A Cost-Effectiveness Analysis of Screening Methods for Dysphagia After Stroke

Richard D. Wilson, MD, MS, Evan C. Howe, MD, PhD

Objective: To provide a cost-effectiveness analysis of dysphagia screening in the acute poststroke period with use of a videofluoroscopic swallowing study, a clinical bedside swallowing evaluation, or a combined approach.

Design: Decision-analysis model.

Methods: A decision-analysis model was used with information derived from multiple data sources, including meta-analyses and other relevant clinical studies. Univariate and probabilistic sensitivity analyses were performed.

Main Outcome Measures: The analysis assessed direct medical costs of pneumonia. Strategies were compared on the basis of an incremental cost-effectiveness analysis, with effectiveness measured in quality-adjusted life-years.

Results: The strategy of having each patient undergo a videofluoroscopic swallowing study for dysphagia was more effective and less costly than the strategies of clinical bedside swallowing evaluation alone or a combined approach. The model was most influenced by the reduction in the risk of pneumonia attributable to the treatment of mild/moderate and severe dysphagia, the effectiveness of treatment with clinical bedside swallowing evaluation, the baseline probability of pneumonia, and the cost of a videofluoroscopic swallowing study.

Conclusions: A videofluoroscopic swallowing study is cost-effective and often saves costs compared with a clinical bedside swallowing evaluation alone or a combined approach. Research aimed at improving the understanding of the effectiveness of treatment for dysphagia in the prevention of aspiration pneumonia and resulting mortality would improve the model.

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INTRODUCTION

Dysphagia is common after stroke and contributes to the subsequent morbidity and mortality experienced by stroke survivors. Stroke survivors with dysphagia experience dehydration, malnourishment, poorer outcomes, and greater morbidity [1-3]. Aspiration pneumonia, in particular, is more common in dysphagic stroke survivors and is related to increased mortality [1,2,4-7]. The risk has been well recognized, and guidelines have recommended that formal dysphagia screening protocols be put in place for stroke survivors [8-11]. Although the need for dysphagia screening may be well understood, no consensus exists about the method of screening that should be used.

The videofluoroscopic swallowing study (VFSS), also called the modified barium swallow study, is considered the criterion standard but comes at a substantial monetary cost, entails radiation exposure, has limited standardization, and is not feasible for all patients [12]. A clinical bedside swallowing evaluation (CBSE) is an often-used alternative and is generally free of additional costs. A chief complaint concerning the CBSE is that it is not a sensitive enough screening test [13-16]. Many clinical evaluations for dysphagia rely on the patient to cough or a have an audibly wet sound to phonation in response to ingested water. The primary drawback of this method is the phenomenon of "silent aspiration," or the lack of external response to aspirated material, which results in a falsely negative examination being obtained by the examiner [17,18]. The risk to silent aspirators is compounded because they are at greater risk of experiencing pneumonia than are those who have an overt external response to aspiration on examination [19].

R.D.W. MetroHealth Rehabilitation Institute of Ohio, MetroHealth Medical Center, 2500 MetroHealth Dr, Cleveland, OH 44109; and Case Western Reserve University School of Medicine, Cleveland, OH. Address correspondence to R.D.W.; e-mail: rwilson@metrohealth.org

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E.C.H. Fairview Hospital-Cleveland Clinic Family Medicine Program, Cleveland, OH

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Clinicians who care for stroke survivors in the acute setting are faced with determining how best to diagnose dysphagia. The body of literature about dysphagia does not establish a best practice for screening. In the absence of data and clear findings to guide the choice of a diagnostic method, a model that uses the best available data can improve the decisions made by medical providers. The objective of this study is to provide a cost-effectiveness analysis of dysphagia screening by a VFSS, a CBSE, or a combination of these methods in the acute setting for stroke survivors.

METHODS

We developed a decision-analysis model with use of information derived from published studies and performed univariate and probabilistic sensitivity analyses. We compared 3 strategies for the detection of dysphagia in acute stroke survivors: (1) the VFSS for all acute stroke survivors, (2) the CBSE followed by a VFSS for those who have clinical dysphagia, and (3) the CBSE alone. We assessed the direct medical costs from a societal perspective. Strategies were compared on the basis of incremental cost-effectiveness analysis, with effectiveness measured in quality-adjusted life-years (QALYs).

Decision Model

The decision model was developed with TreeAge Pro 2011 (TreeAge Software, Inc., Williamstown, MA) (Figure 1). The reference case for this model is a typical hospitalized stroke survivor who does not have previous evidence of dysphagia or a contraindication for the examination and who is able to participate in the examination. The 3 strategies we compared in the decision analysis are the VFSS, the CBSE, or a CBSE for each stroke survivor followed by a VFSS for those with clinically abnormal swallows.

