Nasolaryngoscopic Validation of a Set of Clinical Predictors of Aspiration in a Critical Care Setting

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Background: Aspiration is frequent in patients with acute neurologic disorders and swallowing dysfunction. Its incidence in stroke, as high as 51%, increases mortality by up to 3 times. Pneumonia, its main complication, further increases morbidity, mortality, and patient care costs. The objective of this study was to evaluate a set of bedside predictors of aspiration ["wet voice," 3-oz water swallow test, and cervical auscultation in an intensive care unit (ICU)] and compare them with nasolaryngoscopy as the gold standard.

Methods: We conducted a prospective, nonblinded study of bedside predictors of aspiration risks in 65 consecutive ICU patients with an acute neurologic disorder or a severe medical or surgical condition with decreased level of consciousness.

Results: Endoscopic aspiration was detected in 17 patients. Sensitivities for wet voice, 3-oz water swallow test, and cervical auscultation were 58.82%, 88.23%, and 82.35%; specificities were 78.26%, 62.50%, and 80.43%. Positive predictive values were 50%, 45.45%, and 60.86%, and negative predictive values were 83.72%, 93.75%, and 92.50%, respectively. Positive likelihood ratios were 2.70, 2.35, and 4.20, respectively. The association of 2 positive clinical predictors, wet voice and cervical auscultation or wet voice and 3-oz water swallow test, improved specificity to 92.85% and 84.61%, positive predictive values to 83.33% and 69.23%, and likelihood ratios to 10.76 and 5.85, respectively.

Conclusions: Bedside clinical predictors for aspiration risks are a useful screening tool for ICU patients presenting with risk factors for this complication.

Key Words: dysphagia, swallowing dysfunction, aspiration pneumonia, upper airway, stroke, laryngoscopy

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Swallowing dysfunction and aspiration pneumonia constitute major risk factors of morbidity and mortality in acute neurologic patients[1–4] and other intensive care unit (ICU) patients. Both are frequently seen during the acute and recovery periods of stroke and account for up to 33% of mortality at 6 months. Nonetheless, swallowing dysfunction in patients with stroke recovers in up to 87% of patients at 6 months.[1–4] The same is seen in other acute neurologic conditions, such as cerebral trauma, postneurosurgical procedures, and toxic metabolic encephalopathies.[4–7]

The affected brain area determines the type of swallowing dysfunction. A left hemisphere lesion presents with apraxia and deterioration of the oral phase of feeding. In a right hemisphere injury, the pharyngeal phase is altered, resulting in a high risk of aspiration. In a brain stem lesion, severe involvement of the pharyngeal phase is characteristic.[2–4]

This study aims to validate a set of common and simple bedside clinical predictors of aspiration using nasolaryngoscopy as the gold standard for diagnosis. The purpose is to identify this complication early and, hence, reduce its impact in patients with acute neurologic involvement admitted to ICU.[8–11]

METHODS

A prospective, nonblinded, observational study was carried out in the ICU of our tertiary university hospital. The study involved the clinical monitoring of aspiration (CMA) in patients at risk of swallowing dysfunction and aspiration. CMA was performed according to clinical judgment as indicated by the critical care team or the attending neurologist. The procedures were carried out by a trained speech pathologist and a respiratory physician just before initiating oral feeds. This study was approved by the hospital scientific investigation institutional committee.

Diagnostic criteria were (a) stroke: sudden onset of focal neurologic deficit, characteristic ischemic or hemorrhagic stroke images (computed tomography scan or magnetic resonance imaging), excluding nonvascular causes; (b) multi-infarct dementia: earlier diagnosis of dementia, decrease in conscious level and characteristic images of multiple old cerebral infarctions or small vessel disease; (c) cerebral trauma: history of head trauma, decreased conscious level, and characteristic images on computed tomography scan or magnetic resonance imaging; (d) central

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nervous system tumors: conscience involvement and characteristic neurologic images; (e) others: medical or surgical patients with severe toxic metabolic encephalopathies; medical or surgical patients hospitalized for prolonged periods in an ICU with reduced conscious level and normal neurologic images.

The standard of care in our institution for monitoring aspiration consists of clinical examination of the head and neck, evaluation of the cranial nerves, characteristics of phonation, cough, laryngeal elevation, velopalatal movement, gag reflex, 3-oz water test, and cervical auscultation.[12–17] In this study, we specifically evaluated 3 clinical predictors: wet voice, 3-oz water test, and cervical auscultation. An abnormal 3-oz water test was classified when the patient presented cough or stridor at swallowing water. On cervical auscultation, a phonendoscope was applied over the lateral side of the trachea while swallowing jelly. A net click and clear apnea and expiration were classified as normal. Noisy and wet auscultation was classified as pathologic.

