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What is This?
A Frailty Index Identifies Patients at High Risk of Mortality after Tracheostomy

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Abstract

Objective. To evaluate the utility of a modified frailty index as an indicator of postoperative mortality in patients undergoing tracheostomy.

Study Design. Case series with chart review.


Subjects and Methods. A chart review was conducted of consecutive tracheostomies performed between April 2007 and September 2012. A modified frailty index consisting of 11 items based on the Revised Minimum Data Set Mortality Rating Index (MMRI-R) was retrospectively applied using the patient’s status immediately prior to tracheostomy. The resultant 6-month calculated mortality risk was compared with both the Veterans Health Administration Surgical Quality Improvement Program’s (VASQIP) 30-day calculated mortality and actual mortality.

Results. One hundred consecutive tracheostomies were analyzed. No patients were excluded. Sixty-nine patients died within the study period, with 1-, 6-, and 12-month mortality rates of 25%, 43%, and 59%, respectively. The average calculated 6-month mortality risk using the modified frailty index was 40.5% for nonsurvivors compared with 25.4% for survivors ($P = .001$). Both the VASQIP calculator and modified frailty index differentiated mortality risks between patients without head and neck cancer who survived less than 6 months versus those who survived longer than 6 months ($P = .006$ and .01). However, neither the VASQIP nor the modified frailty index differentiated mortality risks for head and neck cancer patients who survived less than 6 months versus those who survived greater than 6 months ($P = .94$ and .26).

Conclusion. A modified frailty index identifies patients without head and neck cancer at high risk of postoperative mortality after tracheostomy.

Keywords

tracheostomy, frailty, mortality, VASQIP, risk calculator

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T he United States population older than 65 years is projected to increase from approximately 40 million to nearly 90 million over the next 30 years.\textsuperscript{1} A third of these patients will undergo a surgical procedure in their last year of life.\textsuperscript{2} It is difficult to accurately determine which patients are at risk for postoperative morbidity and mortality. Preoperative assessment often depends on the subjective clinical assessment of the surgeon, sometimes called the “eyeball test.”\textsuperscript{3} In an attempt to objectify this test, multiple risk calculators have been devised to assess more accurately postoperative morbidity and mortality after colorectal,\textsuperscript{4} cardiac,\textsuperscript{5} and orthopedic surgery,\textsuperscript{6} among others. These calculators have the disadvantage of being cumbersome to administer and are frequently disease, organ, or operation specific.

As age and medical conditions have been identified as primary predictors of postoperative outcomes, research has identified frailty to be a useful risk factor.\textsuperscript{7–9} The definition of frailty is controversial, and agreement on the preoperative identification of frail patients remains elusive\textsuperscript{10}; however, it is generally accepted to represent a state of reduced physiological reserve across multiple organ systems with increased susceptibility to disability.\textsuperscript{2,11} Studies evaluating frailty as a predictor of postoperative outcomes have been published in orthopedics,\textsuperscript{12} colorectal,\textsuperscript{13} general,\textsuperscript{8} and cardiac surgery\textsuperscript{14} but were only recently introduced in the otolaryngology/head and neck literature.\textsuperscript{15}
In this study, we evaluated the utility of a modified frailty index as an indicator of postoperative 6-month mortality risk after tracheostomy in a population of veterans. We compared this index to the Veterans Affairs Quality Improvement Program (VASQIP): a risk-adjusted 30-day mortality calculator that is validated in a broad surgical population.16 We chose to evaluate tracheostomy as it has a low rate of postoperative complications and is rarely the direct cause of patient mortality.17 However, it is frequently performed in the context of critical illness at a key juncture in decision making regarding whether to pursue treatment with intent to cure versus palliation. We simulated administering the frailty index preoperatively at the bedside as this information could help to identify patients who are nearing the end of their lives and may not benefit from tracheostomy. This also provides otolaryngologists with an opportunity to educate patients, their families, and other providers regarding likely outcomes at this point in care. We hypothesized that this frailty index would be able to identify tracheostomy patients at high risk of short-term postoperative mortality and would compare well with the VASQIP calculator.