Persons who experience dysphagia have a greater risk of pneumonia. Persons who have dysphagia with aspiration have a greater risk of pneumonia than do persons who have dysphagia without aspiration. The risk of pneumonia is ameliorated by appropriate preventative measures implemented after dysphagia is detected. Contraction of pneumonia incurs a greater risk of mortality. The time horizon for pneumonia is the acute hospitalization. The time horizon for mortality caused by pneumonia is short term, during the acute care hospitalization, with effectiveness accounting for the improved life expectancy beyond the end of the model's time horizon. The analysis assesses the direct medical costs in 2010 U.S. dollars from a societal perspective. Strategies were compared on the basis of incremental cost-effectiveness analysis, with effectiveness measured in QALYs.

Discussion of Parameters, Estimates, and Major Assumptions

The parameters and estimates for this study are listed in Table 1 [6,14,17,20-32]. The parameter estimates were derived from a literature review wherever possible. Estimates that were not available in the literature were obtained from expert opinion (physicians from the lead author's institution with 10 or more years of experience in dysphagia evaluation with the VFSS and the CBSE in stroke survivors). The rationale for the estimated variables is provided in the following sections.

Prevalence of Dysphagia With and Without Aspiration. The authors of 3 studies diagnosed swallowing abnormalities with the use of VFSS in patients during the acute poststroke period and found the prevalence of dysphagia without aspiration to be between 35%-42% and the prevalence of dysphagia with aspiration to be between 22%-22.5% [33-35]. Studies that only diagnosed aspiration in the acute poststroke period with the use of VFSS estimated the prevalence of aspiration to be 21%-38% [13,14,17,20,36,37]. For this study, the point estimate for the prevalence of dysphagia with aspiration is 20%, with a range of 10%-30%, and the

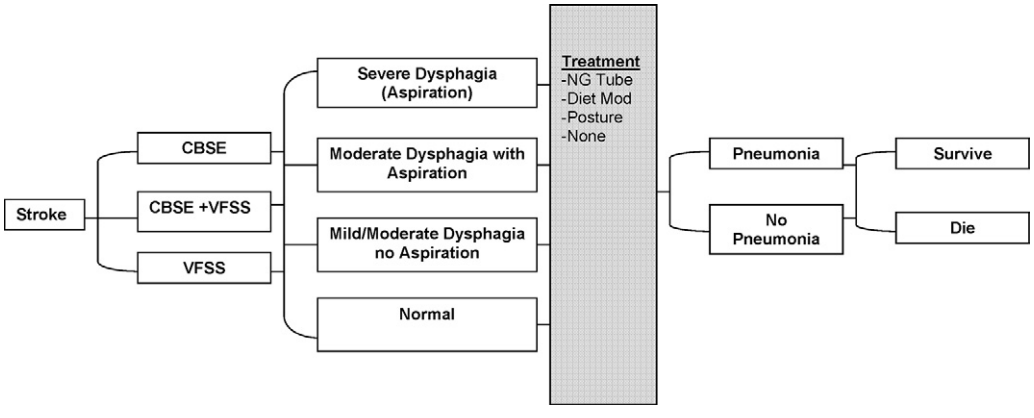


Figure 1. Decision tree. CBSE = clinical bedside swallow evaluation; Diet Mod = diet modification; NG = nasogastric; VFSS = videofluoroscopic swallow study.

Table 1. *Parameter list (plus ranges for sensitivity analysis and distributions for probabilistic sensitivity analysis)**

Variable	Baseline	Low	High	Distribution	Source(s)
Prevalence					
Mild and moderate dysphagia (without aspiration)	0.35	0.30	0.40	Beta	Estimate
Moderate and severe dysphagia (with aspiration)	0.20	0.10	0.30	Beta	Estimate
Pneumonia risk					
Probability of pneumonia, no dysphagia	0.037	0.02	0.08	Beta	Estimate
Relative risk of pneumonia with dysphagia, no aspiration	2.0	1.0	3.0	Log-Normal	Estimate
Relative risk of pneumonia with dysphagia and aspiration	7.0	5.0	9.0	Log-Normal	Estimate
Reduction in relative risk for pneumonia with treatment					
Mild/moderate dysphagia	0.9	0	1	Beta	Estimate
Severe dysphagia	0.5	0	1	Beta	Estimate
Reduction in treatment effectiveness with CBSE	0.75	0	1	Beta	Estimate
Mortality risk					
Probability mortality	0.045	0.04	0.05	Beta	6
Relative risk of mortality with pneumonia	2.0	1.9	2.1	Log-Normal	6
CBSE accuracy					
Sensitivity aspiration	0.68	0.52	0.86	Beta	14, 17, 20, 22-24
Specificity aspiration	0.67	0.5	0.86	Beta	14, 17, 20, 22-24
Sensitivity dysphagia	0.69	0.5	0.85	Beta	24
Specificity dysphagia	0.46	0.35	0.6	Beta	24
Costs					
VFSS initial	$337	$250	$500	Normal	26
VFSS follow-up	$245	$200	$300	Normal	26
Nonoral feeding	$1,187	$500	$1,500	Gamma	21, 26-28
Pneumonia	$25,000	$20,000	$30,000	Gamma	6, 25
Outcomes					
Median life expectancy, y	4	3.5	4.5	Normal	29, 30, 32
Quality of life	0.47	0.42	0.52	Beta	31
Dead	0				

