

## Ensuring that patient-controlled anaesthesia is safe

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### Abstract

Pain is now regarded as the “fifth vital sign” and pain relief to be a basic human right. Patient-controlled anaesthesia (PCA) is effective because it enables self-titration to individual requirements. PCA is perceived to be inherently safe because of the lockout interval, and because sedation purportedly stops the patient from pressing the button. Nevertheless, because of respiratory depression, increasing numbers of adverse events are serious cause for concern. Respiratory depression comprises three components: central respiratory depression, airway obstruction and sedation. Together, these effects result in opioid-induced respiratory impairment (OIVI). Strategies for safety improvement include an understanding of opioid pharmacokinetics and pharmacodynamics, appropriate dosing regimens, establishing guidelines and written orders, appropriate monitoring and record-keeping, staff training for PCA competency, preoperative patient education and oxygen administration when appropriate, e.g. sleeping patients. Initial postoperative analgesia should be established personally by the attending practitioner who should titrate small doses of opioid to the desired effect. It is emphasised that counting breathing rates is an unreliable index of OIVI is that the quality of breathing should be assessed, and that sedation occurs before OIVI, is clinically obvious. Therefore, monitoring and recording a sedation score at regular intervals is essential. During opioid administration, sedation should be regarded as the “sixth vital sign”.

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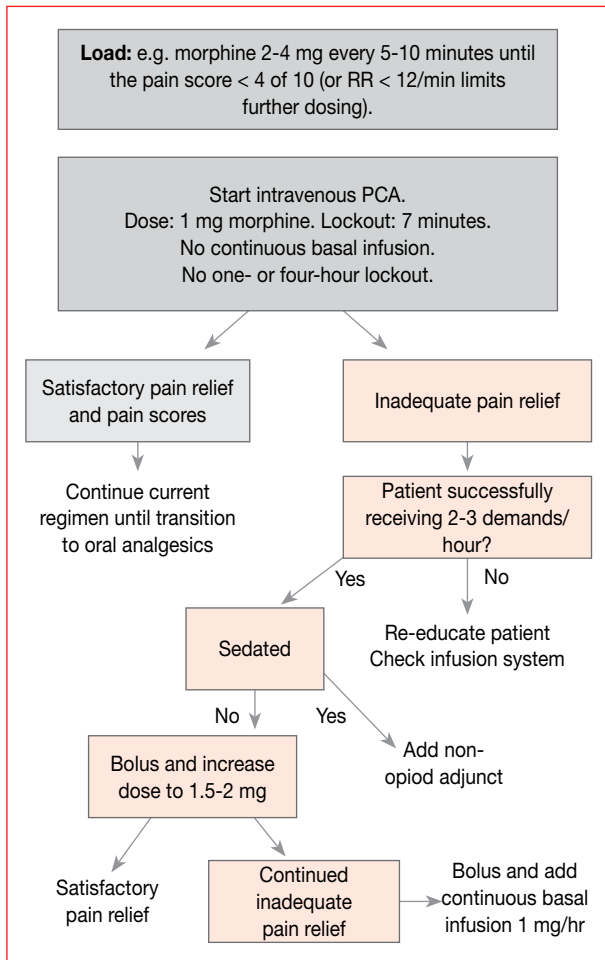
### Introduction

Inadequate pain relief after surgery results in increased stress responses and an increased incidence of complications. Pain is now regarded as the “fifth vital sign” and pain relief to be a basic human right. Opioid requirements vary greatly between patients, hence the necessity to tailor dosage according to the needs of the patient. Patient-controlled analgesia (PCA) has been proved to be extremely effective in this regard and is perceived to be inherently safe because a point is supposedly reached at which the patient becomes analgesic and sedated and stops self-administration. Hypothetically, the lockout time also contributes to patient safety. Nevertheless, increasing reports of adverse events resulting in patient harm or death because of respiratory depression has prompted various government organisations, hospital accrediting bodies and professional associations, such as the Anesthesia Patient Safety Foundation, to express concern.

There are three basic components to respiratory depression that is caused by opioids:

- Decreased respiratory drive (central respiratory depression).
- Airway obstruction (a decreased genioglossus tone, following a specific effect by opioids on the hypoglossal motor nucleus).
- Sedation (a state of decreased consciousness that results in diminished responses to stimuli, for example tolerating an obstructed airway).

Together, these effects result in opioid-induced ventilatory impairment (OIVI). CO<sub>2</sub> narcosis contributes to a vicious circle that ends with severe hypoxaemia and patient harm. Generally, the incidence of OIVI during PCA is estimated to be between 0.25% and 0.5%, but it is difficult to estimate due to different definitions of OIVI and under-reporting. Furthermore, it is likely that many critical events are unrecognised. Consequently, the incidence of OIVI is likely to be much greater than that generally supposed.



**Figure 1:** Proposed treatment algorithm for patient-controlled anaesthesia treatment

Strategies to improve patient safety include a thorough understanding of opioid pharmacokinetics and pharmacodynamics, appropriate dosing, the establishment by hospitals of care guidelines and written standing orders, monitoring, record-keeping, education and oxygen administration.

