



Patient-controlled analgesia for infants and children

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Abstract. *Patients controlled analgesia (PCA) pump is an analgesic system where the patient is being delivered a continuous minimal basal infusion of analgesics (mostly opioids), and the patient can deliver himself an additional bolus of drug by pushing the button. PCA pump is used for moderate to severe pain which requires multiple doses of IV analgesia. It is said that as soon as a child can play computer games, he can use and understand the PCA system. PCA allows the patient to have better analgesia with less dose of drugs than when it is used around the clock. During the first 24 hours, low doses of continuous infusions (background) improve the quality of sleep in pediatric patients without increasing side effects. PCA is most commonly used on children for analgesia after major surgery, trauma with preserved sensorium, burns, sickle cell disease, malignancy or painful consequences of chemo-therapy (pain due to mucositis) and in some cases of chronic pain. Patients are generally started on a morphine infusion. Opioid switching in children is strongly recommended in the presence of inadequate analgesic effect and intolerable side effects. The usual, safe dose of morphine that provides adequate postoperative analgesia is in pediatric patients 10–30 mcg/kg/h. In pediatric population for PCA, fentanyl continuous infusions (1 mcg/kg per hour) plus fentanyl boluses (1 mcg/kg) can be safely used. The advantage of PCA is that it eliminates the high peaks and low troughs by allowing the patient to press the demand bolus button when they begin to feel pain. Most of them are very satisfied that they have participated in their own pain management. PCA allows safe analgesia in pediatric patients and lowers frequency of side effects. Patient indicates that their pain level is at a level acceptable to them and that they are happy with this method of analgesia.*

Key words: *patients controlled analgesia, PCA, children analgesia, pain management*

Pain in pediatric patients has long been ignored because of the wrong belief that children feel less pain, do not remember it, and that pain does not leave the consequences (1). The assessment of pain in a child is a special challenge. Today we know that the anatomical components necessary for the feel of the pain have been developed already in the 25th week of gestation (2). On the other hand, endogenous descending inhibitory pathways are developing completely when child is six months old (3). Good analgesia not only reduces stress response, but there are evidence that it reduces morbidity and mortality, in particular in pediatric patients (2).

About 20 years ago, about 40% of surgical pediatric patients had moderate to severe postoperative pain, and about 75% did not have adequate analgesia (4). Except for the above reasons, the cause was the fear of the side effects of analgesics. Since then, knowledge has been advanced about safe and effective analgesic techniques.

Patients controlled analgesia (PCA) pump was developed and introduced by Philip H. Sechzer in the late 1960s and described in 1971 (5). It is an analgesic system where the patient is being delivered a continuous minimal basal infusion of analgesics (mostly opioids), and the patient can deliver

himself an additional bolus of drug by pushing the button. PCA pump is used for moderate to severe pain which requires multiple doses of IV analgesia.

It is said that as soon as a child can play computer games, he can use and understand the PCA system (even children aged 4 or 5 years) (6, 7). PCA allows the patient to have better analgesia with less dose of drugs than when it is used around the clock (8). During the first 24 hours, low doses of continuous infusions (background) improve the quality of sleep in pediatric patients without increasing side effects (9).

If a nurse or a patient's parent press the button, nursing or parent controlled analgesia (NCA), usually larger doses for background infusion with a longer "lockout" interval (approximately 30 minutes) are being used (2). If a patient is an infant, there is usually no 'background' infusion, which allows the nurse to titrate analgesic doses or to predict painful episodes, with the implication of slower clearance of morphine at this age.

Patient controlled epidural analgesia (PCEA) provides excellent pain relief and few adverse events, but there is not enough experience in pediatric patients (10, 11).

Patient Selection

PCA is most commonly used on children for analgesia after major surgery, trauma with preserved sensorium, burns, sickle cell disease, malignancy or painful consequences of chemo-therapy (pain due to mucositis) and in some cases of chronic pain (2). Children who are suitable for using PCA are identified by the anaesthetists preoperatively. The child and parents should be explained that only a patient can press the button and that the pain may not completely disappear, but will become tolerable and the patient is not overly sedated.

If we did not have time to preoperatively explain to the patient the PCA system, we can do it in ICU immediately after extubation as soon as the patient is able to understand it (12). The child must have the physical ability and willing to push the button of the handset and has a basic understanding of what happens when the button is pushed (13). It is beneficial for patients who like to maintain control of their environment, but some patients do not want to accept this responsibility. Some children like to block out potentially unpleasant experiences (14) and are more likely to expect an adult to take responsibility for their pain relief. These children are unlikely to use the PCA to its full potential.