CBSE = clinical bedside swallow evaluation; VFSS = videofluoroscopic swallowing study.
*Explanation of parameters, estimates, and major assumptions are listed in the online methods supplement (http://stroke.ahajournals.org).

prevalence of dysphagia without aspiration is estimated to be 35%, with a range of 30%-40%.

Severity of Dysphagia. The proportions of survivors with various severities of dysphagia, which is modeled to influence effectiveness of treatment, were determined on the basis of expert opinion and guided by published studies. For this model, it is assumed that half of those who experienced dysphagia with aspiration have severe dysphagia and the remaining half have moderate dysphagia. This assumption is based on a study of stroke survivors, 11% of whom had severe dysphagia [38], which is approximately half of those who are found to aspirate in other studies. It is assumed that patients who have dysphagia without aspiration have mild or moderate dysphagia, based on 2 studies in which 36%-39% of stroke survivors had mild dysphagia and 28%-50% had moderate dysphagia [17,38]. Thus in this model, 5%-15% of stroke survivors will have severe dysphagia with aspiration; 5%-15% will have moderate dysphagia with aspiration; and 30%-40% will have mild or moderate dysphagia without aspiration.

Risk of Pneumonia With Dysphagia. Few investigators have estimated the risk of pneumonia for differing degrees of dysphagia severity documented by a VFSS among stroke survivors in the acute setting. The authors of a cohort study found that pneumonia developed within 2 weeks in 68% of those who aspirated within 3 days of admission compared with 6% in persons who did not aspirate [39]. When adjusted for the severity of stroke by stratified analysis, the relative risk (RR) for pneumonia in persons who aspirated was 7.0 (95% confidence interval [CI] 1.7-28.5). Unfortunately, no information is provided on how the severity of stroke was determined or at what level the groups were stratified.

The authors of one mixed pathology cohort of patients referred for a VFSS, with stroke being the single largest group, evaluated the occurrence of pneumonia within 6 months of a VFSS based on the severity of dysphagia [19]. Those who aspirated had a greater risk of pneumonia compared with those who had a normal VFSS (22.4% versus 2.7%; calculated RR 10.3, 95% CI 3.5-30.8), and those who had dysphagia without aspiration had a greater risk of pneumonia than did those with a normal VFSS (9% versus 3%; calculated RR 3.5, 95% CI 1.1-10.7). These findings likely overestimate the RR of pneumonia during the acute setting because the time frame for pneumonia was longer than a

typical acute stay, selection bias was present, and adjustment for important confounders was not performed. The estimates for this study of a risk of pneumonia of 7.0 for those with aspiration (range, 5.0-9.0) and a risk of pneumonia of 2.0 for those with dysphagia (range, 1.0-3.0) are assumptions based on the aforementioned studies and their limitations.

Baseline Pneumonia Risk. Researchers have estimated that the incidence of pneumonia in stroke survivors who do not have swallowing abnormalities is between 3%-16% [1,2,4,35,39-43]. These studies are limited because the authors did not use a VFSS to establish dysphagia or may not have distinctly diagnosed aspiration [1,40,43], provided vague descriptions of pneumonia diagnosis [1,2], or combined dysphagic and nondysphagic stroke survivors for analyses [39,41]. Thus the probability of pneumonia in persons who do not have dysphagia was derived with the use of a historical average of poststroke pneumonia incidence of 9.2% for "controls" who did not undergo dysphagia screening [44] and the proportionally weighted relative risks of pneumonia for dysphagic patients with and without aspiration. The derived estimate for baseline pneumonia risk is 3.7%, with a range of 2%-8%.

Risk of Mortality After Pneumonia. The RR of dying during the acute care hospitalization for stroke survivors who experience pneumonia is based on a study of a national sample of adult stroke survivors that found an adjusted RR of 2.0 (95% CI 1.9-2.1) [6]. The baseline mortality rate was estimated from the same study by calculating the attributable risk percent [45] and removing that proportion from the mortality rate of those with pneumonia to find a mortality rate if pneumonia was prevented. The baseline mortality rate if pneumonia was prevented is estimated to be 4.5% (range, 4%-5%).

