Poststroke dysphagia occurs in 29% to 78% of patients with stroke and is associated with increased risk of pneumonia, hospital readmissions, and increased mortality.1 Guidelines recommend dysphagia screening for patients with acute stroke and referral to speech/language pathologists for those with abnormal results.2 Dysphagia screening in patients with acute stroke before oral intake is a hospital-level performance measure in nationwide stroke care quality improvement (QI) programs including the Paul Coverdell National Acute Stroke Registry.3 This measure is defined as: “Percentage of ischemic and hemorrhagic stroke patients who undergo a screen for dysphagia using a simple, valid bedside testing protocol before receiving any food, fluids or medication by mouth.”

In the Minnesota Stroke Registry (part of the Paul Coverdell National Acute Stroke Registry), although overall care quality was high, performance on the dysphagia screening measure was low for ischemic strokes (range, 30%–60%) and still lower for hemorrhages. We report outcomes of a focused QI initiative addressing compliance to the dysphagia screening measure at 1 registry hospital.

Methods
A pre- versus postintervention comparison design was used. The intervention was an electronic medical record (EMR) -based clinical decision support system (CDS) embedded within the stroke admission orders. The intervention goal was dysphagia screening performance measure (DSPM) compliance improvement.

Results—DS measure compliance increased from 36% to 74% (P=0.001). Chart audits found screened patients were more likely to have clinical DS-embedded admission orders initiated or stroke unit admission.

Conclusion—The electronic medical record offers a ready platform for clinical DS implementation. DS is a difficult performance measure to improve. The described clinical DS has the potential for improving performance on this challenging care quality measure. (Stroke. 2012;43:3399-3401.)

Key Words: clinical decision support ◼ dysphagia screening ◼ EMR ◼ organized stroke care ◼ outcomes ◼ stroke care ◼ stroke units

Impact of an Electronic Medical Record-Based Clinical Decision Support Tool for Dysphagia Screening on Care Quality

Kamakshi Lakshminarayan, MD, PhD; Nassir Rostambeigi, MD, MPH; Candace C. Fuller, MPH; James M. Peacock, PhD; Albert W. Tsai, PhD, MPH

Background and Purpose—Dysphagia screening (DS) before oral intake in patients with acute stroke is a hospital-level performance measure. We report outcomes of an initiative to improve compliance to this quality measure.

Methods—The design was a pre- versus postintervention comparison study. The Intervention was an electronic medical record-based clinical DS system embedded within stroke admission orders. The clinical DS was designed to facilitate DS in patients with stroke. The primary outcome was compliance to a process measure in patients with ischemic stroke: performance of a swallow screen before oral intake.

Results—DS measure compliance increased from 36% to 74% (P=0.001). Chart audits found screened patients were more likely to have clinical DS-embedded admission orders initiated or stroke unit admission.

Conclusion—The electronic medical record offers a ready platform for clinical DS implementation. DS is a difficult performance measure to improve. The described clinical DS has the potential for improving performance on this challenging care quality measure. (Stroke. 2012;43:3399-3401.)

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The online-only Data Supplement is available with this article at http://stroke.ahajournals.org/lookup/suppl/doi:10.1161/STROKEAHA.112.662536/-/DC1.

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DSPM compliance was assessed by examining the dysphagia screen time as documented in the EMR admission history or admission orders. Patient intake and medication records were examined for times of food, fluids, or medication intake and were compared with dysphagia screening times.

Additional Data
Place of care delivery (ie, stroke unit admission) and use of the EMR stroke orders (neither were mandatory stroke registry data elements) were collected on a random sample of patients to examine CDS use and reasons for DSPM noncompliance.

Intervention
An EMR-based CDS embedded in stroke admission orders had the following key components (the online-only Data Supplement has details): (1) dysphagia screening flowchart accessible through a hyperlink (Figure). Currently, no consensus designated standard dysphagia screen tool exists. Hence, the Figure flowchart is institution-specific and is not being promoted as standard of care. The online-only Data Supplement discusses the dysphagia screen design; (2) hard stop dysphagia screening order to be completed before admission orders could be signed; (3) default nothing by mouth diet, which had to be unselected to choose a different diet option; and (4) prompt for documentation of dysphagia screening time and results in the EMR admission note. The intervention went online in November 2009; providers were trained through December 2009.

Analysis
Patient characteristics and intervention outcomes were compared preintervention (Year 2009) and postintervention (Years 2010–2011) using STATA IC 10 (StataCorp, College Station, TX). Chi-square test or Fisher exact test was used to determine statistical significance for categorical variables; Student t test was used for continuous variables.

Results
Between 2009 and 2011, the study hospital entered 1387 acute events into the stroke registry. After exclusions (361 transient ischemic attacks/stroke mimics; 94 intubated or nothing by mouth throughout hospitalization), 952 events were included. Online-only Data Supplement Table I compares patient characteristics pre- versus postintervention.

There were significant differences in pre- versus post intervention DSPM compliance (Table 1). Ischemic stroke compliance rose from 36% to 74% (P=0.001). Hemorrhagic stroke compliance rose from 4% to 28% (P=0.001).

