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Early Detection of Hospitalized Patients with Previously Diagnosed Obstructive Sleep Apnea Using Computer Decision Support Alerts

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Abstract

Obstructive sleep apnea (OSA) is a worldwide problem affecting 2-14% of the general population and most patients remain undiagnosed. OSA patients are at elevated risk for hypoxemia, cardiac arrhythmias, cardiorespiratory arrest, hypoxic encephalopathy, stroke and death during hospitalization. Clinical screening questionnaires are used to identify hospitalized patients with OSA; especially before surgery. However, current screening questionnaires miss a significant number of patients and require more definitive testing before specific therapy can be started. Moreover, many patients are admitted to the hospital with a previous diagnosis of OSA that is not reported. Thus, many patients with OSA do not receive appropriate therapy during hospitalization due to the lack of information from previous inpatient and outpatient encounters. Large enterprise data warehouses provide the ability to monitor patient encounters over wide geographical areas. This study found that previously diagnosed OSA is highly prevalent and undertreated in hospitalized patients and the use of early computer alerts by respiratory therapists resulted in significantly more OSA patients receiving appropriate medical care ($P < 0.002$) which resulted in significantly fewer experiencing hypoxemia ($P < 0.006$). The impact was greater for non-surgery patients compared to surgery patients.

Keywords:

Obstructive sleep apnea, OSA, decision support.

Introduction

Obstructive sleep apnea (OSA) is a common sleep disorder that underlies many medical conditions including psychiatric disorders, hypertension, coronary artery disease, congestive heart failure, neurovascular disease and metabolic disturbances [1-5]. Untreated OSA may also increase the risk for hypoxemia (oxygen deficiency) and numerous studies have reported an association of OSA and perioperative complications[6]. Of note, the likelihood of having OSA increases in the perioperative period due to the effects of forced supine sleeping position, effects of anesthesia, use of opioids and other sedatives as well as the effects of sleep deprivation and subsequent rebound of rapid eye movement sleep[7].

The prevalence for OSA is 7-14% in males and 2-7% in females[8] and it has been estimated that the diagnosis of OSA is missed in 82% males and 93% females[9]. The prevalence of OSA (diagnosed or undiagnosed) in the hospitalized population has not been firmly established but is suspected to be much higher than in the general population.

Positive airway pressure (PAP) is the therapy of choice for the treatment of hospitalized patients with OSA. While continuous positive airway pressure (CPAP) is the most common mode, bi-level positive airway pressure (BPAP), and autotitrating positive airway pressure (APAP) may be more comfortable modes for some patients[10]. When properly titrated, PAP minimizes the number of sleep-related breathing disorder events and reduces the perioperative complication rate[11,12].

Providing proper PAP therapy to hospitalized patients depends upon early recognition of OSA. A number of screening questionnaires including the Sleep Apnea Clinical Score (SACS), Berlin Questionnaire, and the STOP-Bang Questionnaire have been used in the pre-operative setting.[12-15] However, screening questionnaires are limited by their sensitivity and specificity, and still require more definitive polysomnography testing before specific therapy can be administered [16, 17]. The feasibility of performing polysomnography in hospitalized patients using a wireless wide area network was previously reported, but this technology is not universally available [18]. Moreover, in many cases, patients are admitted to the hospital with a previous diagnosis of OSA that is not reported and thus do not receive proper treatment. This study reports the findings of using previous documentation of OSA from a large enterprise data warehouse (EDW) in combination with current patient information in the electronic medical record (EMR) to improve the early detection of hospitalized patients with previous OSA documentation and increase appropriate therapy.

Materials and Methods

Background

Intermountain Medical Center (IMC) in Salt Lake City, Utah, USA is a 456-bed teaching hospital affiliated with the University of Utah School of Medicine and is Intermountain Healthcare's (IH) Level One trauma facility. IH is comprised of 22 hospitals, 197 clinics, instacares, physician offices and home health. The key feature of the hospital information system is the integrated EMR that contains most clinical infor-

mation including bedside charting by respiratory therapy. The coded data in the EMR facilitates the development and use of clinical decision support programs to analyze the data and constantly monitor patient care. IH also has an extensive EDW where most clinical and business information is updated every night from all inpatient and outpatient facilities and provides the ability to generate decision support alerts as soon as patients are admitted[19]. In 2011, we developed a computer application that uses patient information from the EMR and EDW to identify patients with previously documented OSA.