Effectiveness of Treatment. Little is known about the effectiveness of treatments in preventing pneumonia. In practice, multiple treatments and strategies are used in various combinations in an attempt to decrease aspiration, and treatments often are tailored to the individual. The primary methods are to restrict consistencies of food or liquid intake to those that move slowly through the oral and pharyngeal cavities, increase the force of peristalsis, and reduce swallowing delay [46-50]. Aspiration was decreased by 75.5% in subjects with neurologic impairment when boluses of thicker consistency were administered [51]. Postural change has been shown to improve aspiration in 77% of a group of aspirators with neurologic impairment and eliminate it in 25% [52].

The authors of one study evaluated the incidence of pneumonia in a population with stroke after implementation of a comprehensive dysphagia treatment program in which a VFSS was used. In this study, patients with dysphagia who were treated with swallowing therapy, postural changes, diet alteration, or nonoral feeding had a 3-month incidence of pneumonia of 1.8%, which is considerably lower than published rates of pneumonia [17]. The authors of 2 studies have shown that a formal dysphagia screening program reduces the incidence of aspiration pneumonia, and one completely eliminated it, although the diagnostic criteria for aspiration pneumonia are not provided [7,53]. The many individualized treatment options for stroke survivors with dysphagia, combined with little research into effectiveness, required an estimate based on opinion for the effectiveness of treatment for this study. The effectiveness of treatment for mild to moderate dysphagia in reducing aspiration pneumonia, with or without aspiration, was estimated at 90%, with a wide range due to uncertainty of the estimate (range, 0%-100%). The effectiveness for severe dysphagia with aspiration was handled differently, as explained in the next paragraph.

Administration of complete nonoral nutrition, often by a nasogastric tube or a gastrostomy tube, is not completely effective at preventing pneumonia. This strategy often is reserved for patients who are the most severely ill or have severe dysphagia. It is believed that these patients are at a greater risk of pneumonia despite treatment because nonoral feeding does not protect them from aspirating their own secretions. The severity of stroke has been found to be a risk factor for the development of pneumonia in the acute poststroke setting among patients who receive nasogastric tube feeding for dysphagia [21]. It has been found that patients with dysphagia in the postacute care setting who received nasogastric tube feeding were more disabled, had greater cognitive impairments, and had an incidence of aspiration pneumonia 5.5 times the rate of that of dysphagic patients receiving modified diets who were less impaired [54]. In this model, the effectiveness of nasogastric tube feeding in the prevention of pneumonia in persons who had severe dysphagia with aspiration was estimated to be 50%, with a wide range due to uncertainty of the estimate (range, 0%-100%).

The effectiveness of treatment for dysphagia detected by a CBSE, compared with treatment prescribed by a VFSS, also is unknown. In this model, it is assumed that a CBSE is not as effective in preventing aspiration pneumonia because less information is available to providers to allow tailored treatment interventions. Whereas the VFSS provides real-time visual information from the oral and pharyngeal cavities about various bolus volumes, bolus textures, and compensatory strategies on swallowing, the CBSE relies on external signs of dysphagia only. Thus it is assumed that the effectiveness of treatment for dysphagia or aspiration detected by a CBSE is 75% as effective as a treatment prescribed after a VFSS, with a wide range due to uncertainty (range, 0%-100%).

The Clinical Bedside Evaluation Test Characteristics. Multiple versions of the clinical bedside evaluation have been created. A commonly used method is to monitor for external signs of aspiration, such as coughing or a wet voice, after the stroke survivor ingests a sip of water [22]. This method served as the prototype CBSE for the literature search for sensi-

tivity and specificity for detecting dysphagia with and without aspiration. Only comparisons to a VFSS were included. The sensitivity for dysphagia with aspiration is 68% (range, 50%-86%), with a specificity of 67% (range, 50%-86%) [13,14,17,18,20,22-24]. The sensitivity of the CBSE for detecting dysphagia without aspiration is 69% (range, 50%-85%) with a specificity of 46% (range, 35%-60%) [24].

Costs. Costs are presented in 2010 U.S. dollars (Table 1). Cost estimates, with the exception of the incremental cost of pneumonia, came from the literature or from the 2010 Medicare fee schedules. When necessary, established costs from the literature were inflated using the medical component of the Bureau of Labor Statistics Consumer Price Index. Costs were not discounted because of the short interval for costs to be incurred.