Audit of a random sample of 50 charts from the postintervention period revealed that screened patients were more likely to have been admitted to the stroke unit and/or had the CDS-embedded order set initiated (Table 2).

There was no difference in secondary patient outcomes including mean length of hospital stay, in-hospital mortality, or pneumonia rates pre- versus postintervention.

Discussion
The following was learned. First, the EMR offers a ready platform for CDS. EMR-based CDS for improving stroke
Table 1. Outcomes are Pre- and Postimplementation of Clinical Decision Support (CDS) Orders for Dysphagia Screening*

<table>
<thead>
<tr>
<th>Primary outcome</th>
<th>No. (%) Pre- and Post-CDS Intervention Total N=952</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-CDS (N=369)</td>
<td>Post-CDS (N=583)</td>
</tr>
<tr>
<td>Ischemic strokes (N=706)</td>
<td>101/278 (36)</td>
<td>316/428 (74)</td>
</tr>
<tr>
<td>Hemorrhagic strokes (N=246)</td>
<td>4/91 (4)</td>
<td>44/155 (28)</td>
</tr>
<tr>
<td>Secondary patient outcomes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of stay, d, mean (±SD)</td>
<td>6.6 (+6)</td>
<td>6.9 (+6)</td>
</tr>
<tr>
<td>In-hospital pneumonia</td>
<td>34 (9)</td>
<td>42 (7)</td>
</tr>
<tr>
<td>In-hospital mortality</td>
<td>31 (8)</td>
<td>32 (5)</td>
</tr>
</tbody>
</table>

*The primary outcome is compliance to dysphagia screening performance measure.

Table 2. Stroke Order Set Use (With Embedded Dysphagia Screening Decision Support) and Stroke Unit Admissions for Cases Compliant With the Dysphagia Screen Performance Measure Versus Noncompliant Cases*

<table>
<thead>
<tr>
<th>Dysphagia Screen Measure Compliance</th>
<th>Yes (N=25)</th>
<th>No (N=25)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke unit admission</td>
<td>16 (64)</td>
<td>8 (32)</td>
<td>0.04</td>
</tr>
<tr>
<td>Stroke order set initiated</td>
<td>22 (88)</td>
<td>10 (40)</td>
<td>0.001</td>
</tr>
<tr>
<td>No stroke unit admission AND</td>
<td>1 (0.04)</td>
<td>12 (48)</td>
<td>0.001</td>
</tr>
<tr>
<td>No stroke order set initiated</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*A random sample of 50 cases from Year 2011 was examined.

rates may be explained by insufficient power to detect intervention effects and short hospital stays precluding detection of evolving pneumonia cases. In our prior work, unscreened patients had higher aspiration pneumonia rates than screened patients. Hinchey et al found institutions with formal dysphagia screening protocols had lower pneumonia rates. Hence, interventions improving screening rates such as EMR-based CDS will decrease pneumonia rates and improve outcomes.

We acknowledge our study is not a randomized controlled trial. There is ongoing debate about the role of randomized controlled trials in evaluation of QI interventions. Although randomized controlled trials are the gold standard for evaluating simple therapeutic interventions (eg, medication trials), the complexity of most QI interventions creates challenges for randomized controlled trial design and implementation. Randomized controlled trials testing QI intervention evaluation are ideally resource-intensive group randomized trials in which the units of randomization are hospitals rather than individual patients. In our study, because the CDS was a change in hospital ischemic stroke order sets, patients could not be randomized; hence, all patients with ischemic stroke received the intervention. Patients with hemorrhagic stroke formed a natural concurrent control group because the CDS was not yet implemented in order sets used in their care.

We concur with experts that QI intervention evaluation should use a wide range of methodologies. Our pre/post study design is commonly used in evaluating QI interventions; furthermore, we used a group of concurrent hemorrhagic stroke controls and undertook an additional evaluative step (Table 1) to understand the intervention’s effectiveness and if other factors (eg, stroke unit care) were facilitating measure compliance (Table 2).

Dysphagia screening is a difficult measure to improve care quality. Despite multiple national stroke QI initiatives, reports of EMR-embedded CDS targeting stroke care are lacking. To our knowledge, the only similar report is an EMR-based “smart order set” for venous thromboembolism prophylaxis.

CDS implementation was associated with improved DSPM compliance. Compliance was associated with order set use and stroke unit admission. Noncompliance was higher when both factors were absent (Table 2). Despite the CDS, measure compliance remained imperfect. One reason for imperfect compliance was frequent change of providers at the study hospital, requiring repeated orientation to order sets and CDS use.

Hemorrhagic strokes, typically admitted to surgical services without CDS admission order sets, showed poor DSPM compliance. Nevertheless, even in hemorrhagic strokes, measure compliance improved. A 2009 accreditation review at the study hospital identified DSPM compliance as an improvement area. Hence, hospital attention given to dysphagia screening in patients with stroke may explain improved care quality in hemorrhagic strokes.

Although our study showed a significant intervention effect in the primary, process outcome, there was no improvement in secondary clinical outcomes of pneumonia or in-hospital mortality. Lack of statistical significance in secondary outcome
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