An Audit of Changes in Outcomes of Acute Pain Service Evolution Over the Last 2 Decades

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Abstract: Acute pain services (APS) have evolved over time. Strategies nowadays emphasize multimodal analgesic regimes using a combination of nonopioid adjuvant analgesic drugs, peripheral nerve blocks, and local anaesthetic wound infiltration where appropriate. APS should be assessed over time to evaluate changes in outcomes which form the basis for future development.

In this audit, data of patients under APS care in Queen Mary hospital, Hong Kong, between 2009 and 2012 were analyzed and compared with data from a previous audit between 1992 and 1995. The use of patient-controlled analgesia (PCA) was increased (from 69.3% to 86.5%, P < 0.001), while the use of epidural analgesia reduced (from 25.3% to 8.3%, P < 0.001) significantly. Although postoperative pain scores did not improve, PCA opioid consumption and the incidence of analgesia-related side effects were significantly less (all P < 0.001). More patients graded their postoperative analgesic techniques used as good when the results from these 2 audit periods were compared (P < 0.001 and P = 0.001 for PCA and epidural analgesia, respectively).

In conclusion, there has been a change in analgesic management techniques, but there has been no improvement in overall pain relief. While changes over time have led to improvement in important parameters such as the incidence of side effects and patient satisfaction, further and continuous efforts and improvements are warranted to reduce acute pain relief and suffering of the patients after the surgery.

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INTRODUCTION

Over 80% of patients undergoing surgery experience postoperative pain and in 39% this is severe to extreme. It is well recognized that patients should be able to access best practice care including appropriate assessment of their pain and effective pain management strategies. Suboptimal acute pain management results in numerous undesirable effects such as increased risk of myocardial ischaemia or infarction, thromboembolic and pulmonary complications, persistent postoperative pain, prolonged hospital stay, increased hospital admission, reduced quality of life, and side effects due to analgesic consumption. The first acute pain service (APS) run by anaesthesiologists was introduced in 1988 and such teams have since become ubiquitous in modern healthcare.

A Hong Kong survey in 1996 identified a need for increased resources, training, awareness, and staffing in pain management and Queen Mary Hospital organized a multidisciplinary APS team that involved anesthesiologists, pain nurses, surgeons, and ward nurses. Eighty-six percent of the hospitals in Hong Kong that provided anaesthetic services were running an acute pain service by 2000. Our acute pain management has expanded over the years to now include accredited pain specialists, full time pain nurses, and pain fellowship trainees.

Advances in APS include increasing emphasis on the implementation of multimodal analgesia and toward procedurespecific management, where pain protocols are targeted to specific surgical operations. Benefits in terms of postoperative pain, incidence of adverse effects due to analgesia, quality of life, and patient satisfaction were demonstrated with the implementation of quality management systems using procedure-specific and multimodal pain protocols adapted to individual patients. Various strategies targeting the preoperative, intraoperative, and postoperative period have been employed as part of a multimodal analgesic regimen. Examples include the use of peripheral nerve blocks and infusions, as well as numerous adjuvant medications such as nonsteroidal antiinflammatory drugs (NSAIDs), paracetamol, ketamine, and anticonvulsants (such as pregabalin and gabapentin).

In view of the increased demand for pain management services and the large number of patients utilizing the APS, regular audit is mandatory to ensure the delivery of quality care and demonstrate effectiveness of such treatments to facilitate future service planning. The aim of this audit is to compare the APS in Queen Mary Hospital between the epochs 2009 to 2012 and 1992 to 1995. More specific objectives were to identify the changing trends of pain management modalities; evaluate
effectiveness in terms of pain relief, morphine consumption, and patient satisfaction; determine safety and tolerability by comparing incidence of various complications associated with pain management.

METHODS

This retrospective study was conducted in Queen Mary Hospital, a tertiary referral hospital in Hong Kong, and approved by the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster. This study was registered at ClinicalTrials.gov (registration number NCT02155413). Data were collected from the patient records kept by the APS team of the Department of Anesthesiology, Queen Mary Hospital, Hong Kong. Data from patients under APS care between 2009 and 2012 were collected, validated, and analyzed. These data were then compared with data from our previous audit of the period between 1992 and 1995. Patients were excluded from the analysis if they were ventilated after surgery or if essential data were missing. Chronic pain patients, opioid or sedative users or drug addicts, patients with language barrier with difficulty in pain assessment after operation, and patients involved in other ongoing research were also excluded.