Cost of Pneumonia. The cost of pneumonia, based on a national sample of stroke survivors, is estimated to be $28,599 (95% CI $28,024-$28,966) [6]. In this study the average marginal cost of pneumonia on hospitalization was based on adults, with those who died within 3 days of hospitalization being excluded. The hospital costs were adjusted for comorbid illness, likelihood of experiencing pneumonia, severity of illness, setting from which the patient was transferred, teaching status of the hospital, and rural/urban setting of the hospital. The authors of a regional study limited to Medicare beneficiaries estimated that the cost of pneumonia, inflated to 2010 U.S. dollars, is $22,109 (95% CI $21,512-$22,705) [25]. Because of the uncertainty of differences in cost estimates, the cost estimate in this study was $25,000, with a range of $20,000-$30,000.

Cost of the VFSS. The cost of a VFSS was estimated with use of the Medicare fee schedules [26] to establish costs for an examination by a team of providers. The costs include the physician and technical fees for radiology, the physician professional fee for the examination, and the technical fee for a speech-language pathologist. A first-time VFSS is $337 (range, $250-$500), and a follow-up VFSS is $245 (range, $200-$300), reflecting the lower fee for a physician follow-up.

The Cost of Nonoral Feeding. The cost for nonoral feeding was found in one article by Hamaoui et al [27]. Costs included the feeding formula, the administration set, the pump, the tubes, other supplies, the irrigation solution, and the irrigation kit, which are estimated to be an average daily cost of $106.37. One study estimated that the average time for nonoral feeding after stroke was 10.3 days [21]. Current practice often includes obtaining an abdominal film to ensure proper gastric placement. The technical and professional fees from the Medicare fee schedules [26] for an average 3.7 abdominal films per patient were included [28]. The total estimated cost for nonoral feeding was $1187 (range, $500-$1500).

Estimation of Quality-Adjusted Life Expectancy. The median life expectancy after stroke is approximately 4 years (range, 3.5-4.5 years) from the index hospitalization, with a range of 3.5-4.5 years based on studies of long-term outcomes after stroke [29,30]. Life expectancy was not discounted because the life expectancy is relatively short. The health-related quality of life (QOL) after a stroke is estimated to be 0.47 (range, 0.42-0.52), based on the North East Melbourne Stroke Incidence Study [31]. QALYs are an estimation of health-related QOL and length of life in a state of health that is less than perfect. To obtain the QALY estimation, the QOL is multiplied by the estimated median life expectancy. In the baseline estimate from this study, the median life expectancy of a stroke survivor is 4 years, and the QOL is 0.47, so the quality adjusted life expectancy is 1.88 QALYs (range, 1.68-2.12).

Estimation of Life Expectancy. The median life expectancy for persons who have sustained a stroke is approximately 4 years (range, 3.5-4.5 years) after the index hospitalization, with a range of 3.5-4.5 years based on studies of long-term outcomes after stroke [29,30,32]. We did not discount life because the life expectancy was relatively short.

Calculation of Cost-Effectiveness

The cost-effectiveness was estimated as the incremental cost incurred for each additional QALY gained, or the incremental cost-effective ratio. Incremental cost-effectiveness is the additional cost of one strategy versus another compared with the additional effectiveness delivered.

Table 2. *Base-case results*

Strategy	Cost	Incremental Cost*	Effectiveness, QALYs	Incremental Effectiveness*	ICER*
VFSS	$1853	—	1.791	—	—
CBSE + VFSS†	$1943	$90	1.790	(−0.001)	Dominated‡
CBSE	$1968	$25	1.789	(−0.001)	Dominated‡

QALY = quality-adjusted life-year; ICER = incremental cost-effectiveness ratio; VFSS = videofluoroscopic swallow study; CBSE = clinical bedside swallow evaluation.

*Incremental cost, effect, and cost-effectiveness ratio calculated in reference to the next less costly strategy.

†CBSE followed by VFSS for abnormal swallows.

‡More costly and less effective.

Sensitivity Analyses

To assess the effect of uncertainty around our estimates and assumptions, we performed a one-way sensitivity analysis of our model by varying each parameter within the specified ranges (Table 1). To assess the effect of multiple sources of uncertainty, we performed a Monte Carlo probabilistic sensitivity analysis using parameter-specific distributions (Table 1). The model was recalculated 1000 times with the use of randomly sampled parameter values from their specific probability distributions. Cost-effectiveness was calculated in each iteration to produce an empirical distribution of model results.

RESULTS

Base-Case Results

Table 2 presents results from the base-case analysis of a typical hospitalized survivor of a stroke without previous dysphagia. The strategy of having each patient undergo a VFSS for dysphagia was more effective and less costly than the strategies of using a CBSE alone or the combined approach of using both a CBSE and a VFSS for abnormal swallows. The VFSS strategy led to an outcome of 1.791 QALYs at a cost of $1853.