System Description

We developed a structured query language (SQL) program that is activated by the Windows Scheduler each night to scan the entire EDW and look for new patients with ICD9 codes ('327.23' OBST SLEEP APNEA, '780.57' HYPERSOMNIA WITH SLEEP APNEA, '780.53' SLEEP APNEA UNSPECIFIED) for OSA from any IH inpatient or outpatient facility. Every patient identified as having OSA is stored in an Oracle table located on a staging server on the network. Since the EDW is not guaranteed to be up 24/7, the program always looks for new records of OSA for three days back in time. Another java program with embedded SQL is also activated at 6:00 and 18:00 every day and scans the IH enterprise-wide encounter table in the EMR for every patient that has a new inpatient encounter within the past 12 hours. Each of those patients is then compared with the patients with previous documentation of OSA. When a patient with previous OSA is found, the java program then accesses the EMR to see if that patient is currently on PAP, a ventilator or has a tracheostomy tube. If not, that patient is included on the OSA patient alerts which are sent via secure email to the respiratory therapy supervisors (Figure). Each alert contains the patient name, enterprise-wide number, current encounter number, admission date, age, gender, room number, current body mass index (BMI), whether the patient is currently on antihypertensive, antidepressant or opioid medications and then the date and facility where the latest previous documentation of OSA was found. The patient in the figure had been diagnosed with OSA almost a year and a half before the current admission at Dixie hospital 305 miles south of IMC.

Study Design

To validate the accuracy of the OSA program to identify patients with previous OSA documentation and not already on PAP, a ventilator or a tracheostomy tube, we sent the initial OSA email reports to a respiratory therapy intern who compared each alert with respiratory therapy documentation for 2 months. After the computer logic was found to be reliable, respiratory therapists were educated concerning the use of the OSA alerts. A prospective observational study was then conducted from January 2012 through October 2012 that included notifying respiratory therapy of all inpatients and observational patients having previous OSA documentation and not on PAP, a ventilator or have a tracheostomy tube at IMC. For each of those OSA alerts, the day and night shift supervisors visited each patient and checked to see if the patient met criteria for PAP, oxygen therapy or sleep medicine testing.

Patients were placed on PAP if they wore a PAP mask at home or if their medical history reflected a PAP prescription. Patients not needing PAP were provided oxygen therapy if nocturnal oxygen had been recommended based upon previous sleep medicine testing. Respiratory therapy recommended patients for sleep medicine testing if they had initiated but not completed a sleep lab test, participated in a previous and not completed oximetry study, or were previously diagnosed with OSA but had not worn their PAP mask for a year or longer.

If patients agreed to have PAP, the respiratory therapist requested a PAP order from the attending physician. Once the order was received, PAP was set up for use at bedtime and while napping. PAP settings were based on the previous sleep lab report. If no previous sleep lab documentation was found, automatic APAP machines (Resmed S9 Auto; Resmed, Poway, California) with a range of 5-20 cmH_2O and an oxygen bleed-in to maintain the SpO2 above 90% were used. For patients needing oxygen therapy, an increase/decrease protocol was used to increase oxygen as fast as needed to maintain a SpO2 above 90% and then carefully wean the patient off oxygen. If further assessment was requested and deemed medically appropriate, the sleep medicine service was consulted. Those patients were reevaluated with inpatient diagnostic polysomnography or underwent formal titration to initiate therapy with a fixed PAP pressure.

From January 9, 2012 to February 24, 2012, the respiratory therapy director and a nurse practitioner from the sleep medicine service followed up and documented the respiratory therapy evaluation and patient visits for 500 patients alerted as having previous documentation of OSA.