All patients managed by the APS received one of the postoperative analgesic regimens outlined in Table 1. They were also managed according to a standard protocol. Monitoring included continuous pulse oximetry for 24 h postoperatively, hourly respiratory rate, and sedation score, 4 hourly blood pressure, pulse rate, pain scores using numerical rating scale (NRS), and analgesic related side effects including nausea and vomiting. During the preoperative visits, patients were given detailed information about postoperative analgesia and asked to report any side effects including nausea, vomiting, dizziness, pruritus, or lower limb weakness (for epidural infusion). In addition, nursing staff would also specifically ask about these side effects, while charting the pain scores at 4 hourly intervals. Patients were advised to report any other effects that they felt might be related to their treatment.

After the operation, patients were transferred to the recovery area where their vital signs including blood pressure, oxygen saturation, electrocardiogram, and NRS pain scores at rest and during cough were assessed. Pain management including boluses of intravenous morphine or local anaesthetic via the epidural route would be given by the attending anesthetist until the NRS score was 3 or less before transfer to the ward. Rescue pain medications and antiemetic use were also documented.

Patients were reviewed daily. The NRS pain scores, cumulative opioid or local anaesthetic use, rescue analgesics, and complications were also documented. If patients had epidural analgesia, bromage scores, sensory levels were noted and insertion site inspected. When oral intake was permitted, oral analgesics including paracetamol, NSAIDs, gabapentinoids, and opioids were prescribed by the APS. Suitability for termination of APS review and pain management was reviewed during the visit. Patients were then asked to grade their satisfaction on pain management as “good,” “fair,” or “unsatisfactory” at discharge from the APS service.

The APS team or on-call anesthetist was informed if a severe adverse event occurred. These included loss of consciousness (unrousable and a sedation score of 3 or less), bradypnoea (respiratory rate <10/min), hypotension (systolic BP < 90 mm Hg), hypercapnoea (PaCO2 > 7 kPa), or oxygen desaturation (SpO2 < 90%). Management of such adverse events would initially include cessation of analgesic technique and appropriate resuscitation. In the event of possible opioid-induced respiratory depression (bradypnoea, hypercapnoea, or oxygen desaturation) that failed to resolve with simple manoeuvres, naloxone 0.2 mg could be given intravenously until resumption of normal respiration with an oxygen saturation of >90%. Management of hypotension also included administration of intravenous fluids with intravenous ephedrine 5–10 mg every 5 min as required. Surgeons were also informed if surgical complications (e.g., haemorrhage) were suspected to be the cause.

Demographic data, postoperative pain scores, prevalence of complications and adverse events, and patient-rated satisfaction for postoperative analgesia were compared between time periods. Parametric values were tested by t test and are presented as mean ± SD. Nonparametric values were tested by the Mann–Whitney U test and presented as median [interquartile range (IQR)]. Categorical values were tested by χ2 test or Fisher exact test as appropriate and presented as number (percentage). The significance level was set at 0.05. All analyses were performed using Statistical Package for the Social Sciences (SPSS) Statistics version 20 (SPSS Inc, Chicago, IL).

RESULTS

A total of 7659 records of postoperative APS patients were audited between 2009 and 2012. Of these, 1452 (18.8%) records were excluded from data analysis. The results of the 2009 to 2012 audit were compared with the data of a similar audit done

| TABLE 1. Standard Regime for Postoperative Analgesia |
| Regime | Drugs | Loading Dose | Infusion (mL/h) | Demand Dose/ Lockout Interval | 1 h Maximum |
|--------|-------|--------------|----------------|-----------------------------|-------------|
| PCA    | Morphine | 1–1.5 mg every 10 min until patient is comfortable | 1–1.5 mg bolus. 5–10 min lockout | 4.5–7.5 mg |
| CEA    | Levo Bupivacaine 0.1%; Fentanyl 2 mcg/mL | Levo; Bupivacaine; 0.25–0.5%; (4–8 mL) before skin incision | 6–12 mL/h | Nil |
| OR     | Ropivacaine 0.15%; Fentanyl 2 mcg/mL | Ropivacaine 0.375% (4–8 mL) before incision | 6–12 mL/h | Nil |
| CPNB (femoral catheter) | Ropivacaine 0.2% | 5–10 mL/h | 5–10 mL/h | Nil |

CEA = continuous epidural analgesia; CPNB = continuous peripheral nerve block; PCA = patient-controlled analgesia.
for the same centre between 1992 and 1995. For the purpose of clarity in presentation these audits will henceforth be referred to as audit 1 (1992–1995) and audit 2 (2009–2012).