Nasolaryngoscopy is considered the gold standard in the evaluation of dysphagia in different publications.[1,5,8,9] It is a simple bedside diagnostic tool and is more readily available than videofluoroscopy in our institution. In our medical center, both pulmonary physicians and laryngologists are qualified to perform nasolaryngoscopies. The endoscopic criteria of aspiration that we have used have been described earlier: (a) hypopharynx flooding by bronchial secretions, (b) epiglottic vallecula and piriform pouches flooding by bronchial secretions, or (c) observation of aspiration of secretions or colored jelly through the glottis.[1,5,8,9] After clinical evaluation, a fiberoptic nasolaryngoscopy was performed by a nonblinded respiratory physician. In each patient, a laryngoscopic report indicated whether the patient fulfilled the aspiration criteria. When present, CMA indicators were also reported. A flow diagram of the study that was carried out is presented in Figure 1.

Statistical Analysis

Nasolaryngoscopy was considered the gold standard for detecting aspiration. To define the accuracy of CMA and compare it with nasolaryngoscopy, we calculated sensitivity, specificity, predictive values, likelihood ratios, and posttest probabilities for each clinical predictor. The same calculations were performed for the association of 2 positive clinical indicators: wet voice plus cervical auscultation and wet voice plus 3-oz water test.

Sensitivity is the proportion of the patients with aspiration who have a positive clinical predictor; specificity is the proportion of the patients without aspiration who have a negative clinical predictor. Positive predictive value is the proportion of the patients with a positive clinical predictor who are aspirators; negative predictive value is the proportion of the patients with a negative clinical predictor who are not aspirators. Likelihood ratio is the likelihood that a given test result would be expected in a patient with aspiration, compared with the likelihood that the same result would be expected in a patient

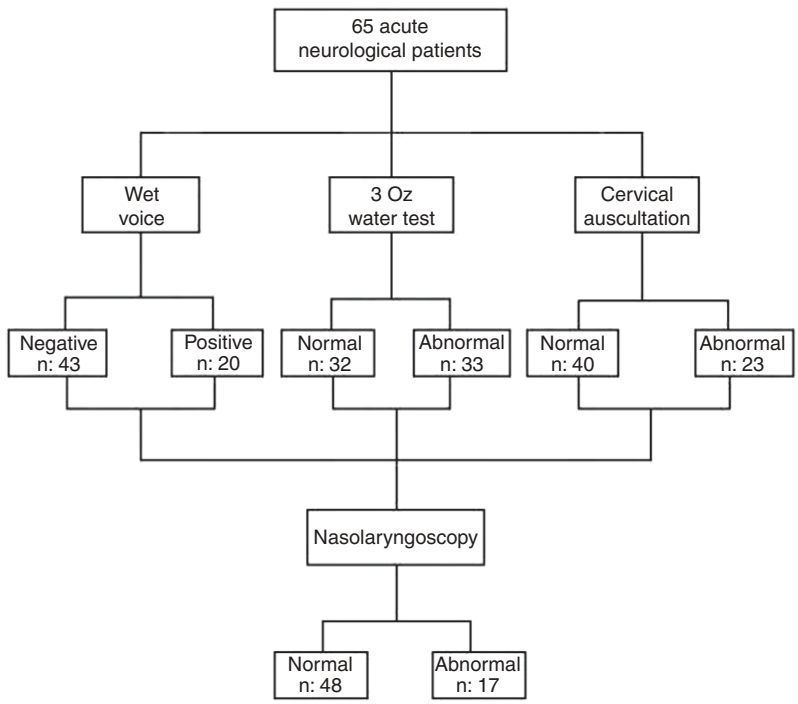

FIGURE 1. Flow diagram of diagnostic accuracy of the set of clinical predictors of aspiration.

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TABLE 1. Baseline Characteristics of the 65 Patients Evaluated With Clinical Monitoring of Aspiration

Characteristic	N
Male sex (%)	68
Mean age (SD)	70 (17)
Diagnosis	
Multi-infarction dementia (%)	31
Ischemic stroke (%)	23
Medical or surgical pathology associated with toxic metabolic encephalopathy (%)	22
Hemorrhagic stroke (%)	9
Tumors of the central nervous system (%)	9
Cerebral trauma (%)	6

without aspiration. With the positive likelihood ratios, we calculate the posttest probabilities.

We also registered the decisions made by the critical care team and the attending neurologist after the evaluation. Minor decisions were considered suspension of oral feeds and rehabilitation with a speech pathologist. Major decisions considered the performance of invasive procedures such as percutaneous gastrostomy or tracheostomy.