Methods

We performed a chart review of consecutive patients who underwent a tracheostomy procedure at the Omaha VA Medical Center from April 2007 to September 2012. Institutional review board approval for this pilot study was obtained from the VA Nebraska Western-Iowa Health Care System Research Service. All patients who underwent tracheostomy in the defined study period were included, and there were no exclusion criteria. Patients were identified by Current Procedural Terminology (CPT) codes for tracheostomy, including 31600, tracheostomy planned; 31603, tracheostomy emergency; and 31610, tracheostomy fenestration procedure with skin flaps. A total of 100 tracheostomies were identified in 99 patients. For the purposes of this study, a “short-term survivor” was defined as surviving 6 months or less, and a “long-term survivor” survived greater than 6 months.

We used 2 mortality calculators. The first, termed the Risk Analysis Index (RAI) at our institution, is a modification of the Revised Minimum Data Set Mortality Rating Index (MMRI-R): a 12 item, 6-month mortality index designed for use in nursing home residents using regression analysis of the US Minimum Data Set.18 The RAI includes certain data points required for the RAI had to be estimated based on the available data in the chart. The 3 items most frequently absent from medical records and therefore estimated were loss of appetite, cognitive decline, and activities of daily living. When necessary, loss of appetite was estimated to be present when the patient had lost >10 lb over a 3-month period. Cognitive decline and activities of daily living were extrapolated from social work, occupational therapy, physical therapy, admission, and discharge notes. Data were acquired by authors M.S.J. and T.L.B. Calculations were reviewed by both authors to increase interrater reliability. The calculator produced a score for each patient with a possible range of 0 to 81. A 5-point band system was then used based on the MMRI-R model to assign a 6-month mortality risk.

The second mortality calculator is the VASQIP: an objective calculator that uses age, lab values, American Society of Anesthesiologists class, and functional status among other items to produce a projected 30-day mortality risk for operative patients. This calculator can be applied prospectively to patients undergoing select major surgeries at VA hospitals and was calculated retrospectively for tracheostomies. Other data points included length of survival, tracheostomy performed with anticipation of long-term requirement (ie, ventilator-dependent patients) or short-term requirement (after cancer resection), and whether the tracheostomy was the primary procedure or performed in conjunction with another operation such as a head and neck cancer resection.

Descriptive statistics were calculated by survival status. Numerical variables were compared between survivors and non-survivors using 2-sided independent sample t tests, and categorical variables were assessed using x^2 tests. Nonparametric tests and Fisher exact test were used as appropriate.

Results

All patients were male, with ages ranging from 35 to 89 years and a median age of 64 years. At the time of data retrieval, 69 patients had died and 30 were alive after surgery, for a total of 99 patients undergoing 100 tracheostomies. For those who died after tracheostomy, length of survival ranged from 0 days to 1172 days (3.21 years). Those who survived were between postoperative days 47 and 2067 (5.66 years) at the time of data retrieval. Of those who died after tracheostomy, 64% survived less than 2 years, 59% less than 1 year, 43% less than 6 months, and 25% less than 1 month (Figure 2).

Seventy-two tracheostomies were primary procedures, and 28 were performed in conjunction with another surgery. Forty-eight tracheostomies were performed for prolonged ventilation, failure to extubate, or palliation; 10 treated an obstruction; and 38 were performed with a head and neck cancer surgery. All procedures were performed in the operating room. Fifty-one patients had active cancer at the time of surgery, and 28 were performed in conjunction with another surgery.
The RAI and VASQIP calculated risks were tabulated and compared between survivors and nonsurvivors. The RAI was 40.5% (95% confidence interval [CI], 35.4%-45.6%) for nonsurvivors versus 25.4% (19.8%-31.0%) for survivors \((P = .001)\). These values correlate to the MMRI-R predicted 6-month mortality risk but are not intended as predicted rates in this study as the RAI is not yet validated for predictive capabilities. The VASQIP was 9.1% (6.3%-11.9%) for nonsurvivors versus 5.2% (1.6%-8.7%) for survivors \((P = .1)\); [Figure 3](#). These values represent the VASQIP 30-day predicted mortality rate.

