot exclude the possibility that their prompt evaluation enabled tPA patients to receive the therapy, earlier arrival intervals after symptom onset were independently associated with shorter evaluation times, which supports the presence of patient triaging. Thus, stratification according to the time interval to arrival is important in interpretation of individual hospital performance.

Caution should be used when interpreting data regarding the time imaging results were received. There was significant variability in times, possibly reflecting different and perhaps inconsistent methods of abstraction for this data element. The data element was present in only one third of the cases. For purposes of ongoing quality management, it may be useful to redefine the time targets in terms of data points that hospitals may reliably track.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Evaluation Times</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To MD</td>
</tr>
<tr>
<td>Midnight–3:59</td>
<td>11</td>
</tr>
<tr>
<td>4–7:59</td>
<td>19</td>
</tr>
<tr>
<td>8–11:59</td>
<td>51</td>
</tr>
<tr>
<td>Noon–15:59</td>
<td>81</td>
</tr>
<tr>
<td>16–19:59</td>
<td>50</td>
</tr>
<tr>
<td>20–23:59</td>
<td>41</td>
</tr>
</tbody>
</table>

Values in parentheses 25th and 75th percentiles.
*Excludes patients with an ED diagnosis of transient ischemic attack and ED transfers.

Figure 1. Median times to evaluation according to method of arrival. Patients with unknown method of arrival and with ED diagnosis of transient ischemic attack are excluded. Results are not adjusted for time from symptom onset to arrival. *Wilcoxon rank-sum test.

Figure 2. Intravenous tPA use across hospitals for patients with no documented exclusions. Results are for ischemic stroke patients arriving within 3 hours. Information was available for 8 hospitals.
The high percentage of missing data related to acute stroke management has been noted by others and highlights the importance of systematic approaches to improving documentation. The variability in available information raises the possibility of documentation bias; patients who were treated more swiftly according to protocol may be more likely to have times recorded in the chart, especially for poorly documented items such as time to interpretation. Cleveland-area hospitals are developing individual approaches to improve documentation. A strategy successful at 1 hospital has been placing the data form on the ED record, with those elements requiring ED physician input highlighted. Another potential strategy is the development of a standard ED documentation sheet for stroke patients that has reminders of inclusion and exclusion criteria for intravenous tPA, the elements necessary for billing, and the clinical and time elements important for the evaluation of institutional readiness. Prospective data collection is another option but would require extensive cooperation among physicians and nurses working all shifts in all EDs, reducing the chance that all hospitals in the county would be able to participate.

There is wide variation in speed of evaluation among hospitals, with median hospital times to initial MD contact ranging from 0 to 32 minutes and median hospital times to initiation of imaging ranging from 28 to 122 minutes. The rate of intravenous tPA use among potentially eligible patients ranged from 6.8% to 100% across hospitals. Although the percentage of tPA-eligible patients varies across institutions, these data suggest significant differences in Cleveland hospitals in either institutional preparedness or documentation, and we hope that the countywide data collection will alert poorly performing hospitals and rouse them to improve their system for managing acute stroke patients. Only 64% of patients arrived to the ED via ambulance. Patients arriving to the ED via ambulance had shorter times to contact with a physician, independent of the time from symptom onset to arrival. Although this may be due in part to a higher acuity of illness in these patients, the data suggest that in addition to being transported more quickly, the evaluation is initiated more quickly in patients using EMS. This has been found in other studies and is another reason to educate potential stroke patients regarding the importance of calling 911 if they have stroke-like symptoms.

There was no significant improvement in the speed of evaluation or patient use of EMS transport over the 15-month period that this information was collected, despite the active presence of OS in our county. However, there was no opportunity to use the data to effect change. Cleveland hospitals received only 1 report near the end of the 15-month period. We strongly recommend that community projects use a system that allows immediate reporting of the data such as that available from Web-based software. Cuyahoga County OS began using Ethos, the Internet version of the form that provides immediate comparative reports, in November 2001. Currently, 18 of 20 hospitals in Cuyahoga County and 1 affiliated hospital from neighboring Geauga County are actively entering data through the Internet.

Our regional data collection system has several limitations, including lack of information on the reliability of the data. In this initial effort, auditing of charts was not feasible. We hope that funding for this type of activity will become possible with the Stop Stroke Act currently before Congress. In addition, as discussed above, a significant percentage of specific time points was missing. We are actively working to improve the routine documentation of this information in the hospitals in Cleveland. Although a list of exclusion criteria for intravenous tPA was part of the data collection, the completeness of chart abstraction for these items is not known. Despite these limitations, this countywide quality improvement effort has demonstrated a community-wide commitment to optimize stroke care and provided important insights into the care of stroke patients in the Cleveland metropolitan region.

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References

Cuyahoga County Operation Stroke: Speed of Emergency Department Evaluation and Compliance With National Institutes of Neurological Disorders and Stroke Time Targets

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