### Patient Demographic and Surgery Types

Demographic data of audit 1 and audit 2 was shown at Table 2. While gynaecological surgeries (22.9%) were the most frequent surgery requiring APS in audit 1, limb surgeries were the most frequent in audit 2 (Figure 1). There was also a 7.2% increase in the number of patients aged over 65 years ($P < 0.001$). More than 50% of the patients undergoing either colorectal, hepatobiliary, or limb surgeries were above 65 years. Mean body weight increased from 55.8 kg to 60.3 kg ($P < 0.001$) over the last 2 decades. The proportion of American Society of Anesthesiologists physical status classification system (ASA) II and III patients using APS also increased by 4.2% and 8.9%, respectively. The proportion of emergency surgery also increased significantly from 90% to 1% in the latest audit.

### Postoperative Analgesic Techniques

Postoperative analgesic techniques used are described in Table 3. There was a significant increase in PCA use from 69.3% to 86.5% ($P < 0.001$). Epidural use decreased markedly from 25.3% to 8.3% ($P < 0.001$) and the majority of its use recently was in upper gastrointestinal surgery with an increase from 10.7% to 27.8% ($P < 0.001$). Peripheral nerve block use has been routinely documented since 2009, with 2.6% of operations from 2009 to 2012 applying it and majority of its use occurring in limb surgery. Intramuscular injections diminished significantly from 90% to 1% in the latest audit.

### Duration of APS Use, Opioid Consumption, and NRS Pain Scores

Duration of postoperative PCA and epidural use has increased by 5.4 and 37 h, respectively (all $P < 0.001$, Table 4). Morphine consumption (for PCA use) in audit 2 decreased from a mean of 49.6 to 36.2 mg ($P < 0.001$). The mean NRS pain scores when coughing at day 2 to day 3 postoperatively with PCA use were higher ($P < 0.001$) in audit 2 than audit 1. For patients receiving epidural analgesia, patient-reported NRS pain scores at rest were higher on days 2 and 3 in audit 2 ($P < 0.025$ and $P < 0.001$ respectively, Table 5).

### Common Side Effects and Serious Adverse Events

There was no bradypnoea or hypoxia, and hypotension decreased from 1.0% to 0.1% between audits 1 and 2 ($P < 0.001$, Table 6). There was a significantly lower incidence of hypotension and lower limb weakness following epidural use (all $P < 0.001$).

The incidence of all adverse events following PCA use decreased recently. There was a statistically significant

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**TABLE 2. Patient Demographic**

|                | 2009–2012 (n = 6207) | 1992–1995 (n = 2319) | $P$ Value |
|----------------|----------------------|----------------------|-----------|
| Age (mean)     | 58.9                 | 54.5                 | <0.001    |
| Body weight (mean kg) | 60.3                 | 55.8                 | <0.001    |
| ASA I          | 14.3                 | 27.4                 | <0.001    |
| ASA II         | 54.4                 | 50.2                 |           |
| ASA III        | 30.4                 | 21.5                 | <0.001    |
| Emergency surgery | 13.7                 | 5.1                  | <0.001    |

**TABLE 3. Distribution of Analgesic Techniques Used**

|            | 2009–2012   | 1992–1995   | $P$ Value |
|------------|-------------|-------------|-----------|
| PCA        | 5524 (86.5) | 1606 (69.3) | <0.001    |
| EPI        | 518 (8.3)   | 586 (25.3)  | <0.001    |
| PNB        | 164 (2.7)   | 0 (0.0)     | N.A.      |
| IM         | 1 (0.02)    | 90 (3.9)    | N.A.      |
| IV         | 0 (0.0)     | 37 (1.6)    | N.A.      |

*Data in n (%). EPI = epidural; IM = intramuscular; IV = intravenous; PCA = patient-controlled analgesia; PNB = peripheral nerve block.*

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**FIGURE 1.** Different types of operation performed in 1992–1995 and 2009–2012.
reduction in dizziness, pruritus, nausea, vomiting, and rescue antiemetic use (all $P < 0.001$, Table 7). For epidural use, patients also reported less pruritus, nausea, vomiting, and rescue antiemetic use ($P < 0.001$, Table 7).

