Capnography monitoring during opioid PCA administration

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INTRODUCTION

Opioid administration by patient-controlled analgesia (PCA) apparatus in hospital settings is standard therapy during the acute postoperative period. Whether medication is taken intravenously (IV) or using the new method of transdermal iontophoretic PCA administration, some patients require very close monitoring for respiratory depression.[1] Currently, hospitals use pulse oximetry to spot-check respiratory status, but with the recent availability of capnography monitoring in general care units, an evaluation of this new respiratory assessment is warranted. The goal of this article is to describe the use of capnography during safe and effective administration of opioids by PCA in spontaneously breathing (nonventilated) patients.

RESPIRATORY DEPRESSION

Respiratory depression is a consistent effect of all opioids and is usually related to excessive doses in opioid-naïve individuals, but it may occur with therapeutic doses. Alveolar gas exchange is diminished by effects on respiratory rate, minute volume, and tidal exchange. The decreased responsiveness of brainstem respiratory neurons to carbon dioxide (CO_2) is dose related. With sufficient suppression of CO_2 responsiveness, hypoxia may be the only stimulus for respiration, initiated through chemoreceptors in the aortic arch and carotid body. In such instances, administration of supplemental oxygen and the subsequent maintenance of oxygen saturation may completely suppress the breathing reflex.

Although IV PCA is a well-accepted means of controlling postoperative pain, there are many logistical steps and processes that may lead to errors resulting in respiratory depression. A meta-analysis of 116 studies found the incidence of respiratory depression during acute opioid therapy to be 1.1 percent.[2] Historically, reported medication errors have been an underestimation of the true incidence rate of opioid-induced respiratory depression.[3] The errors related to IV PCA may include programming errors, patient and family tampering, and device malfunctions.[4,5] MEDMARX, a national, internet-accessible database that hospitals and healthcare systems use to track and trend adverse drug reactions and medication errors, reported that four of the top 10 medications resulting in harm or fatality are opioids.[6] The use of IV PCA is associated with a 3.5-fold greater risk of patient harm compared to other IV medications. The most common types of errors involving IV PCA pumps submitted to MEDMARX^{SM} were improper dose and/or quantity of analgesic, accounting for nearly 38.9 percent (1,873 out of 5,110) of all errors examined; other common errors included unauthorized drug(s) (18.4 percent), omission errors (17.6 percent), and prescribing errors (9.2 percent).[7]

Because adverse events can arise quickly and require immediate intervention, adequate patient monitoring is essential in minimizing patient harm. Reversing the effects of opioid overdose may require extensive medical intervention and naloxone administration, resulting in increased hospital stays.[2,8,9] A change in respiratory status is a primary assessment tool for determining potential adverse events during opioid administration. Assessment of sedation level, while a helpful indicator of a potential adverse event, does not provide sufficient information on respiratory status. Intermittent nurse assessments may stimulate an oversedated patient, leading to a falsely high level of consciousness and providing an inaccurate estimation of true respiratory status.[10]

Currently, pulse oximetry is used in most US hospitals on a continuous or intermittent "spot-check" basis to measure arterial oxygen saturation (SpO_2). However, case reports suggest that using pulse oximetry alone can lead to an inaccurate assessment of a patient's condition, especially when supplemental oxygen is being used.[11,12] These case reports show that even with a low respiratory rate, SpO_2 may be maintained, especially with supplemental oxygen, resulting in an erroneous assessment of respiratory status.[12]

CAPNOGRAPHY

The American Society of Anesthesiologists has described ventilation and oxygenation as separate but

related physiological processes, and the assessment of oxygenation by pulse oximetry is not a substitute for monitoring ventilatory function by capnography.[13]

Capnography measures end-tidal carbon dioxide ($EtCO_2$) and monitors quality of respiration, changes in respiratory rate, levels of exhaled CO_2, and apneic events. Capnographic monitoring may anticipate a patient's desaturation by warning of a decrease in respiratory rate and rise in $EtCO_2$. In a procedural sedation study of $EtCO_2$ monitoring, capnography captured 100 percent of incidences of respiratory distress, while pulse oximetry captured only 33 percent.[14] Case studies have shown that early detection of declining respiratory status, before a patient goes into respiratory depression, may prevent harmful adverse events and avert transfer to an intensive care unit.[12,15,16]

In the past, continuous capnography has been limited to critical care areas and monitored units because of the requirements for intubation and heavy, complex devices. Now, there are handheld devices and portable modular units that measure SpO_2 and $EtCO_2$ in spontaneously breathing patients in the general care nursing units. The $EtCO_2$ disposable nasal cannulas are used to sample the exhaled breath, as well as to administer supplemental oxygen.

CONCLUSION

Opioids are associated with high error rates, which may result in harmful events. The clinical application of capnography in spontaneously breathing patients receiving opioids by PCA and supplemental oxygen may reduce harmful events during opioid administration. Monitoring of respiratory status in patients receiving supplemental oxygen by pulse oximetry and/or manual count of respiratory rate may provide inaccurate assessments. The availability of lightweight, handheld capnography devices and small, modular capnography monitors for general care units warrants evaluation of such instruments' efficacy in clinical studies.

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