We then divided the cohort into patients who survived greater than 6 months versus less than 6 months. The RAI was 39.2% (32.6%-45.9%) for the short-term survivors versus 32.9% (27.7%-38.0%) for the long-term survivors \((P = .13)\). The VASQIP was 12% (8.0%-16.0%) for short-term survivors versus 4.4% (2.4%-6.3%) for long-term survivors \((P < .001); \text{Figure 4}\).

The cohort was then divided into patients with head and neck cancer and those without head and neck cancer. The RAI was 44.9% (38.8%-51.0%) for those with head and neck cancer versus 30.2% (25.1%-35.3%) for those without head and neck cancer \((P < .001)\). The VASQIP was 2.7% (1.6%-3.9%) for those with head and neck cancer versus 11.0% (7.7%-14.3%) for those without head and neck cancer \((P < .001)\). The actual 6-month mortality rates were 26.3% for those with head and neck cancer versus 58.1% for those without cancer \((P = .002); \text{Figure 5}\).

Finally, we subdivided head and neck cancer–associated tracheostomies and those without cancer into short-term and long-term survivors. The RAI was 44.9% (38.8%-51.0%) for those with head and neck cancer versus 30.2% (25.1%-35.3%) for those without head and neck cancer \((P < .001)\). The VASQIP was 2.7% (1.6%-3.9%) for those with head and neck cancer versus 11.0% (7.7%-14.3%) for those without head and neck cancer \((P < .001)\). The actual 6-month mortality rates were 26.3% for those with head and neck cancer versus 58.1% for those without cancer \((P = .002); \text{Figure 5}\).
long-term survival subgroups in an attempt to ascertain why the RAI indicated that cancer-associated tracheostomies were at higher risk of postoperative mortality in contrast to their actual 6-month mortality rates. For those with head and neck cancer, the RAI was 50.6% (34.8%-66.4%) for short-term survivors versus 42.9% (36.2%-49.5%) for long-term survivors ($P = .26$). For the same group, the VASQIP calculated 2.6% (0.1%-5.2%) for short-term survivors versus 2.8% (1.4%-4.1%) for long-term survivors ($P = .94$; Figure 6). We then examined patients who underwent tracheostomy not associated with head and neck cancer. In this group, the RAI calculated 36.1% (28.7%-43.4%) for short-term survivors versus 22.1% (16.2%-28.0%) for long-term survivors ($P = .006$). For the same group, the VASQIP was 14.6% (9.8%-19.4%) for short-term survivors versus 6.1% (2.3%-9.9%) for long-term survivors ($P = .01$; Figure 7).

**Discussion**

We developed the RAI with the intended use as a preoperative frailty calculator that could be completed within 2 to 3 minutes at the bedside, without access to the patient’s medical records, and with several variables that are part of a standard nursing intake assessment. As the RAI is not yet validated, we used the VASQIP as a validated means of comparison. The VASQIP uses regression analysis to calculate the probability of death or complications within 30 days after an operation. The VASQIP calculator is specific for the specialty and procedure being performed. It requires approximately 20 minutes per patient and access to patient records, making it cumbersome and difficult to perform in an immediate preoperative setting.

We sought to determine if the RAI would identify frail patients as being at higher risk of short-term mortality. Commonly accepted mortality measures use 30-day mortality rates. When developing the original MMRI, Porock et al noted, “Identifying those most at risk of death—in other words, making the diagnosis of dying—is the first step in ensuring that the goals of care are appropriate and the wishes of the resident are known, documented, and respected.” In addition, recent studies suggest long-term survival may be a more important measure of outcomes in the critically ill. In agreement with these studies, we used 6 months rather than 30 days as a separator in our analysis.