**Patient-Rated Satisfaction**

Despite higher pain scores in audit 2, 87.5% rated the PCA technique as good compared with only 80.4% in audit 1 ($P < 0.001$, Table 8). Significantly fewer patients reported their postoperative PCA analgesic technique as fair or unsatisfactory ($P < 0.001$, Table 8). There was no statistically significant difference in the patient-rated satisfaction on epidural analgesia between the 2 time periods.

**DISCUSSION**

PCA has become the most commonly used analgesic technique now, but with a lower morphine consumption. Peripheral nerve block is gaining popularity. Postoperative pain scores were not improved whether PCA or epidural analgesia was used. Common side effects such as dizziness, nausea, and vomiting, as well as serious adverse events such as hypotension, bradypnoea, and hypoxia, were significantly reduced. Although patients reported higher satisfaction with PCA use, the same was not shown with epidural analgesia.

**TABLE 4.** Duration of Different Postoperative Analgesic Techniques and the Number of Patients on Different Postoperative Analgesia in the First 3 Days

|        | 2009–2012 | 1992–1995 | $P$ Value |
|--------|-----------|-----------|-----------|
| **PCA** |           |           |           |
| Duration (h) Mean | 51.7 | 46.3 | <0.001 |
| Day 1 n (%) | 5524 (100.0) | 1606 (100.0) |    |
| Day 2 n (%) | 4299 (77.8) | 1310 (81.6) |    |
| Day 3 n (%) | 2237 (40.5) | 451 (28.1) |    |
| **EPI** |           |           |           |
| Duration (h) Mean | 82.3 | 45.3 | <0.001 |
| Day 1 n (%) | 518 (100) | 586 (100) |    |
| Day 2 n (%) | 510 (98.5) | 479 (81.7) |    |
| Day 3 n (%) | 493 (95.2) | 137 (23.4) |    |

EPI = epidural; PCA = patient-controlled analgesia.

**TABLE 5.** Mean Pain Scores (Using NRS From 0 to 10) During the First, Second, and Third 24 Postoperative Hours Using Postoperative Analgesic

|        | 2009–2012 | 1992–1995 | $P$ Value |
|--------|-----------|-----------|-----------|
| **PCA** |           |           |           |
| Day 1 | Rest | 2.3 | 2.6 | <0.001 |
|        | Cough | 5.3 | 5.1 | 0.051 |
| Day 2 | Rest | 1.6 | 1.6 | 0.083 |
|        | Cough | 4.7 | 4.3 | <0.001 |
| Day 3 | Rest | 1.5 | 1.4 | <0.003 |
|        | Cough | 4.7 | 4.2 | <0.001 |
| **EPI** |           |           |           |
| Day 1 | Rest | 1.8 | 1.7 | 0.986 |
|        | Cough | 4.1 | 3.9 | 0.265 |
| Day 2 | Rest | 1.3 | 1.0 | 0.025 |
|        | Cough | 3.8 | 3.5 | 0.129 |
| Day 3 | Rest | 0.9 | 0.4 | <0.001 |
|        | Cough | 3.5 | 3.3 | 0.768 |

Statistical method used: Mann–Whitney U test. EPI = epidural; PCA = patient-controlled analgesia.