Statistical Analysis

Two-tailed Chi-square tests with Yates' correction were used to compare differences in proportions between outcomes of patients with previous OSA documentation admitted from January through October 2012 with those admitted during the same months in 2011. The same 10 months of the year were included to account for potential seasonal respiratory influences. The two-tailed t-test was used to compare the differences in averages between patients. This study was approved by the Intermountain Office of Research for Publication.

Intermountain Medical Center
OSA Patient Alerts for the Past 12 Hours
Run Time: 9/13/2012.06:00

Name	Enterprise No.	Encounter No.	Admit Date	Age	Sex	Room	BMI	Anti-Hyper	Anti-Depr	Opioids	Previous OSA
Doe, Jane Q.	11111111	0000000	09/13/2012	54	F	9999	32.9	0	0	1	04/19/2011 Dixie
Comments:											
Follow Up:											

Figure – Example of an OSA patient alert.

Results

During the two month evaluation of the program logic, 648 patients were identified as having previous OSA documentation and not being on PAP, a ventilator or tracheostomy tube. While all of the alerted patients had a previous documentation of OSA, 634 (98%) of the alerts were found to be correct and 14 (2%) of the patients were either already on PAP or a ventilator when visited by the respiratory therapy intern. All 14 false positive alerts occurred during the first two weeks of the evaluation. Initially, the program was looking for PAP and ventilator data from the EDW which is only updated each night. After the first two weeks, the PAP and ventilator data were collected from the EMR in real time and no false positive alerts occurred during the remaining 7 weeks.

During the total 20 month study period in 2011 and 2012, 35,695 inpatients and observational patients were admitted at IMC. During the 10 month prospective observational period in 2012, 18,150 inpatients and observational patients were admitted of which 5,037 (28%) had previous documentation for OSA compared to 4,733 (27%) of 17,545 patients admitted during the same ten months in 2011 (Table). No difference in gender or average age was noted. However, patients with previous OSA documentation during 2012 were hospitalized an average of 0.55 days less but had an average increase in hospital costs of $400. However, significantly more of the OSA patients received respiratory therapy in 2012 compared to 2011 (1,975 (39%) vs. 1,676 (35%); $p < 0.0002$) and 1,671 (33%) were placed on PAP during 2012 compared to 1,396 (29%) in 2011 ($P < 0.006$). While significantly fewer total OSA patients had an SP02 less than 90% in 2012 ($P < 0.006$), no significant difference was found in transfers to the intensive care unit (ICU) or the number of expired patients.

The patients were placed on PAP an average of 1.1 days after admission in 2012 compared to 1.2 days in 2011. Although more patients were placed on PAP in 2012, total days of PAP use was less in 2012 compared to 2011 and may be related to 0.8 fewer days of hospitalization. While significantly fewer patients on PAP had a SPO2 < 90% in 2012 ($P < 0.03$), there was no difference in ICU transfers or a significant difference in the number of expired patients. Since many patients were not placed on PAP during the first day of admission, we also compared SPO2 < 90% after 24 hours of admission.

There were 1,571 (31%) of the OSA patients that had surgery in 2012 compared to 1,392 (30%) in 2011. While more surgery patients were placed on PAP during 2012, no significant differences were found between patients with a SPO2 < 90%. While days of hospitalization were lower in 2012 (5.6 vs. 6.3) the average cost of hospitalization was only $21.00 less. However, significantly larger differences were found in increased PAP placement and SPO2 < 90% during 2012 for non-surgery patients.

From January through October 2011, 181 patients at IMC had medical emergency team (MET) calls of which 63 (35%) were OSA patients compared to 148 of which 44 (30%) in 2012 (19 fewer OSA patients, 11% decrease; $p = 0.4068$).