RESULTS

We studied 65 patients with a mean age of 70 (± 17) years, with 44 male (68%) and 21 female (32%) patients. Fifty-one of them presented acute neurologic conditions, and 14 had medical or surgical conditions associated with toxic metabolic encephalopathy. The mean Glasgow coma score was 14.65 (± 0.48). Individual diagnoses are detailed in Table 1.

Airway aspiration was endoscopically detected in 17 patients (26.15%). Table 2 represents a comparison between CMA predictors and nasolaryngoscopy evaluation. There were 2 determinations not registered (1 for wet voice and 1 for cervical auscultation).

Wet voice identified only 10 aspirators and failed to detect 7, showing a sensitivity of 58.82% and a specificity of 78.26%. The positive predictive value was 50% and the negative predictive value was 83.72%. Three-ounce water test identified 15 aspirators and failed to detect 2, resulting in a sensitivity of 88.23%, a specificity of 62.5%, a positive predictive value of 45.5%, and a negative predictive value of 93.7%. Cervical auscultation detected 14 aspirators and failed to detect 3, showing a sensitivity of 82.35%, a specificity of 80.43%, a positive predictive value of 60.86%, and a negative predictive value of 92.5%. The results obtained are presented in Table 3.

The positive and negative likelihood ratios for wet voice were 2.7 and 0.52, increasing the posttest probability from 26.98% to 50%. For the 3-oz water test it was 2.35 and 0.18, respectively, increasing the posttest probability from 26.15% to 45.45%. For cervical auscultation the positive and negative likelihood ratios were 4.2 and 0.21, respectively, with an increase of posttest probability from 26.98% to 60.86% (Table 3).

The association of 2 positive clinical predictors increased their power as diagnostic tools, improving the specificity and positive predictive values. Wet voice and abnormal cervical auscultation showed sensitivities and specificities of 76.92% and 92.85%, positive and negative predictive values of 83.33% and 89.65%, and positive and negative likelihood ratios of 10.76 and 0.24, respectively, increasing the posttest probability from 31.7% to 83.33%. In addition, wet voice and abnormal 3-oz water tests showed sensitivities and specificities of 90% and 84.61%, positive and negative predictive values of 69.23% and 95.65%, and positive and negative likelihood ratios of 5.85 and 0.11 respectively, increasing posttest probability from 27.7% to 69.23% (Table 4).

In 19 patients (29%), oral feeding was delayed and rehabilitation by a speech pathologist was initiated as minor decisions. In 5 patients (7.69% of all patients and 29.41% of the patients with aspiration), major decisions were undertaken, with percutaneous gastrostomy performed in all of them and a tracheostomy in 1 patient.

DISCUSSION

This study shows that simple clinical evaluation of a set of predictors, such as wet voice, 3-oz water test, and cervical auscultation, is an acceptable clinical tool for the screening of aspiration at the bedside, with high sensitivity and negative predictive values. Association of 2 clinical predictors improves the accuracy of CMA, increasing the specificity, the positive predictive value, the positive likelihood ratio, and posttest probability.

Swallowing dysfunction and aspiration are frequent complications in patients with neurologic involvement. Aspiration can cause laryngospasm, bronchial obstruction, and pneumonia with the consequent increase in mortality. In stroke patients,

TABLE 2. Frequency Distribution of Normal and Abnormal Tests According to Aspiration Diagnosis

	Wet Voice (−)	Wet Voice (+)	Normal 3-oz Water Test	Abnormal 3-oz Water Test	Normal Cervical Auscultation	Abnormal Cervical Auscultation
Aspiration (+)	7	10	2	15	3	14
Aspiration (−)	36	10	30	18	37	9

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TABLE 3. Sensitivity, Specificity, Predictive Values, and Likelihood Ratios for the Evaluated Clinical Predictors

Clinical Indicator of Aspiration	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Positive Likelihood Ratio	Negative Likelihood Ratio
Wet voice	58.82	78.26	50	83.72	2.70	0.52
3-oz water test	88.23	62.50	45.45	93.75	2.35	0.18
Cervical auscultation	82.35	80.43	60.86	92.50	4.20	0.21

NPV indicates negative predictive value; PPV, positive predictive value.

the prognosis at 6 months is closely related to the medical complications in the acute phase.[1,4–11] Aspiration syndrome is responsible for more than 50% of medical complications, with pneumonia being the principal respiratory complication, with an in-hospital mortality rate of 23%.[18–21]

CMA constitutes a valuable bedside clinical instrument in these patients. It allows the detection of swallowing dysfunction and aspiration and therefore reduces erroneous decision making regarding initiation of feeds. This results in the reduction of aspiration in patients with neurologic involvement.[18–21] We performed this study in an ICU, using clinical predictors as screening tools of swallowing dysfunction and validating them with nasolaryngoscopic certification as a gold standard. The rationale in performing this evaluation had different aspects: (a) to protect the upper airway from aspirative syndrome, (b) to reduce the incidence of pneumonia, and (c) to define procedures that guarantee nutrition and protect the upper airway.