Table 3. *Selected univariate sensitivity analyses (undominated strategies)*

	Strategy	Cost	Effectiveness	ICER*
Baseline probability of pneumonia				
0.02	VFSS	$1269	1.79308	$92,937
	CBSE + VFSS	$1216	1.79251	$171,538
	CBSE	$1163	1.79220	
0.08	VFSS	$3330	1.78611	—
	CBSE + VFSS	$3784	1.78383	Dominated
	CBSE	$4003	1.78261	Dominated
Proportion aspirators (of all with dysphagia)				
0.1	VFSS	$1611	1.79164	$34,021
	CBSE + VFSS	$1589	1.79099	$12,844
	CBSE	$1585	1.79064	—
0.3	VFSS	$2095	1.79056	
	CBSE + VFSS	$2294	1.78910	Dominated
	CBSE	$2351	1.78832	Dominated
Reduction of relative risk for pneumonia with treatment of mild/moderate dysphagia				
0	VFSS	$2568	1.78869	$469,848
	CBSE + VFSS	$2432	1.78840	$634,086
	CBSE	$2334	1.78824	—
1.0	VFSS	$1773	1.79137	—
	CBSE + VFSS	$1889	1.79023	Dominated
	CBSE	$1927	1.78962	Dominated
Reduction of relative risk for pneumonia with treatment of severe dysphagia				
0	VFSS	$2120	1.79020	$13,353
	CBSE + VFSS	$2125	1.78902	Dominated
	CBSE	$2104	1.78902	—
1.0	VFSS	$1586	1.79201	—
	CBSE + VFSS	$1762	1.79066	Dominated
	CBSE	$1832	1.78994	Dominated
Reduction of relative risk for pneumonia with treatment by clinical diagnosis				
0	VFSS	$1853	1.79110	—
	CBSE + VFSS	$1943	1.79005	Dominated
	CBSE	$2471	1.78778	Dominated
1.0	VFSS	$1853	1.79110	$49,759
	CBSE + VFSS	$1943	1.79005	Dominated
	CBSE	$1800	1.79005	—
Cost of VFSS				
$250	VFSS	$1766	1.7911	—
	CBSE + VFSS	$1901	1.79005	Dominated
	CBSE	$1947	1.78948	Dominated
$500	VFSS	$2016	1.7911	$5269
	CBSE + VFSS	$2024	1.79005	Dominated
	CBSE	$2007	1.78948	—

ICER = incremental cost-effectiveness ratio; VFSS = videofluoroscopic swallow study; CBSE = clinical bedside swallow evaluation.
*ICER: cost/quality-adjusted life-year, calculated in reference to the next less costly strategy.

Sensitivity Analysis

The model is relatively robust with regard to the estimates for the variables. The model was most influenced by the reduction in risk of pneumonia as the result of treatment of mild/moderate and severe dysphagia, the effectiveness of treatment with a clinical bedside swallowing evaluation, the baseline probability of pneumonia, and the cost of a VFSS (Table 3). If the baseline risk for pneumonia is less than 1.5%, then a VFSS is not considered cost-effective compared with a CBSE for willingness to pay for a QALY of $50,000. If willingness to pay for a QALY is $100,000, a VFSS remains a cost-effective strategy if the baseline risk for pneumonia is greater than 1.15%.

The probabilistic sensitivity analysis (Figure 2) indicated that the optimal strategy is a VFSS in more than 48% of the trials with the willingness to pay $1 for an additional QALY, 57% of the trials with the willingness to pay $50,000 for an additional QALY, and more than 64% of the trials with the willingness to pay $100,000 for an additional QALY. Comparison of the VFSS to the CBSE demonstrated a probability of 61% that the VFSS is cost-effective with the willingness to pay $50,000 for an additional QALY and a probability of nearly 53% that the VFSS is less expensive and more effective than a CBSE (Figure 3).

DISCUSSION

Without clear guidance as to which strategy is best for screening and prescribing treatment for dysphagia, a well-constructed model can be used to improve decisions made by providers and policy makers. The results of this study indicate that, given the estimates of this model, a VFSS commonly would be considered cost-effective in the acute poststroke period for detecting dysphagia and prescribing treatment compared with a CBSE alone

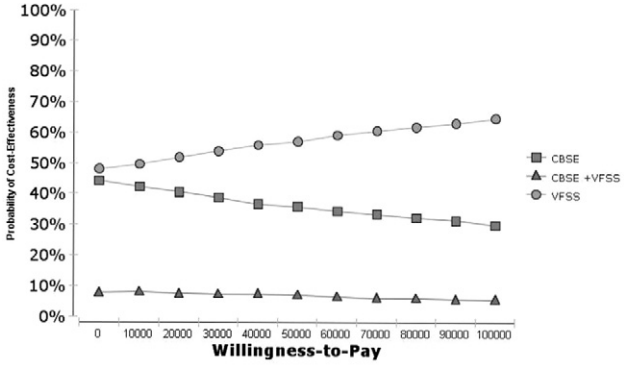


Figure 2. Acceptability curve of the probabilistic sensitivity analysis. The graph indicates the probability that videofluoroscopic swallow study is cost-effective compared with clinical bedside swallow evaluation and a combined approach for differing levels of cost for each quality adjusted life-year gained, taking into account the uncertainties of the model.

