Intravenous patient-controlled analgesia for acute postoperative pain

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ABSTRACT

Intravenous patient-controlled therapy is used routinely in postoperative care in much of the developed world. Intravenous patient-controlled analgesia results in higher patient satisfaction than conventional administration of analgesics, although it appears to have no advantage over conventional analgesia in terms of adverse effects and consumption of opioids. Standard orders and nursing procedure protocols are recommended for patients receiving intravenous patient-controlled analgesia to monitor treatment efficacy and development of adverse effects. Some subgroups of patients need special consideration. For example, opioid-tolerant patients need higher postoperative opioid doses to achieve satisfactory analgesic effect. In patients with renal or hepatic insufficiency, the elimination of some opioids may be substantially impaired, and the optimal opioid should be selected based on its pharmacokinetic properties.

1. Introduction

“The pathetically grim and perspiring patient, fearful of moving or breathing, has become a constant fixture on postsurgical wards. His suffering was anticipated by his physician and is accepted in the knowledge that it will disappear in time.” (Keats, 1956).

This description of acute postoperative pain was published more than 50 years ago. Today, it is widely agreed that this suffering is unnecessary and not acceptable. Although the course of acute postoperative pain is relatively predictable, its incidence is still very high. About 70% of patients undergoing surgery in the 1970s reported moderate to severe pain postoperatively (Marks and Sachar, 1973); more than 60% in those undergoing surgery in 1995 reported moderate to severe pain (Warfield and Kahl, 1995); and recent research shows only mild improvement in postoperative pain management throughout the years, with more than 40% of the patients still reporting moderate to severe pain (Sommer et al., 2008). These findings are bothersome, especially in light of the significant advances in the molecular understanding of pain processing (Basbaum et al., 2009; Julius and Basbaum, 2001; Woolf and Salter, 2000), the discovery of opioid receptors (Pert and Snyder, 1973), and the understanding of opioid pharmacokinetics.

Several efforts have been made over the years in order to optimize the management of postoperative pain. These efforts include an increased use of regional and multimodal analgesia (Dahl et al., 2010). Despite the attention directed towards the effects of opioid-sparing strategies on postoperative morbidity and hospitalization, opioids are still used extensively in the postoperative setting (Popping et al., 2008). Opioids are often prescribed as needed (pro re nata (PRN)), but nurse administered PRN dosing may be suboptimal for several reasons, including the risk of delay in timely drug administration. In this respect patient-controlled administration of opioids represents a clear step forward.

In the late 1960s devices were developed for bolus drug delivery upon patients’ demand (Evans et al., 1976; Sechzer, 1971). The term “patient-controlled analgesia” (PCA) was coined and PCA is now routinely used in postoperative care through much of the developed world (Hudcova et al., 2006; Popping et al., 2008). Most commonly, PCA involves the administration of intravenous opioids, although newer techniques such as patient-controlled epidural analgesia and patient-controlled regional analgesia are increasingly being used.

The present review will focus on the intravenous administration of opioids. Key issues such as programming, efficacy, and adverse effects will be discussed. For more comprehensive reviews, please see (Hudcova et al., 2006; Macintyre, 2005; Schein et al., 2009).

2. Patient-controlled analgesia devices and their set-up

PCA devices consist of a programmable pump which can be activated by the patient through the use of a handheld button that
connects to the pump via a cord. The medication is typically contained in a cartridge or a syringe loaded in a secure housing that can only be accessed by a key. Parameters that must be programmed include drug concentration, bolus dose, lockout interval (e.g., 1 mg of morphine sulfate per request every 10 min), 1- or 4-h maximum dose, and basal infusion rate (if desired). A basal infusion is a continuous delivery of medication released automatically by the PCA device. It is generally not recommended as it increases the risk of opioid toxicity, while the analgesic effect may not be enhanced (Sidebotham et al., 1997; Smythe et al., 1996).

Additional requests by the patient above the programmed limits will not result in additional medication administration by the PCA device. The modern PCA pumps provide the health care provider with information on required vs. administered medication doses, which may give additional information on the patient’s pain pattern. Table 1 shows examples of a PCA set-up in opioid-naïve patients.

### 3. Opioids used with PCA

Many opioids have been used with PCA, but those having very short (e.g., alfentanil, remifentanil) and very long duration of action (e.g., methadone) are usually not recommended. Pethidine (meperidine) is generally not recommended because of the risk of accumulation of its potentially neurotoxic metabolite (norpethidine). Partial opioid receptor agonists or agonist–antagonists (e.g., buprenorphine) are used less commonly than pure agonists. There is little evidence to suggest major differences in efficacy and side effects between the opioids used. Factors that may influence drug selection include medical comorbidities, for example, opioids with active metabolites (e.g., morphine) should be avoided in patients with renal failure. Also, some patients may have positive or negative experiences with prior exposure to a specific opioid. Table 2 summarizes the pharmacokinetic characteristics of opioids commonly used with PCA (Davies et al., 1996; Dean, 2004; Tegeder et al., 1999).

