ABSTRACT

Context: Tissue plasminogen activator (tPA) is underutilized for treatment of acute ischemic stroke.

Objective: To determine whether the probability of tPA administration for patients with ischemic stroke in an integrated health care system improved from 2009 to 2013, and to identify predictors of tPA administration.

Design: Retrospective analysis of all ischemic stroke presentations to 14 Emergency Departments between 2009 and 2013. A generalized linear mixed-effects model identified patient and hospital predictors of tPA.

Main Outcome Measures: Primary outcome was tPA administration; secondary outcomes were door-to-imaging and door-to-needle times and tPA-related bleeding complications.

Results: Of the 11,630 patients, 3.9% received tPA. The likelihood of tPA administration increased with presentation in 2012 and 2013 (odds ratio [OR] = 1.75; 95% confidence interval [CI] = 1.26-2.43; and OR = 1.63; 95% CI = 1.24-1.86 respectively), and decreased with increasing age (OR = 0.98; 95% CI = 0.97-0.99), ambulance arrival (OR = 0.33; 95% CI = 0.22-0.49), and female sex (OR = 0.61; 95% CI = 0.47-0.80). Likelihood varied by Emergency Medical Center (pseudo-intraclass correlation coefficient 13.5%). Among tPA-treated patients, median door-to-imaging time was 15 minutes (interquartile range, 9-23 minutes), and door-to-needle time was 73 minutes (interquartile range, 55-103 minutes). The rate of intracranial hemorrhage was 4.2% and 0.9% among tPA- and non-tPA treated patients (p < 0.001).

Conclusion: Acute ischemic stroke care improved over time in this integrated health system. Better understanding of differences in hospital performance will have important quality-improvement and policy implications.

INTRODUCTION

As US health care reform leads to growth of the accountable care organization model, it is important to understand how these systems perform in the care of patients with ischemic stroke. Integrated health systems, with aligned incentives and efficiencies, function similarly to accountable care organizations. However, aside from the Veterans Health Administration, patterns of acute ischemic stroke care delivery in an integrated health system have not been well described,1 and other settings have reported underuse of recommended acute ischemic stroke treatment.2-5

This study describes patterns of tissue plasminogen activator (tPA) delivery in an integrated health system (Kaiser Permanente Southern California [KPSC]), which comprises multiple Emergency Departments and hospital systems, and serves approximately 3.8 million members. Our primary objective was to determine whether the probability of tPA administration for patients with acute ischemic stroke in the KPSC system has improved from 2009 to 2013, and to identify predictors of tPA administration. Secondarily, we aimed to describe trends in door-to-imaging time and door-to-needle time metrics during the same period, and to describe complication rates among patients treated with tPA. In 2014, the KPSC health care system implemented a telemedicine stroke (“telestroke”) initiative to improve the delivery of ischemic stroke care. This report will provide important baseline performance data to inform future analyses of the telestroke implementation.

METHODS

Data Source and Populations

Structured data from electronic health and administrative records identified all patients presenting to a KPSC Emergency Department between 2009 and 2013 with a primary or secondary diagnosis of ischemic stroke (International Classification of Diseases, Ninth Revision [ICD-9] codes 433.xx, 434.xx, 436). Patients were seen at 1 of 14 KPSC Medical Center Emergency Departments (EDs) of varying size and urbanicity (degree to which a geographic region is urban), 2 of which are academic with inhouse neurology house staff. We excluded patients younger than age 18 years, those with a stroke within 90 days, and those with missing or implausible outcome variables. Human subjects approval was obtained through the KPSC institutional review board.
Outcome Measures

The primary outcome was tPA administration, identified by pharmacy code. Secondary outcome variables were door-to-imaging time and door-to-needle time for tPA delivery. Complications examined included intracranial and gastrointestinal bleeding, defined as ICD-9 codes of 432.xx, 430, 431 and 578.xx. One of the authors (AS) reviewed all patients’ charts in which there was a question about the presence of the outcome variable.

Statistical Analysis

Patient and hospital characteristics were summarized as percentages, means (standard deviation [SD]), or median (interquartile range, [IQR]) as appropriate. Descriptive statistics were used to determine the proportion of patients receiving tPA as well as the mean and median door-to-imaging and door-to-needle times. The annual trend in tPA administration was assessed by ED by plotting the annual proportions by year, separately for each ED.

