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Evaluation of nursing approach to assessment of post-operative respiratory depression using a simulation model

Abstract

Introduction: Assessments of post-operative patients that have been carried out by health care providers before critical opioid-induced respiratory events often do not detect respiratory depression. We hypothesise that opioid-induced respiratory patterns present during sleep may not be properly recognised as providers typically awaken patients for vital sign checks, and awake state assessment is recorded. We used a simulation manikin model to test this hypothesis.

Methods: Nurses who work on a standard post-operative hospital ward volunteered to participate in a study designed to record vital signs on an adult male manikin. None of the nurses had formal critical care or post-operative care unit education. This simulation consisted of an elderly male patient who had undergone a hernia repair and was randomised to have two breathing patterns while asleep – persistent bradypnoea (respiratory rate of six breaths per minute) and intermittent apnoea (respiratory rate of 18 breaths per minute with 30-second pauses); both breathing patterns terminated after nurses woke the patient.

Results: Twenty-seven nurses participated: 14 in the bradypnoea scenario, and 13 in the intermittent apnoea scenario. Upon entering the room, 24 (89%) participants woke the patient to begin respiratory assessment, and three (11%) assessed respirations while the patient remained asleep. Eleven (79%) participants noted abnormal breathing in the bradypnoea scenario, while only one (4%) noted abnormal breathing in the intermittent apnoea scenario.

Conclusion: This simulation model demonstrated that most nurses awaken patients before vital sign assessments, which could prevent detection of respiratory depression present during sleep. Nurses on hospital wards should be educated to follow respiratory status assessment guidelines not to wake the patient for respiratory status assessment.

Keywords: opioid-induced respiratory depression, simulation model, nursing assessment, apnoea, bradypnoea

Background

Post-operative, opioid-induced respiratory depression (OIRD) is a severe, life-threatening condition that can be prevented if recognised early[1,2]. Evolving technology has allowed better understanding of the phenotypic presentation of OIRD as it presents on post-operative wards[3]. Despite a widespread perception that the typical pattern of OIRD is bradypnoea, the most common presentation is repetitive apnoea and partial apnoea episodes interspersed with normal breathing patterns[3,4].

Severe post-operative OIRD seems to occur suddenly without warning, developing even after apparently reassuring nursing assessments[5]. Analyses have consistently found respiratory depression is indicated in nursing notes documented before these critical events[1]. The most common nursing note documented before naloxone administration was somnolence, but not respiratory depression[6].

Health care workers on hospital wards might not be proficient in recognising a repetitive apnoea as phenotypic presentation of post-operative OIRD. This breathing pattern, which is consistent with respiratory depression, may become extinguished when a patient is woken during routine vital sign checks[7]. In other words, from the nursing perspective the awakened patient with appropriate breathing rate and without respiratory pauses is noted in medical records as 'somnolent'. However, as soon as the nurse leaves the room the patient can resume sleep and this OIRD pattern could develop again.

The aim of this simulation study was to evaluate how nurses perceive two hypothetical breathing patterns that are associated with respiratory depression (bradypnoea and intermittent apnoea during sleep). In this study enrolled health care workers were asked to evaluate vital signs on a manikin that was programmed to snore loudly and have either of the two breathing patterns consistent with respiratory depression. Specifically, the two breathing patterns were bradypnoea during sleep and intermittent apnoea spells during sleep; both breathing patterns normalised after the patient was woken up. We hypothesise that nursing assessments will readily recognise bradypnoea as respiratory depression, while recognition of intermittent apnoea will be frequently missed.

Materials and methods

Overview

This simulation study was performed in the standardised post-operative surgical ward at our institution, a major academic quaternary medical centre. The study was approved by the local Institutional Review Board. Participation in this research study was completely voluntary. Oral informed consent of the study participants was obtained.

Participants

All participants were nurses working on a general surgical ward; participants had various levels of experience in the clinical setting. The main inclusion criterion was direct involvement in the care of post-operative patients. Participant experience levels, including number of years nursing and being patient care assistant, were self-reported. In addition, participants reported if they had any experience in the intensive care unit (ICU), post-operative care unit or emergency department. By design, we did not collect data which could be used to identify the participants (i.e. age, gender, name) as this was felt to be a potential barrier to participation.

Participants who met the inclusion criteria and provided oral informed consent were randomly assigned to one of two simulated scenarios for assessing the vital signs of a post-operative patient. In one scenario the manikin had sustained bradypnoea, in the other scenario the manikin had intermittent apnoea spells.

