A stroke care has highly time-dependent treatments that require teams of personnel to achieve good outcomes. It is estimated that for every minute the middle cerebral artery remains blocked in an ischemic stroke, 1.9 million neurons are lost. Reducing the variance and improving door-to-needle (DTN) time for thrombolysis and time from computed tomography (CT)-to-groin puncture for endovascular therapy will improve outcomes for patients with stroke. Therefore, reducing variance and improving treatment times are critical components for quality assurance efforts in stroke care. Feedback of DTN performance data has been used in quality improvement initiatives for acute stroke treatment. In a similar manner, we have observed that the first step of simply providing healthcare personnel with their measured metrics is an inducement to improve and work faster. However, the acute stroke performance data need to be presented in manner that is easy to understand, and it should be available through commonly used modalities to facilitate widespread use.

**Innovation**

**Background on Information Visualization**

Information visualization is a discipline in its own right that combines graphical display in static or dynamic form to reveal a new understanding of data. In clinical medicine, novel methods of information visualization can lead to improved clinical outcomes at both the population and individual levels. Famously, in the mid-1800s, John Snow was able to isolate a contaminated water-well and show that cholera was water born by mapping the location and frequency of cholera infections in London’s Soho district. Florence Nightingale used her rose petal graphic to show the rise in mortality because of hospital-acquired infections during the Crimean war. Simplifying clinical concepts into graphics that are easy to understand can provide insight into the causes of poor health outcomes and lead to positive changes.

**Visualizations in Health Care**

There has been a rise in the use of information visualization to understand and share healthcare performance and to improve quality of care. Many health organizations are using balanced scorecards and dashboards to visualize clinical and operational information. These visualizations have been adopted from the business sector and allow for goal setting and performance measurement along various dimensions such as financial, customer experience, and operations to monitor performance. Typically, these visualizations show tabular data with color-coding to indicate good and poor performance.

**Innovation: Acute Stroke Visualization**

We have designed new visualizations of acute stroke data as part of our improvement program. We have been working on ways to improve the time to thrombolysis (DTN) and endovascular therapy at our center (Foothills Medical Centre) in Calgary, Alberta, Canada. As part of our improvement efforts, we have created weekly reports. The main purpose of the reports is to (1) provide clinicians involved in the acute care of patients with stroke with an understanding of their weekly performance in the speed of thrombolysis and endovascular therapy and (2) show the performance over several months to allow clinicians to discern whether there are improvements in treatment times and any reduction in variation. The design of the weekly reports involved an iterative approach with feedback from stroke neurologists. We designed charts for the weekly reports using Microsoft Excel 2010 (Seattle, WA), the reports are created using Microsoft Word 2010 (Seattle WA), and they are distributed in PDF format (Adobe Systems, San Jose, CA). We chose readily available desktop software, so that the reports were easy to maintain and generate every week by one of our stroke nurses (CS). We adopted standard benchmarks for stroke treatment from the literature on intravenous tissue-type plasminogen activator...
treatment and from our experience with the Endovascular Treatment for Small Core and Proximal Occlusion Ischemic Stroke (ESCAPE) trial for endovascular treatment.

Results

There were 3 principal visualizations or charts that resulted from our iterative design methodology. The first chart (Figure 1) shows a side-by-side visualization of DTN performance (left) and endovascular performance (right) for the week. The main purpose of this chart is to show the interval times for each patient treated, so that the clinicians can better understand the time each step takes in the treatment of patients with stroke during that week. If a patient receives both tissue-type plasminogen activator and endovascular treatment, the bars will align horizontally across the 2 graphs (patients 1 and 3 in Figure 1); thus the charts are to be reviewed together.

The door-to-CT is shown in blue (on both the left and right), the CT-to-tissue-type plasminogen activator is shown in red (on the left), and the CT-to-groin puncture is shown in purple (right). The left chart is aligned at the door time (when the patient arrives at the hospital), and the DTN goal is shown as a vertical red line representing the total in-hospital time that the team is targeting. Figure 1 visually relays that it took patient 4 a long time (85 minutes) to have tissue-type plasminogen activator administered despite moving to the CT scanner quickly (8 minutes from door-to-CT), providing insight that there may be improvements to be made to efficiently treat the patient after the noncontrast CT. The right chart is aligned at the CT start time. The use of the brain imaging as the start time is based on the concepts used in the ESCAPE trial to select patients based on their imaging.4 The goal for CT-to-puncture is shown by a vertical purple line. The time to CT is still shown, but this is now to the left of the zero time. In the example shown in Figure 1, both endovascular patients had their treatment start within the goal of CT-to-groin puncture of 45 minutes.