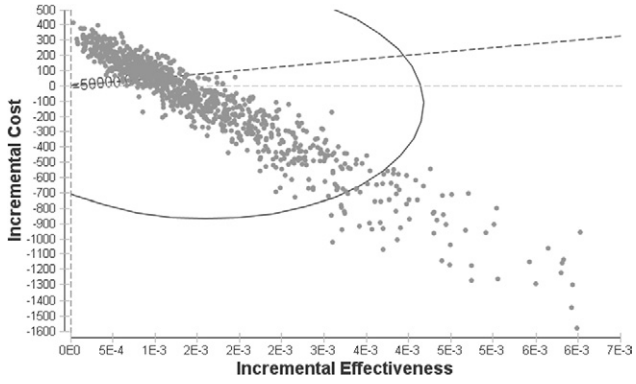
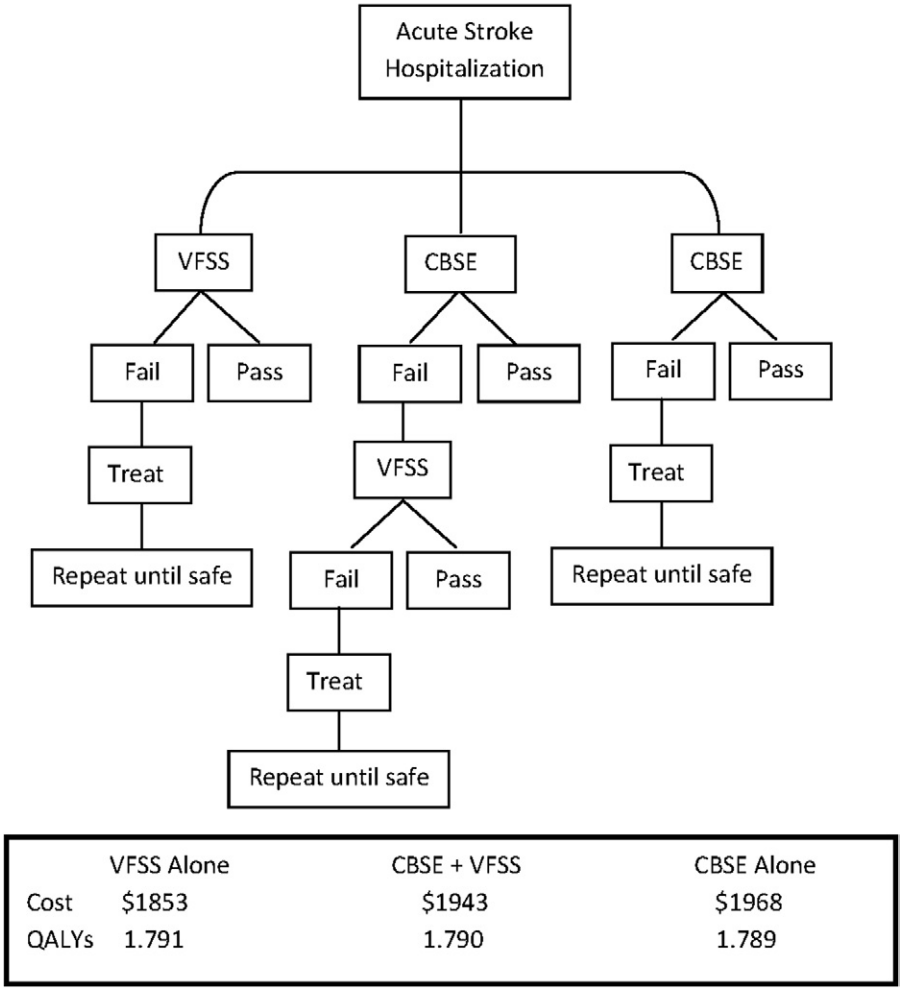


Figure 3. Scatter plot of incremental cost-effectiveness, videofluoroscopic swallow study versus clinical bedside swallow evaluation. The points represent the incremental cost and effectiveness values from the simulation based on videofluoroscopic swallow study relative to clinical bedside swallow evaluation. The ellipsis is the 95% confidence interval. The dashed line represents a willingness to pay cutoff of $50,000.

or a combined CBSE plus VFSS approach (Figure 4). It also appears that the limitations of the CBSE, namely the false-negative results, make a combined approach of a CBSE followed by a VFSS for abnormal swallows less likely to be cost-effective than a CBSE alone.