Other drugs can be combined with PCA opioids, e.g., droperidol for the prevention of nausea and vomiting, and ketamine or clonidine for the improvement of pain relief.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Usual concentration</th>
<th>Usual bolus dose</th>
<th>Typical dose range</th>
<th>Typical lockout</th>
<th>Usual lockout range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphine</td>
<td>1 or 2 mg/mL</td>
<td>1 mg</td>
<td>0.5–2.5 mg</td>
<td>6 min</td>
<td>5–10 min</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>20 or 50 mcg/mL</td>
<td>20 mcg</td>
<td>10–50 mcg</td>
<td>6 min</td>
<td>5–8 min</td>
</tr>
<tr>
<td>Hydromorphone</td>
<td>0.2 mg/mL</td>
<td>0.2 mg</td>
<td>0.05–0.4 mg</td>
<td>6 min</td>
<td>5–10 min</td>
</tr>
</tbody>
</table>

A patient undergoing laparotomy had been taking 240 mg oral slow release morphine daily in divided doses. If an IV-oral conversion factor of 1:3 is used, 50% of the daily consumption will be equivalent to 40 mg/day IV morphine, or a basal infusion rate of approximately 1.6 mg/h IV morphine.

Most opioid-tolerant patients can continue their chronic opioid treatment following non-abdominal surgery. In these cases the intravenous PCA dosing may be increased, both in dose and dosing frequency. The following case illustrates the use of intravenous PCA in an opioid-tolerant patient who continued his intake of pre-admission opioid after surgery.

A 53-year-old male patient had been taking 100 mg of methadone daily for the last 6 years. Following major orofacial surgery because of cancer, he complained of severe pain and during the first 24 h he required 480 mg IV morphine in addition to his regular methadone. A PCA pump was set up and programmed to deliver up to 20 mg morphine per hour. The patient was comfortable and had acceptable pain levels with the established treatment protocol.

### 4. Patient selection

Intravenous PCA can be used in a variety of patient populations including children and elderly patients. In small children a parent can be assigned to administer analgesia, provided that the parent is instructed not to activate the device when the child is asleep. Many patients find the control and autonomy provided by PCA comforting, while others may have concerns about the possibility of accidentally overdosing. Patient education is an important component to successful use of PCA, but if a patient is not fully comfortable with the use of the PCA device, a nurse can be assigned to administer the analgesia.

There are few contraindications to the use of intravenous PCA. Patient refusal, severe cognitive impairment, and inadequate monitoring capability are among the reasons why PCA may be contraindicated. Caution must be taken in cases of severe organ dysfunction, such as renal or hepatic dysfunction, obstructive pulmonary disease, or sleep apnea.

### 5. Intravenous PCA vs. conventional use of opioids

Three meta-analyses have been published on the use of intravenous PCA vs. conventional use of opioids; the most recent is a Cochrane review from 2006 (Ballantyne et al., 1993; Hudcova et al., 2006; Walder et al., 2001). To the best of our knowledge only two RCTs have been published on the subject within the last 5 years and they both confirm the results found in the three meta-analyses (Bell et al., 2007; Morad et al., 2009).

#### 5.1. Efficacy

The three meta-analyses all conclude that the use of intravenous PCA results in a small, but significant improvement of pain relief compared to the traditional analgesia methods 2006 (Ballantyne et al., 1993; Hudcova et al., 2006; Walder et al., 2001). However, the improvement is very small (in most studies less than 10 on a 0–100 visual analog scale) and it may not be clinically significant.

#### 5.2. Patient satisfaction

Numerous clinical trials have reported higher patient satisfaction with PCA. In fact, no RCT has reported higher patient satisfaction with conventional dosing that with PCA (Ballantyne et al., 1993; Hudcova et al., 2006; Walder et al., 2001).
5.3. Consumption of opioids

The meta-analyses by Ballantyne et al. (1993) and Walder et al. (2001) found no difference in the amount of opioids used postoperatively. In the Cochrane review by Hudcova et al. (2006) a slightly higher opioid consumption was reported in the PCA group. However, the difference was only about 7 mg IV morphine equivalents/day.

5.4. Adverse effects

Most studies found no significant differences in adverse effects (e.g. sedation, nausea, vomiting, pruritus, urinary retention, bradypnea and hypoxia), although it has been suggested that there is less urinary retention (Rogers et al., 1990), less pulmonary complications (Walder et al., 2001), and a higher incidence of pruritus with intravenous PCA (Hudcova et al., 2006).

6. Monitoring and safety issues

Patients receiving intravenous PCA should be monitored at regular intervals for treatment efficacy and development of adverse effects (Elliott, 2011). Standard orders and nursing procedure protocols are recommended.

The majority of safety concerns with intravenous PCA are related to the medication errors related to programming and operating the PCA pumps (for comprehensive review on IV PCA errors see Schein et al., 2009).

7. Cost benefit

There is a lack of valid data on the cost-effectiveness of intravenous PCA. A formal cost-effectiveness has been performed on the use of disposable PCA devices (D’Haese et al., 1998), but not on traditional PCA infusion pumps. PCA pumps are not cheap to purchase and in addition they require maintenance. However, each device can usually be used for hundreds or thousands of patients and the use of IV PCA apparently reduces the nursing time. A comprehensive cost-effectiveness analysis could elucidate the economic implications of using PCA therapy for postoperative pain relief.

8. Conclusion

Meta-analyses have not been able to demonstrate superiority of intravenous PCA over conventional analgesic methods in terms of adverse effects and consumption of opioids. Intravenous PCA does, however, seem to increase patient satisfaction. In the postoperative setting, opioids are often prescribed as needed (pro re nata (PRN)), but nurse-administered PRN dosing may be suboptimal. The effectiveness depends on successful communication with the patient, as well as on availability of nursing staff and medications. Since all of these may be potential barriers to timely drug administration, it is not uncommon that patients suffer for some time until the medication is administered and the analgesic effect is achieved by PRN opioids. In this respect administration of intravenous opioids by PCA is a clear advantage.

Conflict of interest

None declared.

References