The trend for DTN time and its variance is shown in Figure 2. A solid blue line shows the median time for each month and the dashed blue line shows the 75th percentile. The red solid line shows the median goal and the dashed red line shows the goal for 90th percentile (DTN=60 minutes). In addition, the start of a new improvement initiative (called Hurry Acute Stroke Treatment and Evaluation [HASTE] III in our case) is indicated by a vertical green line. This chart allows easy visualization of any observed improvement over time, and the amount of variability in DTN time as indicated by the 75th percentile line. For example, the month of December 2014 had high DTN variance (75th percentile=73.8 minutes) compared with the median DTN time of 45.5 minutes.

Figure 3 shows the endovascular performance for our site over time. Each CT-to-groin puncture time is shown with a mark, and the goal line is shown as a red line. Once again, a green vertical line indicates the commencement of a new improvement initiative. This chart shows, at a quick visual glance, an understanding of the number of endovascular cases that were treated within our goal. We lowered our goal from 45 to 30 minutes when we started our new improvement initiative, as our visualization showed that we were often successful in meeting our previous goal.3

The excel workbook that was used to create these charts can be found at http://www.ucalgary.ca/quicr/files/quicr/sample-stroke-visualization-worksheet.xls. It is freely available.

Figure 1. Weekly acute stroke treatment performance. This chart shows the door-to-needle times (left) and endovascular times (right) for each patient, and a patient will align across the 2 charges if they receive both treatments. Times are real data from the Foothills Medical Centre.

Figure 2. Monthly acute stroke interval times. This chart shows the median and 75th percentile for each month for door-to-needle (DTN) time. Times are real data from the Foothills Medical Centre. Hurry Acute Stroke Treatment and Evaluation (HASTE) III is an ongoing local quality improvement project.

Figure 3. Endovascular performance for week of Jan 30 - Feb 5. This chart shows the door-to-needle times (left) and endovascular times (right) for each patient, and a patient will align across the 2 charges if they receive both treatments. Times are real data from the Foothills Medical Centre.
Picture to Puncture Performance Over Time

![Graph showing picture to puncture performance over time.](image)

**Figure 3.** Endovascular treatment acute stroke performance. This chart shows the door-to-puncture time for endovascular treatment. Times are real data from Calgary and include patients enrolled into the ESCAPE trial. HASTE III is an ongoing local quality improvement project. CT indicates computed tomography; ESCAPE, Endovascular Treatment for Small Core and Proximal Occlusion Ischemic Stroke; and HASTE, Hurry Acute Stroke Treatment and Evaluation.

We share these charts by pasting them into a word document, converting to PDF and emailing a report weekly to individuals on the stroke team, emergency department, and Emergency Medical Services. The reports are created and distributed by CS and the email includes qualitative feedback on each patient who was treated during the week and provides some context to delays in treatment. We have been using these weekly reports since November 2014, and there has been an increase in dialogue about acute stroke performance.

One of the successes and ease of creation for these visualizations is the simplicity of their design and use of common desktop software tools. The visualizations are maintained and updated by one of our nurses, who did not require additional training on a new software tool; furthermore, there is no need for an analyst or quality improvement consultant to generate these reports each week. The report is sent to >58 clinicians at our center, which allows for a large group of people to receive the report regularly in a familiar format and understand treatment performance at a glance.

**Conclusions**

Through the use of common desktop tools, we have found that it is possible to create simple visualizations that provide insight into potential delays, improvements over time, and variation in treatment times for acute stroke treatment. We have been able to achieve this with existing resources and no additional training or software.

Quality improvement efforts are critical to ensure rapid translation of knowledge into practice. Feedback of data and performance is vital for staff and trainees to understand their performance and to ascertain whether changes are leading to improvements. Visualizations such as these for improving DTN time and picture-to-puncture time should be used along side a broad array of strategies than streamline treatment.\(^9\) This visualization can be implemented at other centers, and the excel file is available for use (http://www.ucalgary.ca/quicr/files/quicr/sample-stroke-visualization-worksheet.xls).

**Sources of Funding**

Partial funding for the ESCAPE trial was provided by Covidien to the University of Calgary.

**Disclosures**

None.

**References**


**Key Words:** acute stroke • quality improvement • tissue-type plasminogen activator