Data from the intensive follow up of 500 OSA alerted patients from January 9, 2012 through February 24, 2012 by the respiratory director and nurse practitioner from the sleep service showed that 141 (28%) were placed on PAP of which 50 (36%) were requested by respiratory therapy following up on OSA alerts. Respiratory therapy requested oxygen for 2 (0.4%) of the patients and requested a sleep medicine referral for 4 (1%). Of interest, 113 (23%) of the patients admitted to having OSA but declined PAP because of the discomfort and another 92 (18%) denied having OSA although they did have previous ICD9 coding documenting otherwise. Fourteen (3%) patients were subsequently placed on a ventilator. Those were surgery patients expected to be on a ventilator and were taken directly from the operating room to an ICU. A total of 35

Table 1– Comparison of patients with (2012) and without (2011) OSA Monitor Alerts

Category	2012 N (%)	2011 N (%)
Total patients	18150	17545
Patients with OSA documentation	5037 (28)	4733 (27)
Av. age; yr	63.2	62.8
Female	2270 (45)	2108 (45)
Av. days of hospitalization	4.25	4.8
Av. cost of hospitalization	16138	15738
Received respiratory therapy	1975 (39)*	1676 (35)
SPO2 < 90%	2358 (47)**	2350 (50)
SPO2 < 90% & > 24 hrs after admission	1858 (37)**	1902 (40)
Transferred to ICU	293 (5.8)	268 (5.7)
Expired	93 (1.8)	111 (2.3)
Placed on PAP	1671 (33)*	1396 (29)
Av. days to PAP placement	1.1	1.2
Total days of PAP use	4634	4729
Av. days of hospitalization	4.7	5.5
Av. cost of hospitalization	16784	17063
SPO2 < 90%	933 (56)#	845 (61)
SPO2 < 90% & > 24 hrs after admission	780 (47)##	735 (53)
Transferred to ICU	112 (7)	96 (7)
Expired	12 (0.7)	18 (1.3)
Not placed on PAP	3366 (67)	3337 (71)
Av. days of hospitalization	3.9	4.0
Av. cost of hospitalization	14802	13858
SPO2 < 90%	1425 (42)#	1505 (45)
SPO2 < 90% & > 24 hrs after admission	1078 (32)**	1167 (35)
Transferred to ICU	181 (5)	172 (5)
Expired	81 (2.4)	93 (2.8)
Surgery patients	1571 (31)	1392 (30)
Placed on PAP	601 (38)	510 (37)
SPO2 < 90%	882 (56)	824 (59)
SPO2 < 90% & > 24 hrs after admission	790 (50)	749 (54)
Av. days of hospitalization	5.6	6.3
Av. cost of hospitalization	27732	27711
Transferred to ICU	90 (6)	68 (5)
Expired	18 (1.2)	22 (1.6)
Non-surgery patients	3466 (69)	3341 (70)
Placed on PAP	1070 (31) *	886 (27)
SPO2 < 90%	1476 (43)**	1526 (46)
SPO2 < 90% & > 24 hrs after admission	1068 (31)**	1153 (35)
Av. days of hospitalization	3.6	4.1
Av. cost of hospitalization	11412	11982
Transferred to ICU	203 (6)	200 (6)
Expired	75 (2.2)	89 (2.7)
Total MET calls	148	181
Patients with OSA documentation	44 (30)	63 (35)

* $P < 0.0002$. ** $P < 0.006$. # $P < 0.03$. ## $P < 0.002$

MET = medical emergency team

(7%) patients did not get visited by respiratory therapy due to the fact that they were short stay patients and discharged before respiratory therapy follow up or 14 (3%) were not in their rooms at the time of the visit.

In an effort to better understand which OSA patients were placed on PAP, average patient age (62.8 vs. 63.2), percent female (40 vs. 47; $p < 0.0001$), BMI (38.47 vs. 35.45; $p< 0.03$) and Charlson comorbidity scores (5.9 vs. 5.9) were compared between patients placed on PAP and those who were not during both study years. Based on those results and the intensive follow up, patient choice or lack of knowledge of potential harm concerning their OSA and increased BMI and female seem to be the main criteria as to which patients with previous OSA documentation were placed on PAP.

Discussion

Many patients with documented OSA do not get placed on appropriate PAP therapy during hospitalization due the lack of information from previous inpatient and outpatient encounters and patient misunderstanding of the potential harm. This study showed that use of early computer alerts of OSA patients by respiratory therapists resulted in significantly more patients receiving appropriate medical care and significantly fewer experienced hypoxemia and may have resulted in fewer OSA patients requiring MET calls.

