Derivation and validation of an automated electronic search algorithm to identify patients at risk for obstructive sleep apnea

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ABSTRACT

Background. Automated extraction of data from electronic health records has allowed high-quality retrospective analyses of large cohorts.

Objectives. To derive and validate an automated electronic search algorithm to identify surgical patients with a diagnosis of or at high risk for obstructive sleep apnea (OSA).

Methods. From 558 adult patients who underwent surgery from January 1, 2011, through December 31, 2015, we constructed a derivation cohort of 100 subjects selected using the initial search algorithm to have equal numbers of patients with high and low likelihood of having OSA. This algorithm conducted a free-text electronic search of patient diagnoses and interrogated results of a preoperative checklist that specifically queried patients regarding OSA history and screened for OSA risk using Flemons criteria. The derivation cohort was then manually reviewed to identify patients with OSA risk and results were used to refine the algorithm. Second, the algorithm was validated with the other 458 patients (the validation cohort). The sensitivity and specificity were compared again with manual chart review of the respective group.

Results. In the derivation cohort, the automated electronic algorithm achieved a sensitivity of 98.2% and a specificity of 100.0% compared with the manual review. In the validation cohort, sensitivity was 100.0% and specificity was 98.4% in this comparison.

Conclusion. An automated electronic search algorithm was developed that interrogates electronic health records to identify, with a high degree of accuracy, surgical patients with a diagnosis of or at high risk for OSA.

Key words: Flemons criteria, obstructive sleep apnea, search algorithm

INTRODUCTION

Background and Importance

Automated extraction of data from electronic health records (EHRs) has become a sophisticated tool that has allowed investigators new avenues for conducting outcomes research on large patient cohorts where manual data extraction is not practical. However, evidence is limited on the derivation and validation of an electronic search technique that identifies these patients and on its effectiveness compared with manual review of EHRs. Herein, we describe the derivation and validation of an automated electronic search algorithm for identifying surgical patients with the diagnosis of or at high risk for OSA.

Objective

The study’s primary objective was to derive and validate an automated electronic search algorithm that identifies which surgical patients should undergo preoperative screening for OSA because of either previous diagnosis or high risk, using an assessment tool. The secondary objective was to calculate sensitivity and specificity values of our electronic search algorithm compared with the reference standard of manual comprehensive EHR review.
METHODS

Participants

The Mayo Clinic Institutional Review Board approved this study. Consistent with Minnesota Statute 144.295, the study included only patients who provided authorization for research use of their EHRs. The setting of this study was the Mayo Clinic Hospital – Rochester Campus, Minnesota. Participants in this report were 558 surgical patients who underwent general anesthesia at the institution from January 1, 2011, through December 31, 2015—a subset included in a separate and unrelated retrospective study designed to assess postoperative outcomes related to anesthetic management variables. For the present study, we randomly selected 100 patients to construct the derivation cohort and selected the other patients (n=458) for the validation cohort.

Manual Data Extraction Strategy

For the present study, manual review of the EHRs was considered the gold standard for identification of patients with or deemed to be at high risk for OSA. Surgical patients on arrival at our institution’s presurgical area undergo a preoperative checklist by a registered nurse. This checklist includes a question of whether the patient has a history of OSA, with the answer marked yes or no. If the answer is negative, the patient is screened for OSA using the Flemons criteria, to categorize patients with high or low risk of OSA. (9) The results of this inquiry are recorded in the EHR.

For this study, the EHRs of the patient cohort were manually reviewed by the lead author (O.O.O.). The review consisted of evaluating the EHR antecedent to the date of surgery, including past medical history and diagnosis sections of all clinical notes, as well as information obtained during the nursing preoperative checklist.

Automated Electronic Data Extraction Strategy

Our institution uses the United Data Platform and identify pertinent clinical data, such as specific keywords. To develop the electronic search query for OSA, we entered synonyms, abbreviations, and medical acronyms associated with OSA into an ACE text query. Furthermore, a comprehensive list of terms to exclude patients who did not have OSA was developed to make the electronic search algorithm more specific. For instance, we excluded such phrases as "no history of," "denies," "rule out," and "negative for" OSA. To establish a more uniform methodology, we restricted the application of the automated algorithm to note searches to the Diagnosis section of a patient’s clinical notes. In addition, we interrogated the nurse-administered preoperative checklist obtained on the day of surgery. Patients who provided an affirmative response (ie, "yes") to the nurse's query regarding a history of OSA were coded by ACE as having OSA. Patients who denied a history of OSA (ie, a "no" response) subsequently underwent OSA screening with Flemons criteria. (9) Patients whose Flemons scores were consistent with a high risk of OSA were coded by ACE as having OSA. The results of queries were combined, and when a patient had a diagnosis of OSA, affirmed a history of OSA during the checklist, or had a high risk of OSA, the patient was coded to "yes" for OSA. Subjects were divided into derivation and validation cohorts. The derivation cohort of 100 subjects was constructed using the initial OSA electronic search algorithm to consist of two equal samples of subjects at high or low likelihood for OSA. The derivation cohort underwent manual review of subject medical records to detect a true risk or presence of OSA. On the basis of obtained information from the manual review, the initial algorithm was refined to incorporate mismatches between automated search and manual review. Using this refined algorithm, we queried the remainder of the study patients as a validation cohort (figure 1). Disagreements between the automated searches and the manual searches were adjudicated by the senior author (T.N.W.), to whom the search results were masked. These 2 authors (O.O.O. and T.N.W.) were not involved in algorithm design and implementation.

Statistical Analyses

The study subjects were divided into derivation and validation cohorts as described above. For each sample, the sensitivity and specificity of the final automated electronic search algorithm for identifying OSA were calculated using the manual review of the EHRs as the gold standard. Findings are summarized using point-estimates and corresponding 95% exact binomial confidence intervals (C.I.). Statistical software (JMP version 10.0; SAS Institute Inc) was used to compare and validate the automated search vs the manual review.

RESULTS

From a pool of 558 adult surgical patients, a derivation cohort of 100 subjects was selected with an initial automated electronic search algorithm for equal numbers of patients with high or low likelihood for OSA. The validation cohort consisted of the remaining 458 subjects. A comparison between manual chart review for OSA and the final automated electronic search algorithm is summarized in the table 1. In the
The present study details the development of an automated digital search algorithm that interrogates EHRs to identify not only surgical patients with the diagnosis of OSA but also those at high risk for OSA. These results reflect our clinical practice, where all surgical patients are preoperatively screened for OSA using an assessment tool.

**CLINICAL RELEVANCE STATEMENT**

OSA is common, is frequently undiagnosed, and is associated with increased risk of postoperative complications in surgical patients. This study describes the development, derivation, and validation of an automated digital search algorithm that interrogates EHRs to identify with a high degree of accuracy the surgical patients who have or are at high risk for OSA.
REFERENCES