Many parents, under the influence of the news from the media, fear of the development of opioid dependence (15, 16). This fear is developing for years, it is difficult to break it up with one conversation and can disrupt the parents' desire that their child uses PCA. Parents should be explained that their child will not become dependent on opioids because they are given to reduce pain. If used for more than a couple of days, dosage should be reduced gradually. Using a PCA does not prevent patients from mobilising. It is when the patient first starts to mobilise that they may need to use the PCA more. PCA should not be stopped because the pa-

tient needs to mobilise. PCA can be used only on the departments with adequate trained staff.

Prescription of the PCA

Patients are generally started on a morphine infusion. Opioid switching in children is strongly recommended in the presence of inadequate analgesic effect and intolerable side effects (17). The usual, safe dose of morphine that provides adequate postoperative analgesia is in pediatric patients 10–30 mcg/kg/h (2) (Table 1). In pediatric population for PCA, fentanyl continuous infusions (1mcg / kg per hour) plus fentanyl boluses (1 mcg/kg) can be safely used (18) (Table 2).

Table 1. Morphine

Dissolution: 1 mg/kg is dissolved to 50 ml 0.9% NaCl (1 ml = 20 mcg/kg)	
Maximal dose in syringe	50 mg
Bolus dose	1 ml (20 mcg/kg)
Lockout interval	5-15 minutes
Background infusion	0–0.75 ml/h = 0–15 mcg/kg/h (Based on maximum. 50 kg TT)
Maximum dose for 4h	300 mcg/kg

Table 2. Fentanyl

Dissolution: 20 mcg/kg is dissolved to 50 ml 0.9% NaCl (1 ml = 0.4 mcg/kg)	
Maximal dose in syringe	1 mg
Bolus dose	1 ml (0.25–0.4 mcg/kg)
Lockout interval	5–15 minutes
Background infusion	0.375–1 ml/h (0.15–0.4 mcg/kg/h)
Maximum dose for 4h	4 mcg/kg

If possible, the cannula should be placed in a non-dominant arm. Naloxone, anti-emetic and additional (non-opioid) analgesics are prescribed with opioids.

Naloxone IV injection (19):

- 1 month – 12 years: 5–10 mcg/kg if no response subsequent dose of 100 mcg/kg (max 2 mg)
- 12–18 years: 1.5–3 mcg/kg if the response is inadequate, give increments of 100 mcg every 2 minutes

Neopoid analgesics save opioids and reduce their side effects (20). Additional opioids should not be prescribed with PCA. Prescription drugs (especially naloxone) should always be prescribed in advance for the treatment of possible side effects. The handset should always be accessible to the child. It should be explained to him that he should press the button before a potentially painful procedure or activity.

Contraindications for PCA:

- Previous reactions to opiates,
- Problematic upper respiratory tract,
- Patient/parent/carer refusal
- Physical inability to operate the PCA demand button
- Impaired mental status
- Head injury
- Insufficient numbers of trained staff to ensure patient safety

Monitoring

Before and after starting the PCA score of pain, the level of sedation and the eventual occurrence of side effects must be documented every hour during the first four hours, then two times on two hours, and then on four hours (12).

Pain can not be adequately treated if it is not regularly evaluated. For the evaluation of pain, the Golden Standard is "Self report". Pain score should always be assessed on movement e.g. coughing, deep breathing. If the score is bigger than 4 at any time, then this should be addressed and reassessed in ½ hour, then recorded hourly until a score below 4 is established.

The pulse oximetry should be monitored for 24 hours. Respiratory frequency, saturation, pulse, blood pressure, sedation level, and pain score are documented 4 hours after PCA is disconnected. Staff education is extremely important (20).

Every hour, you should check and document the number of successful and unsuccessful pressures on the button as well as hourly and overall opioid infusion. All patients should be at least once a day visited by anaesthesiologist or a member of the pain team.

If the patient feels pain despite the properly prescribed doses of the PCA, the cause should be revealed. There are several interventions that can be used. It is necessary to involve parents, play specialist (i.e. for distraction, reassurance, comforting etc) and to stimulate the child to pressure handset if it may not have done so. The bolus dose may need to be altered. Sometimes, if frequent boluses do not correct the condition it is necessary to increase the background infusion that can be increased and/or give prescribed multimodal analgesia. Always check the IV site for patency. The surgical team should be contacted if the pain could be indicative of surgical complications, or another cause.

Side-effects

If a child is in electrolyte disbalance, dependent on opioid or has previously shown side effects on the use of opioids, special attention should be taken.