Study protocol

All participants were asked to perform a routine post-operative assessment of vital signs on a manikin in a general care ward. They were given a form (see supplemental material) that included scenario details, patient information and a previous set of vital signs of the patient. They were asked to enter the patient room and assess and record vital signs, including temperature, heart rate, blood pressure, respiratory rate and oxyhaemoglobin saturation, as well as assess level of pain on a standard ten-point numeric pain score ranging from 0 (no pain) to ten (worst pain imaginable). They were then instructed to indicate if they observed any abnormalities.

The simulation scenario consisted of a 75-year-old, male patient with an elective ventral hernia repair and a history of hypertension and hyperlipidemia. He was admitted to the general care ward after being discharged from the Post Anaesthesia Care Unit (PACU) two hours earlier. The high-fidelity adult male manikin SimMan 3G (Laerdal Medical Corporation, Wappingers Falls, NY) was set up as a patient. For a realistic patient presentation, the manikin was programmed to speak and make snoring sounds, as well as display physical features including respiration and pulse.

In addition, the manikin had a nasal cannula, a blood pressure cuff attached to his arm and an abdominal dressing.

During the case presentation, participants were located outside the 'patient ward', so they could hear the snoring and breathing pattern of the manikin. For the sustained bradypnoea scenario, the manikin was programmed to snore loudly and have a respiratory rate of six breaths per minute (supplemental audio file 1). For the intermittent apnoea scenario, the manikin was programmed to snore loudly and have a respiratory rate of 18 breaths per minute with periodical 30-second respiratory pauses (nine missed breaths) due to temporal cessation of breathing (supplemental audio file 2).

The snoring sounds continued when the participant entered the room. Once the participant woke up the patient, the snoring sounds stopped and the manikin opened the eyes. For the bradypnoea scenario, the respiratory rate remained six breaths per minute. For the intermittent apnoea scenario, the respiratory rate remained at 18 breaths per min, but the apnoeic pauses ceased. The other vital signs were identical in the two scenarios. The temperature was 36.9 °C, heart rate was 74 beats per minute, blood pressure was 132/65 mm Hg and oxyhaemoglobin saturation was 95 per cent. After assessing the vital signs and writing them down, participants were asked to record if patient had any of the following conditions: tachycardia, bradycardia, hypotension, hypertension, bradypnoea, tachypnoea, hypoxaemia, apnoea, dysrhythmia, or none of them.

There was an embedded participant in the room to explain how the manikin worked, facilitate the flow of the scenarios and write down comments and observations related to the performance. Another person was controlling the manikin's vital signs and changing respiratory rate and snoring pattern according to the randomisation information.

Statistical methods

Participants were randomly assigned to the apnoea or bradypnoea scenario. Blocked randomisation was performed using blocks of size N=4 to ensure that after every fourth participant was randomised there were an equal number of participants assigned to each treatment condition. Descriptive statistics were used with results summarised as median, with interquartile range (IQR), and number, with percentage, as applicable.

Results

Twenty-seven nurses were enrolled, 14 in the bradypnoea scenario and 13 in the intermittent apnoea scenario, and all completed the trial. Participants had median work experience of five years (IQR 4 [8-4]); two had prior experience working in an emergency department, but none had experience working in an ICU or PACU.

Upon entering the patient room 24 participants immediately awoke the manikin by announcing they were there for a vital sign check. Of the three participants who initially quietly observed the manikin, two awakened the manikin within 30 seconds to start the assessment. The third participant observed the snoring (apnoea) patient for two minutes and then recorded the pulse oximetry score without assessing respiratory status while asleep.

Bradypnoea scenario

Out of 14 participants in the bradypnoea scenario, 13 (92.9%) awoke the manikin before evaluation of vital signs. Participants in this scenario recorded a median respiratory rate of seven breaths per minute (IQR 3.5 [9.5-6]) with one of them recording a rate of 15 breaths per minute. Nine (64.3%) participants indicated the manikin had bradypnoea, and two (14.3%) participants indicated apnoea (see Figure 1). Three participants expressed concerns for the patient. One of them asked if the patient was sleeping or feeling dizzy. The other one asked if the patient was 'doing okay'. The third participant vocalised that the respiratory rate was less than seven breaths per minute.

Apnoea scenario

Out of 13 participants in the intermittent apnoea scenario, 11 (84,6%) awoke the manikin before evaluation of vital signs. Participants in this scenario recorded a median respiratory rate of 18 breaths per minute (IQR 2 [20-18]) with no respiratory rate below 16 breaths per minute. Two (15.4%) participants interpreted the breathing pattern as tachypnoea. One (7.7%) participant interpreted the breathing pattern as apnoea (see Figure 1), but interestingly recorded a respiratory rate of 18 breaths per minute. One of the participants noticed the patient was snoring while asleep but did not verbalise any concerns about the presence of apnoea.