Our data show that the impact of the OSA alerts was greater for non-surgery patients compared to surgery patients. The international literature has emphasized that patients with diagnosed OSA have an increased incidence of postoperative complications, the most frequent being hypoxemia[6, 7, 20]. Thus, it is not surprising that most surgery patients get screened for OSA before they reach to operating room[12]. In fact, we see a number of OSA patients identified on the surgery schedule at IMC each day.

The computer alerts for previous OSA patients are dependent on patient data from the current EMR in addition to data from previous encounters in the EDW. Enterprise-wide data are needed to monitor patients through all encounters for the continuum of care and current patient information in the EMR is needed to identify new patient encounters, provide valuable information on individual patient risk and reduce false positive alerts. While a number of OSA screening questionnaires have been developed to mainly identify new patients with OSA[13-15], this is the first study to determine if information technology can help improve the early detection and therapy of hospitalized patients with previously documented OSA.

The impact of the study may have been greater if all patients with previously documented OSA had been placed on PAP. The intensive surveillance of 500 OSA patients found that 23% of alerted patients declined the use of PAP due to discomfort. Based on that information, respiratory therapy developed an education sheet with information to inform the patient of the disease and make them more aware of the potential harm of not using PAP during hospitalization. Another 18% of the patients with previous OSA documentation denied having OSA. It is unknown which of those patients really did not have OSA, did not know or remember they had OSA or used that as an excuse to decline PAP use due to discomfort. Two of the ICD9 codes we used to identify OSA do not state "obstructive" in the definition, so that may have been the bases for some patients' confusion. Patients with mild OSA often have a high rate of PAP discontinuation[21]. While polysomnography is the "gold standard" to diagnose OSA, it is time consuming, inconvenient for the patient, may not be universally available and impractical to use in all surgical patients[17, 22]. Thus, some physicians may diagnose patients without polysmnography and may rely on personal use of a screening questionnaire. Some report that most of the clinical screening questionnaires can have inconsistent results[16, 17]. Also, ICD9 coding is not exact and other studies have shown that many patients do not have some medical conditions that are documented by ICD9 codes[23]. Thus, our ability to identify true patients with previous OSA coding and reduce any false positive alerts is dependent on the quality of the data in the EMR and EDW. Therefore, the method used in this study to identify OSA patients based on enterprise-wide documentation may produce some false positive alerts.

Although four respiratory therapy supervisors only received an average of 8-9 OSA alerts twice a day, they must get an order from the physician before they can initiate PAP therapy. Our data showed that during 2011 and 2012, it took an average of 24 hours after admission to get PAP set up if the patient did not bring their own PAP machines. While respiratory therapy were not able to visit 7 percent of the alerted patients before they were discharged and since they did not spend the night, the impact of PAP therapy for those patients would have been minimal. We could generate OSA alerts more often during the day, but current work flow doesn't allow respiratory therapists to visit every patient as soon as they are admitted.

Limitations

Although the OSA alerts are currently being used at 9 IH hospitals, this study just included IMC. While IMC is the largest, results may differ at other IH hospitals and especially outside of IH that do not have a large geographically based EDW.

It is also important to note that while respiratory therapy documents all patient interactions including PAP use every four hours in the EMR, actual time of PAP use by the patients at night and especially during daytime naps is unknown. It is not uncommon for patients to remove the PAP mask and then forget to put it back on. Thus, the actual time of PAP use by individual patients may have varied in this study.

While we compared the number of patients that expired during 2012 and 2011, we were not able to review and determine the exact cause of death for those 204 patients during this study.

Conclusion

Previously diagnosed OSA is highly prevalent and undertreated in hospitalized patients. Respiratory therapist use of computer alerts for patients with OSA resulted in significantly more OSA patients being placed on PAP and significantly less experienced hypoxemia. The impact was greater for non-surgery patients compared to surgery patients.

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