**TABLE 6.** Incidence of Serious Adverse Events With Different Analgesic Techniques

|        | 2009–2012 | 1992–1995 | $P$ Value |
|--------|-----------|-----------|-----------|
| **PCA** |           |           |           |
| Bradypnoea | 0 (0.0) | 6 (0.4) | <0.001 |
| Hypoxia | 0 (0.0) | 20 (1.2) | <0.001 |
| Reintubation | 3 (0.1) | 6 (0.4) | 0.006 |
| Hypotension | 3 (0.1) | 16 (1.0) | <0.001 |
| Confusion | 16 (0.3) | N.A. | N.A. |
| **EPI** |           |           |           |
| Bradypnoea | 0 (0.0) | 2 (0.3) | 0.501 |
| Hypoxia | 0 (0.0) | 9 (1.5) | 0.004 |
| Reintubation | 0 (0.0) | 6 (1.0) | 0.033 |
| Hypotension | 1 (0.2) | 23 (3.9) | <0.001 |
| Lower limb weakness | 1 (0.2) | 98 (16.7) | <0.001 |
| **PNB** (only 2009–2012 data) |           |           |           |
| Lower limb weakness | 0 (0.0) |           |           |
| Hypoxia | 0 (0.0) |           |           |

Data in n (%). EPI = epidural; PCA = patient-controlled analgesia.

**TABLE 7.** Incidence of Common Adverse Events With Different Analgesic Techniques

|        | 2009–2012 | 1992–1995 | $P$ Value |
|--------|-----------|-----------|-----------|
| **PCA** |           |           |           |
| Dizziness | 930 (16.8) | 478 (29.8) | <0.001 |
| Pruritus | 195 (3.5) | 132 (8.2) | <0.001 |
| Nausea | 1737 (31.4) | 708 (44.1) | <0.001 |
| Vomiting | 685 (12.4) | 396 (24.7) | <0.001 |
| Antiemetic | 21 (0.4) | 183 (11.4) | <0.001 |
| **EPI** |           |           |           |
| Dizziness | 51 (9.8) | 72 (12.3) | 0.198 |
| Pruritus | 13 (2.5) | 103 (17.6) | <0.001 |
| Nausea | 82 (15.8) | 172 (29.4) | <0.001 |
| Vomiting | 45 (8.7) | 102 (17.6) | <0.001 |
| Antiemetic | 4 (0.8) | 34 (5.8) | <0.001 |
| **PNB** (only 2009–2012 results) |           |           |           |
| Dizziness | 6 (3.6) |           |           |
| Pruritus | 0 (0.0) |           |           |
| Nausea | 22 (13.3) |           |           |
| Vomiting | 6 (3.6) |           |           |
| Antiemetic | 0 (0.0) |           |           |

Data in n (%). EPI = epidural; PCA = patient-controlled analgesia; PNB = peripheral nerve block.
consists of both anaesthetists and pain nurses.\textsuperscript{17} Expert supervision by APS staff can improve postoperative pain relief and minimize side effects by offering patient selection and education, training of nursing staff, and the regular assessment of pain and treatment efficacy.\textsuperscript{18,19} The advance in pain management techniques and pain medications with evidence-based support also contributes.\textsuperscript{1} Acute postoperative pain management guidelines that include information on different analgesic techniques and postoperative monitoring have also been developed. This is reviewed and amended yearly based on updated evidence. Compared with the period from 1992 to 1995, education about APS is regularly offered to medical and nursing staff who are involved in postoperative pain management. This study gives us an overview of the changes over the last 2 decades and allows us to evaluate their impact. Moreover, regular audit in our APS aids us in identifying our strengths and potential areas for improvement.

Our demographic data suggest that our population is aging and also gaining weight. Elderly patients commonly have altered physiology, decreased opioid requirements, and increased comorbidities such as dementia, with higher risk postoperative cognitive dysfunction. Increasing numbers of obese patients and a higher incidence of obstructive sleep apnoea pose an increased risk of respiratory problems from opioid use. It is, however, encouraging to note that it seemed there was a reduction in the incidence of bradypnoea and hypoxia.

Peripheral nerve block techniques have also gained popularity over the last few years, especially in limb surgeries. Now, there have been interesting technologic advances such as ultrasound-guided peripheral nerve blocks and also declining trends on epidural analgesia, which is also based on the results of pain research in regional analgesia and anaesthesia. The increasing availability of ultrasound and well-described techniques have heralded a surge in ultrasound-guided peripheral nerve blocks.\textsuperscript{32} While use of ultrasound has been associated with an increased overall success rate when compared with nerve