We used a generalized linear mixed-effects model, with a logit link, to identify patient and hospital predictors of tPA administration. Hospital-level random intercepts were included to account for between-hospital variation in baseline rates of tPA use and to allow for any variation in tPA use caused by unmeasured hospital-level factors. Patient-level covariates included in the model were age, race, sex, prior-year stroke, and Elixhauser comorbidity score. Additionally, the following variables describing the presentation of the patient encounter were included in the analysis: arrival by ambulance, arrival from a skilled nursing facility, arrival during “off-hours” (defined as between 5 pm and 8 am Monday through Friday, or anytime Saturday or Sunday), and year of diagnosis. Variation in rates of tPA administration caused by hospital-level variables was assumed to be captured in the hospital-level random intercept. A modified version of the multivariable model treated hospital as a fixed effect to assess whether the annual trend in tPA use varied by ED, after adjusting for the relevant patient and presentation characteristics. When necessary, the likelihood ratio test was used to compare the fit of competing models.

Because change in tPA administration varied between hospitals (Figures 1 and 2), we also tested a multivariable model that included a random slope for year of diagnosis, to allow the change in stroke volume over time to vary between EDs, but we found no significant improvement in model fit compared with the final model.

All descriptive analyses were conducted using statistical software (SAS Version 9.3, SAS Institute Inc, Cary, NC). Figures 1 and 2 and multivariable model results were obtained via the R Project for Statistical Computing software package (Free Software Foundation, Boston, MA).

RESULTS

A total of 11,630 patients with ischemic stroke were seen at the 14 KPSC EDs during the 2009 to 2013 study period. Approximately half were women (49.6%); 47.8% of patients were white, 25.4% were Hispanic, 17.5% were black, 8.4% were of Asian or Pacific Island origin, and 0.9% were other races or ethnicities. Comorbidities included diabetes (31.9%), hypertension (63.2%), heart failure (12%), atrial fibrillation (13.9%), and valvular heart disease (8.6%). A minority of patients arrived by ambulance (37.2%).

Of the overall sample, 3.9% of patients were treated with tPA; the proportion of tPA-treated patients increased during the study period from 2.6% in 2009 to 6.4% in 2013.
Although our overall rate of tPA administration is 74 (58-96) All years 2334 79 (62-112) 94 (67-128) 2013 58 (35-87) 11,630 87 (3.7) 2011 15 (9-22) 2010 16 (8-29) 2343 40.3 53 (2.3) 2163 51 (29-81) 32 31.1 55 (34-84) 13 (8-22) 453 (3.9) 46 (23-76) 2475 2012 73 (55-103) 47 (23-76) 2011 67 (50-89) 47 (25-79) 2010 13 (9-20) 58 (35-87) 2009 15 (9-23) 149 (6.4) 13 (8-22) 87 (3.7)
Our study has several limitations. Because we were unable to determine the time of symptom onset because of inherent limitations of our data, we were unable to define the population of patients eligible for tPA. However, other reports have described rates of tPA administration among all patients with ischemic stroke, and our results can be interpreted in this context. Our use of ICD-9 codes for sample specification and to identify treatment complications may have introduced bias to the sample; however, on a limited chart review by the authors, we found that the ICD-9 codes were appropriately identifying patients with ischemic stroke, and we did not note any change in documentation over the study period to suggest that this would bias the trends we report. We were further limited by our data in our inability to capture the National Institutes of Health Stroke Scale for all patients. Although we were unable to account for stroke severity, we did include the Elixhauser comorbidity index to capture the acuity of patients’ presentation. We were also unable to determine patient eligibility for tPA; thus, it is possible that other factors led to increased tPA utilization. For example, public awareness campaigns may have increased the proportion of patients arriving within the appropriate time window for eligibility, or clinicians may have become more aware of or more comfortable with administration of the treatment. Finally, we may have introduced bias by excluding patients with missing or implausible door-to-imaging times; however, we opted to include only those patients in whom the ED time course and care delivery were consistent with presentation of acute ischemic stroke to avoid the alternative bias of a misspecified sample.

CONCLUSION

In the KPSC integrated health system, acute ischemic stroke care delivery is improving over time, as evidenced by increased rates of tPA delivery and improved door-to-imaging and door-to-needle times. Better understanding of differences in hospital performance in an integrated system will have important implications for quality improvement and policy development.

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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References


Apoplexy

This apoplexy, as I take it, is a kind of lethargy, an’t please your lordship; a kind of sleeping in the blood, a whoreson tingling … It hath its original from much grief, from study and perturbation of the brain. I have read the cause of his effects in Galen. It is a kind of deafness.

— Henry IV, Part II, I, ii, 126, William Shakespeare, 1564-1616, English poet, playwright, and actor