Opiates represent one of the four drug categories that cause more than 60 % of serious adverse events in the United States (the others are anticoagulants, insulin, and antibiotics) (21). Common side-effects of a PCA/NCA, or actually opioids include nausea, sedation, respiratory depression and pruritus (itching). It is very important to document findings and action taken.

Sedation

The sedation level is scored as follows:

- 0 = Alert
- 1 = Mild, easy to rouse
- 2 = Easy to rouse, often drowsy
- 3 = Somnolent, difficult to rouse

If the patient has a sedation score of 3, STOP the infusion, supervise the child, continuously monitor pulse oximetry and give oxygen by mask at 5 litres/min until improvement in sedation score and if necessary naloxone 2 to 4 mcg/kg intravenously. Consider other possible causes of sedation e.g. hypoglycaemia.

Respiratory depression

It is necessary to monitor and document the frequency and depth of breathing as well as the respiratory effort. Respiratory depression can be defined as:

- > 5 years – Respiratory rate <10 breaths/minute
- < 5 years – respiratory rate <18 breaths/minute

If respiratory depression occurs:

Remove the hand set from the child, stop PCA, administer high flow oxygen at 10–15 litres via a non-rebreathe bag and mask (5), monitor oxygen saturation continuously with pulse oximeter and respiratory rate every 5 minutes. Inform the anaesthesiologists and consider naloxone 2 to 4 mcg/kg intravenously. Perform Basic Life Support if necessary (15).

The incidence of postoperative nausea and vomiting depends on many factors including the anaesthetic used, the type and duration of surgery and the patient's gender. Consider non-opioids related nausea and vomiting such as intra-abdominal, sepsis, DKA etc. Our aim is to prevent postoperative nausea and vomiting from occurring.

Nausea and vomiting scores are:

- 0 = None
- 1 = Mild nausea
- 2 = Nausea and retching
- 3 = Vomiting

If the patient complains on nausea or has been vomiting, administer an anti-emetic (e.g. ondansetron 0.1 mg/kg or dexametasonone 0,0625–0,15 mg/kg). Think about stopping oral intake and/or aspirating a nasogastric or gastrostomy tube (if in situ).

Pruritus

Administer an anti-histamine (e.g. chlorphenamine) or naloxone 0.5 mcg/kg intravenously (16).

Urinary retention is defined as the inability to empty the bladder volitionally for greater than 12 hours with a volume of urine greater than expected for age or a palpably distended bladder.

Commence fluid balance chart. Consider intravenous naloxone 0.5 mcg/kg or intermittent catheterisation.

Constipation

Patients receiving PCA may require a laxative prescribed regularly.

Criteria for stopping PCA/NCA include ALL of the following:

- the patient is able to eat and drink and to take analgesia per os
- their PCA opioid usage is minimal
- the child is comfortable and pain free

Discontinuation of the infusion pump:

- Usually is done in the morning
- First explain to the child and parents that we will stop the PCA and why.
- Provide adequate analgesia with other drugs (paracetamol, NSAIDs, oral opioids)
- If the child feels moderate to severe pain after stopping PCA, check the cause (e.g. site operation, blocked urinary catheter, bladder spasms, blocked cannula, colic pain, muscle spasms, muscle stiffness, referred shoulder tip pain) and take appropriate actions (22).

It is not advisable to stop PCA analgesia in favour of intramuscular analgesia. Maintain IV access and observe and record observations for at least 4 hours after discontinuing PCA/NCA. Remember that pain is the 5th vital sign.

One of the indications for PCA is cancer pain. More than 75 % of children dying of malignancies do not have adequate analgesia (16). During the last 2 weeks of life, children usually have a great need for opioids (23). Children on PCA at the end of life are reported to have variable and increasing need for opioids (24). Portable PCA exists in the form of a computerized ambulatory drug device (CADD) and there are few published reports regarding CADD use in the Outpatient setting (25). The indications for PCA CADD use at home include (17):

- an opioid is required for pain management or terminal dyspnea;
- patient requires opioid therapy and the oral route is not tolerated;
- family's desire to be or remain at home and the child has already commenced intravenous opioids in hospital;
- inadequate analgesia using oral medications; and
- incident or breakthrough pain inadequately treated with oral opioid analgesia.

The advantage of PCA is that it eliminates the high peaks and low troughs by allowing the patient to press the demand bolus button when they begin to feel pain. Most of them are very satisfied that they have participated in their own pain management. PCA allows safe analgesia in pediatric patients and lowers frequency of side effects. Patient indicates that their pain level is at a level acceptable to them and that they are happy with this method of analgesia.