### TABLE 8. Patient-Rated Satisfaction With Different Analgesic Techniques

|        | 2009–2012 | 1992–1995 | P Value |
|--------|-----------|-----------|---------|
| PCA    |           |           |         |
| Good   | 4276 (87.5) | 1266 (80.4) | <0.001 |
| Fair   | 512 (10.5)  | 242 (15.4)  | <0.001 |
| Unsatisfactory | 8 (0.2)   | 16 (1.0)    | <0.001 |
| Unknown| 90 (1.8)   | 51 (3.2)    | <0.001 |
| EPI    |           |           |         |
| Good   | 412 (92.8)  | 500 (85.9)  | 0.001  |
| Fair   | 30 (6.8)    | 62 (10.7)   | 0.030  |
| Unsatisfactory | 1 (0.2) | 6 (1.0)     | 0.120  |
| Unknown| 1 (0.2)     | 14 (2.4)    | 0.004  |

PB (2009–2012 only)

|        |           |           |         |
| Good   | 134 (92.4) |           |         |
| Fair   | 9 (6.2)    |           |         |
| Unsatisfactory | 0 (0.0)  |           |         |
| Unknown| 2 (1.4)    |           |         |

Data in n (%). EPI = epidural; PCA = patient-controlled analgesia; PNB = peripheral nerve block.
stimulation, there is no proven research that ultrasound guidance reduces complication rates such as neurologic injuries.\textsuperscript{33,34} Whether an increase in the use of regional blocks for analgesia after surgery improves pain relief and enhances recovery requires further study.

Side effects from PCA are a major concern for patients and medical staff.\textsuperscript{2,20,21} With increasing experience, staff, and patient education, the prevalence of dizziness, pruritus, nausea, and vomiting has shown a statistically significant decline. The side effect that is most prevalent of these is nausea, with 31.9\% of patients still experiencing it with PCA use, which is consistent with findings from other centres.\textsuperscript{5,36} Metoclopramide was used for the management of postoperative nausea and vomiting (PONV) in the 1990s. A regime of intraoperative dexamethasone and ondansetron for patients in high-risk of PONV has been adopted. Identification of patients at higher risk of PONV and concomitant use of nonopioid-based analgesia has seen a significant decrease of this side effect. Propofol-based total intravenous anaesthesia has also become very popular in our center over the last decade and will reduce the incidence of PONV. However, even though a decrease in incidence was observed, the rate is still unacceptable and more work needs to be done.\textsuperscript{36}

The most common side effect with epidural analgesia is also nausea and vomiting with 15.5\% and 8.9\% experiencing it. This could be related to opioid (fentanyl) in the infusion and also from hypotension that is exacerbated by sympatholysis from epidural analgesia, although the prevalence of hypotension following epidural analgesia has decreased to only 0.2\% from 3.9\% in 1992 to 1995. Likewise, the prevalence of lower limb weakness also decreased to 0.2\% from 16.7\%. This could be due to the use of lower concentrations of local anaesthetic namely 0.2\% ropivacaine and 2 mcg/mL fentanyl that is used in our institution. A change from bupivacaine (1992–1995) to ropivacaine (2009–2012) for epidural infusion may also account for a lower incidence of lower limb weakness.

In 2009 to 2012, bradypnoea and hypoxia was not reported and hypotension decreased from 1.0\% to 0.1\% in patients prescribed PCA. There is now more than 20 years of experience in PCA use and PCA is now commonly prescribed. There are a few potential reasons accounting for the improved safety in this study. An hourly upper limit is set for PCA use. In fact, there is a lack of evidence that patients benefit from an hourly upper dose limit,\textsuperscript{24} but this has been kept to increase patient safety. However, again, the hourly limit may attribute partially to the inferior pain relief. Regular multimodal analgesia with nonopioid analgesics has resulted in less opioid consumption. Education to the medical and nursing staff, as well as patients, about PCA has also led more appropriate and correct use of PCA. It can also help in identifying potential adverse events or complications earlier.

In general, there was a significant increase in patient satisfaction with analgesic techniques. However, we are cautious that such reports could be misleading as patients are often reluctant to criticize their treatment after surgery and when their satisfaction is also related to their expectation of pain relief, communication skills, and empathy expressed by health care providers.\textsuperscript{37–39}

In conclusion, our current audit results show that postoperative pain management techniques have been changed with time. Although postoperative opioid consumption and side effects were reduced, such changes did not lead to better pain relief after operation. Further and continuous efforts and improvements are warrant to reduce acute pain relief and suffering of the patients after the surgery.

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