Our results are consistent with the findings of other investigators, showing elevated sensitivities and negative predictive values for clinical evaluation. The 3-oz water test is a well-known screening tool in neurologic patients; studies have shown experiences similar to ours.[8,12] A normal 3-oz water test practically excludes the possibility of swallowing dysfunction. An abnormal test is highly sensitive, duplicates the likelihood ratio, and increases the posttest probability of aspiration from 26.15% to 45.45%.

The role of cervical auscultation and its physiologic relation with aspiration has not been clearly shown in videofluoroscopy.[13–15] We have classified as abnormal a noisy and wet auscultation, obtaining results that support its utility as a screening clinical tool, with elevated sensitivity and negative predictive values (82.35% and 92.5%, respectively) and an elevated positive likelihood ratio of 4.2 for abnormal auscultation, which increases more than twice the posttest probability of aspiration (to 60.85%).

Wet voice as an isolated sign is a weak clinical predictor with acceptable negative predictive value. However, if associated with the 3-oz water test or with cervical auscultation, it increases CMA accuracy, indicating that a patient with 2 abnormal indicators is a patient at high risk of aspiration. If the patient presents wet voice and abnormal cervical auscultation, the specificity increases to 92.85%, with a positive likelihood ratio of aspiration of 10.76 and a posttest probability of 83.33%. If the patient presents wet voice and abnormal 3-oz water test, the specificity increases to 84.61%, the positive likelihood ratio to 5.85, and the posttest probability to 69.23%.

Lim et al[8] reported 50 stroke patients and compared 3-oz water test with laryngoscopic demonstration of aspiration. They obtained similar sensitivity (84.6%) with better specificity (75%). Their negative predictive value was lower than ours (81.8%), with a better positive predictive value (78.6%). They improved the accuracy of the test by adding oxygen saturation as another variable.[8] Leder et al[1,5,9] evaluated 49 stroke patients using diverse clinical indicators of aspiration and endoscopic observation of aspiration as a gold standard, obtaining a sensitivity of 86%, with a negative predictive value of 73% for clinical evaluation.

In this study we registered minor decisions involving initiation of oral feeds or speech therapy in 29% of all patients. Major decisions were made in 29.41% of the patients with aspiration (percutaneous gastrostomies and tracheostomies). In historical

TABLE 4. Sensitivity, Specificity, Predictive Values, and Likelihood Ratios for the Association of 2 Positive Clinical Predictors of Aspiration

Clinical Indicator of Aspiration	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Positive Likelihood Ratio	Negative Likelihood Ratio
Wet voice and cervical auscultation	76.92	92.85	83.33	89.65	10.76	0.24
Wet voice and 3-oz water test	90	84.61	69.23	95.65	5.85	0.11

NPV indicates negative predictive value; PPV, positive predictive value.

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series, the indication of gastrostomy in patients with aspiration varies between 24.3% and 53.3% depending on the study.[22–24] As a standard institutional protocol, we perform gastrostomies in patients with abnormal screening of aspiration and a low probability of neurologic recovery in the first month. This is based on data that show that in stroke patients who aspirate, gastrostomies reduce the relative risk of mortality by 44.5% at 6 weeks compared with nasoenteral feeding.[22–25]

The main weakness of this study was the nonblinded nasolaryngoscopic observation with clinical evaluation performed by the speech therapist; nevertheless, it must be considered that the observation of flooding of the hypopharynx and aspiration to the airway are very evident endoscopic signs, independent of the clinical information.

Stroke units are actively working on this problem and a growing amount of evidence favors the prompt detection of patients with risk of aspiration. We consider that the critical care community should use a similar approach.[19–21,26,27]

In summary, the strength of this study is the validation of a simple and cost-effective set of bedside clinical indicators of aspiration as a screening tool in the ICU. This allows a reduction in the incidence of aspirative syndrome and defines procedures to protect the upper airway from aspiration. Validating this approach in patients with acute neurologic conditions and its impact on the incidence of aspirative pneumonia in this group will need future prospective and randomized clinical trials.[20,21,26–31]

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