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Контрольована пацієнтом аналгезія для немовлят та дітей

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Резюме. Помпа контрольованої пацієнтом аналгезії (КПА) – це система знеболення, що забезпечує пацієнту тривалу мінімальну базальну інфузію анальгетиків (переважно опіоїдів) та надає йому змогу введення додаткового об'єму препаратів при натисканні на кнопку. Помпа КПА використовується для зниження сильного болю, що вимагає введення значних доз внутрішньовенних анальгетиків. Зазначається, що позаяк дитина здатна оволодіти комп'ютером, граючи в ігри, їй також під силу зрозуміти принцип роботи КПА-системи. КПА дозволяє пацієнту забезпечити для себе кращу аналгезію з меншою дозою препаратів, ніж коли вони застосовуються погодино. Упродовж першої доби низькі дози пролонгованих інфузій (базові) збільшують якість сну педіатричних пацієнтів без зростання кількості побічних ефектів. КПА найчастіше використовують для дітей з метою аналгезії після великих оперативних втручань, травм зі збереженою чутливістю, опіків, при серпоподібноклітинній патології, онкологічних захворюваннях чи болючих наслідках хіміотерапії (біль через мукозити) та у деяких випадках хронічного болю. Пацієнти загалом розпочинають з інфузії морфіну. Заміна опіоїду рекомендована у дітей, яким препарати не забезпечують адекватне знеболення або викликають несумісні побічні ефекти. Зазвичай безпечною дозою морфіну, що надає достатнє знеболення у педіатричних пацієнтів, є 10–30 мкг/кг/год. У педіатричній популяції також безпечним є використання КПА за рахунок пролонгованого введення фентанілу (1 мкг/кг/год) разом з болюсним його застосуванням (1 мкг/кг). Перевагою КПА є те, що він обмежує виникнення високих піків та низьких показників, дозволяючи пацієнту натиснути на кнопку потреби болюсу, коли вони починають відчувати біль. Більшість хворих дуже задоволені тим, що вони беруть участь у лікуванні власного болю. КПА забезпечує безпечну аналгезію у педіатричних пацієнтів і нижчу частоту побічних ефектів. Пацієнти визначають, що рівень їхнього болю є допустимим для них і що вони щасливі використовувати даний метод знеболення.

Ключові слова: контрольована пацієнтом аналгезія, КПА, дитяча аналгезія, лікування болю

Контролируемая пациентом аналгезия для младенцев и детей

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Резюме. Контролируемая пациентом аналгезия (КПА) – система обезболивания, при которой пациент обеспечивается пролонгированной минимальной базальной инфузией анальгетиков (в большинстве – опиоидов), что позволяет при нажатии на кнопку ввести ему дополнительный объем препаратов. КПА-аппарат используется для модерирования сильных болевых ощущений, требующих множественные дозы внутривенных анальгетиков. Указывается, что если ребенок способен играть в компьютерные игры, ему под силу также понять работу КПА-системы. КПА позволяет иметь пациенту лучший эффект от аналгезии, при этом используя меньшие дозы препаратов, чем когда они вводятся в соответствии с временными интервалами. На протяжении первых 24 часов низкие дозы пролонгированной инфузии (фоновой) улучшают качество сна у педиатрических пациентов без роста количества побочных эффектов. КПА чаще всего используется у детей для обезболивания после больших оперативных вмешательств, травм с сохранением чувствительности, ожогов, при серповидноклеточной патологии, малигнизации или болезненных последствиях химиотерапии (боль из-за мукозитов) и в некоторых случаях хронической боли. Пациенты в общем начинают с инфузией морфина. Замена опиоидов у детей рекомендуется при наличии неадекватного обезболивания и несовместимых побочных эффектов. Обычно безопасная доза морфина для педиатрических пациентов, дающая хороший анальгезирующий эффект в послеоперационном периоде, составляет 10–30 мкг/кг/ч. Пролонгированные инфузии фентанила (1 мкг/кг/ч) плюс болюсное введение фентанила (1 мкг/кг) могут использоваться без опасения при КПА среди педиатрической популяции. Преимущество КПА состоит в том, что она ограничивает высокие пики и низкие уровни боли, позволяя пациенту нажать на кнопку болюсной надобности, когда он начинает чувствовать боль. Большинство больных удовлетворены тем, что они берут участие в лечении своего болевого синдрома. КПА обеспечивает безопасную анальгезию для педиатрических пациентов и снижает количество побочных эффектов. Пациенты определяют, что уровень их боли является допустимым для них и что они счастливы использовать этот метод аналгезии.

Ключевые слова: контролируемая пациентом аналгезия, КПА, детская аналгезия, лечение боли