### A thorough understanding of opioid pharmacokinetics and pharmacodynamics

Important concepts of opioid pharmacokinetics and pharmacodynamics include the knowledge that:

- Pain antagonises, and pain relief potentiates, OIVI.
- Sleep potentiates OIVI.
- After a bolus dose, morphine's maximum effect occurs 100 minutes later.
- Patients who are resistant to opioid analgesia remain sensitive to OIVI.

### Appropriate dosing

Figure 1 depicts an algorithm for the management of PCA.

The following should be noted:

- Initially, postoperatively, the anaesthesiologist should establish analgesia by titrating small doses, e.g. morphine 2-3 mg.
- The optimum morphine syringe concentration is 1 mg/ml and the adult demand dose, 1 mg.
- Background infusions increase the danger of OIVI.
- Setting maximum one- or four-hourly cumulated doses produces a false sense of security.
- Initial doses in elderly patients should be reduced.
- Multimodal therapy reduces opioid demand, e.g. regional anaesthesia, paracetamol, nonsteroidal anti-inflammatory drugs and ketamine.
- Concomitant administration of other central nervous system depressants, e.g. phenothiazines and benzodiazepines, should be avoided.

### The establishment by hospitals of care guidelines and written standing orders

Rules should include the following:

- Preferably, dedicated PCA infusion lines should be used.
- No other drugs should be administered via the PCA line (no "add a line").
- PCA pumps should be programmed by two competent persons. (When PCA pumps are involved in medication errors, the probability for patient harm increases 3.5 times).
- Opioids should be supplied in syringes prefilled by the hospital pharmacy to help prevent mistakes occurring with drug dilution.
- PCA must not take place by proxy.
- Monitoring frequency should be flexible, depending on patient condition. Initially, it should occur every 15 minutes for the first one hour, then hourly for four hours, and then two-hourly. This cycle should be repeated whenever there is an event or deterioration in patient condition, for example, over-sedation (Pasero Opioid-induced Sedation Scale > 2 or Macintyre Sedation Scale > 1), as well as dosage change, syringe change or shift changeover. At shift changeover, the staff who will be assuming responsibility should carry out an independent check of the pump settings. The outgoing and incoming nurses should assess the patient together.

### Monitoring

Monitoring encompasses the following:

- *Breathing:* Respiratory rate is an unreliable index of respiratory depression (low specificity), but should be monitored because bradypnoea has high sensitivity.
- *Quality of respiration:* Quality of respiration should be assessed, specifying depth of breathing, ventilatory effort and adventitious sounds.
- *Sedation scores:* Less opioid is required to produce

sedation than respiratory depression. Sedation scoring is essential and is the “sixth vital sign” (Table I).

- *Pulse oximetry*: Note that hypoxaemia is a late event, with potential for rapid deterioration, especially if oxygen is being administered.
- *Pupil size*: Pinpoint pupils are a sign of full opioid effect.
- *Future monitoring modalities*: Future monitoring modalities include capnography and bio-acoustic monitoring of breath sounds.

**Table I:** Sedation scales that are applicable to patient-controlled anaesthesia

Pasero Opioid-induced Sedation Scale	
Number	Description
S	Sleep, easily aroused
1	Awake and alert
2	Occasionally drowsy, easy to rouse
3	Frequently drowsy, rousable, drifts off to sleep during conversation
4	Somnolent, minimal or no response to stimuli
Macintyre Sedation Scale	
0	Awake, alert
1	Mild sedation, easy to rouse
1S	Asleep, easy to rouse
2	Moderate sedation, easy to rouse, unable to remain awake
3	Difficult to rouse

## Record-keeping

A dedicated PCA monitoring chart should record the following: sedation score, pain score, breathing (rate and quality), pupil size, amount discharged from the PCA pump and O<sub>2</sub> saturation (if available).

## Education

### Patients

Contraindications in patient selection include patients who do not, or cannot, understand the principles of PCA, and high-risk cases, e.g. morbid obesity and obstructive sleep apnoea.

The postoperative recovery unit or the postsurgical ward is not the occasion at which to introduce the patient to the device.

Patients should understand the following preoperatively:

- The principles of PCA.
- That morphine cannot take the pain away completely,

but helps it to be tolerated.

- How to indicate pain scores, e.g. Wong-Baker FACES® Pain Rating Scale.
- That they will be monitored or wakened frequently to assess sedation levels.
- Instructional handouts should be given to both the patient and his or her family.

### Ward staff

Nurses remain the cornerstone for safe PCA, and should receive training in PCA competency. Important aspects include:

- Basic training in respiratory assessment and airway management.
- *Recognition of OIVI*: It should be emphasised that noisy breathing is obstructed breathing and that it is important to detect paradoxical breathing and/or rib retraction.
- When to administer naloxone and call for help.
- Familiarity with the various PCA devices.

## Oxygen administration

The administration of oxygen is debatable because it can maintain saturation in the presence of OIVI, and result in a false sense of security. However, oxygen does not mask increasing sedation (hence the importance of sedation scoring as an early warning of high-opioid dosing). Hypoxaemia can result in rapid deterioration, whereas hypercapnia develops slowly. Sleeping patients should receive oxygen while ensuring a clear airway, e.g. lying in the “tonsil position”.

## Recommended reading

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