The majority (89%) of post-operative vital signs assessments were performed after the patient had been awoken from sleep, which resulted in failure to witness respiratory depression that was present only during sleep, and not present following stimulation in an awake state. The green background in Figure 1 indicates an inappropriate clinical practice of assessing respiratory effort while the patient is awake.

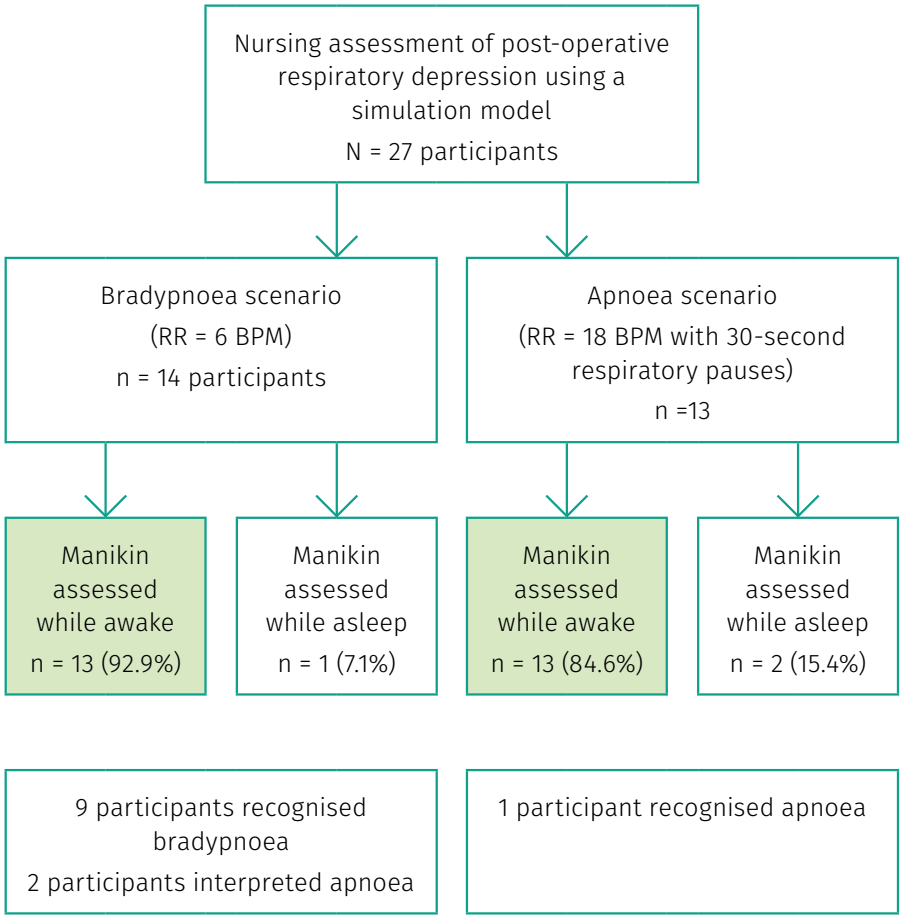

Figure 1: Study design and nursing approach to assessment of vital signs on manikin model.

RR = respiratory rate; BPM = breaths per minute

Discussion

The aim of this study was to explore nursing assessment of post-operative OIRD using a simulation model. The important observation is that the nursing staff, with no formal training in monitoring post-operative or ICU patients, typically woke patients before beginning the assessment of vital signs. The act of waking patients from sleep can extinguish abnormal sleep-disordered breathing patterns.

Most of the participants in the in bradypnoea scenario recognised abnormal breathing. In contrast, only one participant in the intermittent apnoea scenario recognised the presence of apnoea. This supports our hypothesis that nursing staff are more adept at recognising bradypnoea as a concerning breathing pattern; they frequently miss sleep-disordered breathing patterns because they almost routinely wake up the patient for vital sign evaluations.

A prospective, multicentre, international observational which study which used bedside capnography and pulse oximetry (blinded to health care providers) on general care wards found that 46 per cent of patients (614 of 1335 subjects) receiving parenteral opioids experienced respiratory depression episodes, and 97 per cent of these consisted of apnoeas[3,4]. In that study opioid complications were only recognised in 18 patients using routine clinical care[3]. Another study which used bedside pulse oximetry (blinded to health care providers) on post-operative patients on general care wards found 90 per cent of episodes of hypoxaemic events (SpO_2 < 90% for > 1 hour) were missed by routine vital sign assessments[2]. This suggests that there is a need for further investigation and renewed emphasis on training nurses to assess the respiratory status for patients administered opioids and other sedating medications[7].