This model is a step forward in determining best practices for prevention of pneumonia in the acute poststroke period, although it is not the final answer. This analysis has limitations that should be considered. The biggest limitation is attributed to the lack of evidence surrounding many of the necessary estimates included in the model. In particular, when one recommends a test for the detection of dysphagia in stroke survivors, it is implied that a treatment exists that is effective at preventing pneumonia. The effectiveness of interventions prescribed for the treatment of dysphagia, as typically practiced, is not well studied. For example, if the effectiveness of treatment for dysphagia in preventing aspiration pneumonia by a VFSS in those with mild or moderate dysphagia is less than 30%, the cost per QALY for the VFSS is greater than $100,000. Alternatively, if a VFSS allows a treatment plan in those with mild or moderate dysphagia that is 70% effective, the VFSS is less costly and more effective than the alternatives.

In addition, the effectiveness of treatment in preventing aspiration pneumonia prescribed on the basis of information provided by a CBSE is unclear. It is clear that silent aspiration is a major limitation to the CBSE, but how effective are interventions prescribed after a CBSE for those with clinically evident dysphagia, with or without aspiration? A great deal of variation also exists in the protocols with regard to implementing the VFSS and measuring impairment [55-58]. The descriptions of the severity of dysphagia used in this study may not be translated easily into those used in clinical practice. These pieces of information are necessary to determine



	VFSS Alone	CBSE + VFSS	CBSE Alone
Cost	$1853	$1943	$1968
QALYs	1.791	1.790	1.789

Figure 4. Algorithm of clinical decision along with average costs and quality adjusted life-years associated with approach. CBSE = clinical bedside swallow evaluation; QALY = quality- adjusted life-years; VFSS = videofluoroscopic swallow study.

which strategies should be adopted. The uncertainty of the different model assumptions was addressed with the probabilistic sensitivity analysis (Figure 2). This analysis showed that the probability of the VFSS not being cost-effective relative to the other 2 strategies is never greater than 52% and is as low as 36% if the willingness to pay is $100,000. When compared directly with a CBSE, the VFSS appears to cost less and be more effective in more than half of the simulated trials (Figure 3).

Another limitation is that this analysis consists of complications of dysphagia during a relatively short period, the acute hospitalization period, with the outcome of QALYs that result after survival of the acute hospitalization. This simplified viewpoint is necessarily taken because of the lack of information to establish a model of complications and outcomes over a longer period. It is likely that this restriction limits the potential costs caused by poststroke pneumonia. Some stroke survivors will have dysphagia well into the poststroke period, and the potential for complications may persist [34]. In fact, aspiration pneumonitis and infection are the most common reason for rehospitalization after poststroke discharge, causing a readmission rate of 1.7% in the first 30 days and 2.5% in months1 to 4 [59].

The model itself is simplified compared with the real management of stroke survivors with dysphagia. Some patients will receive enteral feeding by a percutaneous enteric gastrostomy tube, which is associated with a higher rate of complications and worse outcomes than a nasogastric enteral feeding [60]. This factor wasn't included in the model because no literature exists about the natural history of dysphagia in stroke survivors and progression through this nonoral method of treatment. It is likely that many persons who use a percutaneous enteric gastrostomy tube are not eligible for swallowing evaluations because of intubation or severity of illness, and the model may not be applicable to that population.

Finally, alternative methods for the detection of dysphagia exist. A fiberoptic endoscopic evaluation of swallowing is one method the clinician can use to directly observe swallowing of boluses in the pharyngeal phase of swallowing [61]. Investigators have shown that the sensitivity and specificity of the fiberoptic endoscopic evaluation of swallowing is in the ranges of the CBSE included in this model [62,63], although investigators disagree about the comparability of the 2 tests [64,65]. Many clinical examinations of varying complexity also are used to detect dysphagia [36,66-68]. This study focuses on the commonly used method of the water sip test, with a range of estimates for sensitivity and specificity that encompass many of the other clinical methods.

CONCLUSION

This model indicates that use of the VFSS for the detection and prescribing of treatment for dysphagia in the acute poststroke hospitalization period more effectively prevents mortality compared with the CBSE alone or a strategy of a CBSE followed by a VFSS for abnormal swallows; it also is more cost-effective. Further research directed toward improving our understanding of the effectiveness of both the evaluation and treatment of dysphagia to prevent aspiration pneumonia would lead to a more refined decision-analysis model.

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