Our results demonstrate that both the RAI and VASQIP differentiated mortality risks between patients without head and neck cancer who survived less than 6 months versus those who survived greater than 6 months. However, neither the VASQIP nor the RAI differentiated mortality risks for patients with head and neck cancer. As the MMRI-R was intended to predict mortality in nursing home residents, these patients were unlikely to be receiving definitive or curative therapy for active cancer, therefore justifying the large increase in their mortality scores for this single variable. However, head and neck cancer patients in this study were undergoing tracheostomy as a part of their treatment for cancer with intent for cure rather than palliation. As such, the cancer variable in the RAI likely overestimates the impact of cancer on postsurgical mortality risk, especially in this population. This study was not designed to evaluate the utility of the RAI in head and neck cancer patients but does identify cancer as an area in need of further investigation to improve the accuracy of the RAI. This study begins to...
provide data that show head and neck cancer patients do not have the same predicted mortality, suggesting less relevance toward their cause-specific mortality.

The goal of this study was to define, at a critical juncture in decision making, those patients at substantially higher risk of short-term mortality based on frailty. These data are pilot data and cannot ascribe an exact 6-month predicted mortality rate. Instead, we were interested in developing a tool that could quickly and accurately identify frail patients who are at increased risk for postoperative mortality compared with a similar patient population. This knowledge could help to increase communication among the patient, physician, and other services to improve preoperative optimization. In addition, this provides an opportunity for discussions regarding end-of-life care and palliative care consultation based on an objective endpoint.

Patients and surgeons alike express concern that surgical care may be rationed in the future. A frailty index labels a patient with a numerical value that could potentially be used by insurance providers, hospitals, or governments to determine who is eligible for a given surgery. Surgeons could also use this index in a binary manner to determine who is not a candidate for surgery without a global assessment of the patient’s condition and without a discussion with the patient and family. As with any predictive tool, there is potential for misuse of this index. However, this has not been the experience at our institution to date, where surgeons, nurses, and ancillary staff have all embraced the RAI. It has allowed for identification of individuals in need of a more thorough preoperative assessment and notifies postoperative providers of patients who need may additional attention to ensure a successful outcome.

As the MMRI-R was designed for prospective use in nursing home patients, there are limitations of applying our modification of this tool to a patient population in a retrospective manner. First, as a retrospective review, estimations for weight, activities of daily living, and appetite often had to be inferred. Second, the study population lacked diversity, consisting of only male veterans receiving care at a VA Medical Center, and will therefore require further validation to confirm that the results are generalizable across all ages, genders, and procedures. Third, our consecutive patient series included tracheostomies performed under urgent conditions in situations that could allow for this type of preoperative analysis to be performed. Although these patients followed the mortality pattern of ventilated patients in our data, further studies may be strengthened by excluding these patients. Finally, although the RAI calculates mortality risk, it is not yet validated to predict a patient’s actual mortality but rather to give an indication for increased risk of death compared with a similar population.

Conclusion
In this pilot study, we showed that the RAI identifies frail patients without head and neck cancer who are at high risk for 6-month mortality after tracheostomy. These preliminary results suggest that the RAI may be a useful preoperative bedside tool to identify patients at higher risk for 6-month mortality. Further research is required to validate this index in a broad otolaryngologic population including head and neck cancer patients.

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Author Contributions
Matthew S. Johnson, conception, design, acquisition of data, analysis and interpretation of data, drafting and revising manuscript; final approval of manuscript; Travis L. Bailey, design, acquisition of data, analysis and interpretation of data, drafting and revising manuscript, final approval of manuscript; Kendra K. Schmid, analysis and interpretation of data, revising manuscript, final approval of manuscript; William M. Lydiatt, analysis and interpretation of data, revising manuscript, final approval of manuscript; Jason M. Johanning, conception, design, acquisition of data, analysis and interpretation of data, drafting and revising manuscript, final approval of manuscript.

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