In 2020, the American Society for Pain Management Nursing (ASPMN) issued revised guidelines on monitoring for opioid induced sedation and respiratory depression[8]. These guidelines recommend assessing the patient before administering an opioid and during peak effect of the opioid (with or without another sedating medication) to ascertain the patient's level of sedation, respiratory rate and quality of breathing, and oxyhaemoglobin saturation[8].

Furthermore, the ASPMN guidelines recommend assessing the respiratory rate first while the patient is asleep and then when the patient is awake[8]. The observation during sleep should last at least for one minute and the nurse should look for signs and patterns similar to those present in patients with obstructive sleep apnoea[8].

Our simulation model replicated the scenario of a patient with OIRD present during sleep; however, it was clear that our participants did not use the recommended assessment approach; rather, the majority simply woke the patient prior to the assessment. A recent review regarding the nursing role

in opioid management research found that only seven per cent of published papers addressed health care provider education[9]. This suggests that there is a need in nursing education for further emphasis on how to properly assess the respiratory status of patients receiving medications with potential to induce respiratory depression.

Technologies which can monitor not only oxyhaemoglobin saturation but also respiratory effort are becoming more readily available for routine clinical care[10]. It has been envisioned that such monitors could be integrated into the health care environment to overcome human health care providers limitations in detecting respiratory depression[10]. However, even if these monitors were used, health care staff would still need to understand that it is critical to assess respiratory status while the patient is asleep[8]. One could envision the scenario where a monitored sleeping patient develops OIRD, generating an alarm. The OIRD extinguishes once the patient is woken, providing false reassurance. Alternatively, health care staff trained to quietly assess respiratory status (without waking patients) could recognise OIRD and therefore could take corrective action before the respiratory status deteriorated to a critical level[8].

Strengths and limitations

This report represents only a hypothesis-generating study and has several limitations. Although simulation is a powerful tool, it has its own disadvantages. We used a high-fidelity manikin as it can reproduce consistent vital signs, including respiratory rate, which would be impossible to maintain at a rate of 6 breaths per minute in a real person. At the same time, the manikin cannot fully simulate the OIRD patient. Specifically, it cannot maintain a conversation or imitate somnolence that would be concerning for nurses. The issue of model fidelity (the artificiality of the manikin) can influence participants' engagement level, and this represents a limitation to our study design. This limitation needs to be considered in any health care study with the use of simulation models.

Further, the presence of research personnel in the study room may have introduced a distraction and/or Hawthorne effect for the research participants[11] (i.e. people will modify their behavior because they are being observed). Thus, post-operative assessments with real patients may render different results than that described in the current study.

Conclusion

Recognition of OIRD is critical in the post-operative period to avoid severe complications. We demonstrated that nurses are adept at recognising bradypnoea as a concerning breathing pattern; however, they fail to recognise respiratory depression related to sleep-disordered breathing patterns because of a flaw in their assessment technique – they wake the patient for vital signs assessment. Our study indicates that there is a need for additional education of hospital ward nurses to train them in proper assessment of respiratory status for patients administered medications with sedating potential. Our small pilot study suggests that nursing staff working on hospital wards should receive formal training in assessment and recognition of respiratory depression.

Declaration of conflicting interests

The authors have declared no competing interests with respect to the research, authorship and publication of this article.

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Supplement: Clinical scenario and data collection sheet completed by the study participants

Scenario/debrief form

Patient data and baseline state				
Name: Doug Eyota, Minnesota, USA		**Medical record number:** 0-000-001		
Gender: male	**Age:** 75 years	**Weight:** 82 kg	**Height:** 182 cm	**BMI:** 24.8 kg/m^2
Current condition: POD#0 elective ventral hernia repair				
Past medical history: HTN, hyperlipidaemia, former smoker (quit 2003)				
Current medications: amlodipine, atorvastatin				
Allergies: sulfa				
Laboratory data: Hg 15 mg/dL, Plt 245.000, Cr 1.1 mg/dL				

Assessment			**Conditions** (circle all that apply)	
Time	14:00	16:00	none	febrile
temperature (°C)	36.8		tachycardia	bradycardia
heart rate (beats per minute)	73		bradypnoea	tachypnoea
Blood pressure (mm Hg)	139/68		hypoxaemia	apnoea
Respiratory rate (breaths per minute)	16		dysrhythmia	
Oxyhaemoglobin saturation	95		Other (please write)	
Cardiac rhythm	normal			
Pain score	4			

Your experience			
Years nursing		Year PCA:	
ICU/Pacu/ED experience			

M = male, BMI = body mass index, POD = post-operative day, HTN = hypertension, Hg = haemoglobin, Plt = platelet, Cr = creatinine, PCA = patient care assistant, ICU = intensive care unit, PACU = Post Anaesthesia Care Unit, ED = emergency department