Cardiothoracic Anesthesia, Respiration and Airway

Patient-controlled *versus* nurse-controlled analgesia after cardiac surgery – a meta-analysis

[L'analgésie auto-contrôlée versus contrôlée par le personnel infirmier après la chirurgie cardiaque – une méta-analyse]

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Background: Patient-controlled analgesia (PCA) has been advocated as superior to conventional nurse-controlled analgesia (NCA) with less risk to patients. This systematic review and meta-analysis sought to determine whether PCA improves clinical and resource outcomes when compared with NCA.

Methods: A comprehensive search was undertaken to identify all randomized controlled trials of PCA *vs* NCA. Medline, Cochrane Library, Embase, and conference abstract databases were searched from the date of their inception to August 2005. The primary postoperative outcome was defined as mean visual analogue scale (VAS) scores. Secondary postoperative outcomes included cumulative morphine equivalents, intensive care unit (ICU) and hospital length of stay, postoperative nausea and vomiting, sedation, respiratory depression, and all-cause mortality. Odds ratios or weighted mean differences (WMD) and their 95% confidence intervals (CI) were calculated for discrete and continuous outcomes, respectively.

Results: Ten randomized trials involving 666 patients were included. Compared to NCA, PCA significantly reduced VAS at 48 hr (WMD -0.73, 95% CI -1.19, -0.27), but not at 24 hr (WMD -0.19, 95% CI -0.61, 0.24). Cumulative morphine equivalents consumed were significantly increased at 24 hr (WMD 6.84 mg, 95% CI 0.97, 12.72 mg), and at 48 hr (WMD 10.46 mg 95% CI 2.02, 18.9 mg) for PCA compared with NCA. Ventilation times, length of ICU stay, length of hospital stay, patient satisfaction scores, sedation scores, and incidence of postoperative nausea and vomiting, respiratory depression, severe pain, discontinuations, and death were not significantly different between groups, but these outcomes were generally under-reported.

Conclusions: In postcardiac surgical patients, PCA increases cumulative 24 and 48 hr morphine consumption, and improves 48-hr VAS compared with NCA.

***Objectif** : L'analgésie auto-contrôlée (AAC) est préconisée comme supérieure à l'analgésie traditionnelle contrôlée par l'infirmière (ACI), avec moins de risque pour le patient. La présente revue systématique et méta-analyse a cherché à déterminer si l'AAC améliore les résultats et exige moins de ressources cliniques que l'ACI.*

***Méthode** : Une vaste recherche a été entreprise pour découvrir toutes les études randomisées et contrôlées sur l'AAC vs l'ACI. Les bases de données de Medline, Cochrane Library, Embase et des comptes rendus de conférences ont été fouillées de la date de leur création à août 2005. Le principal paramètre postopératoire était les scores à l'échelle visuelle analogique (EVA). Les paramètres postopératoires secondaires étaient les équivalents-morphine cumulatifs, la longueur du séjour à l'unité des soins intensifs (USI) et à l'hôpital, les nausées et vomissements postopératoires, la sédation, la dépression respiratoire et toute cause de mortalité. Les*

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risques relatifs ou les différences moyennes pondérées (DMP) et leurs intervalles de confiance (IC) de 95 % ont été respectivement calculés pour des résultats discrets et continus.

***Résultats** : Dix études randomisées comprenant 666 patients ont été retenues. Comparée à l'ACI, l'AAC a significativement réduit les scores à l'EVA à 48 h (DMP -0,73, IC de 95 % -1,19, -0,27), mais non à 24 h (DMP -0,19, IC de 95 % -0,61, 0,24). La consommation d'équivalents-morphine cumulatifs a été significativement plus élevée à 24 h (DMP 6,84 mg, IC de 95 % 0,97, 12,72 mg) et à 48 h (DMP 10,46 mg IC de 95 % 2,02, 18,9 mg) pour l'AAC comparée à l'ACI. Les temps de ventilation, la longueur du séjour à l'USI et à l'hôpital, les scores de satisfaction du patient, les scores de sédation et l'incidence de nausées et de vomissements postopératoires, la dépression respiratoire, la douleur sévère, les interruptions et la mort ne présentaient pas de différence intergroupe significative, mais ces paramètres étaient généralement sous-déclarés.*

***Conclusion** : Après une opération cardiaque, l'AAC augmente la consommation cumulative de morphine à 24 et 48 h et améliore les scores EVA à 48 h comparée à l'ACI.*

ADEQUATE pain control after cardiac surgery has become a growing concern due to the recent trend toward fast track cardiac anesthesia using lower narcotic doses intraoperatively. Reports suggest that many patients undergoing coronary artery bypass grafting (CABG) experience pain, with average visual analogue scale (VAS) scores reported at 3 to 6 in the immediate postoperative period.[1] Patient-controlled analgesia (PCA) has been shown to improve pain control following general surgical procedures.[2,3] It has also been suggested that PCA use reduces pulmonary complications and hypotension attributable to narcotics.[2,4]

A number of randomized trials have been published that evaluate the relative efficacy and safety of PCA *vs* nurse-controlled analgesia (NCA) in cardiac surgical patients. However, these trials have had insufficient power to adequately explore clinically important effects. Presently, no meta-analysis has been published in this area. Appropriate combination of randomized trials through meta-analysis would increase the power to evaluate whether significant differences in efficacy and safety exist between PCA and NCA. We sought to determine, through systematic review with meta-analysis, whether PCA reduces VAS pain scores, morbidity, and resource utilization when compared with NCA.

Methods

Methods of searching for trials

This meta-analysis was performed in accordance with the recommendations of the QUOROM consensus statement,[5] and according to a protocol that prespecified outcomes, search strategies, inclusion criteria, and intended statistical analyses. A search was undertaken in accordance with Cochrane collaboration recommendations to identify all published or unpublished randomized controlled trials of PCA *vs* NCA, in any language. MEDLINE, Cochrane CENTRAL, EMBASE, Current Contents, DARE, NEED, INAHTA databases were searched from the date of their inception to August 2005. Search terms included variants of *patient-controlled analgesia, cardiac surgery, and coronary artery bypass.* Tangential electronic exploration of related articles and hand searches of bibliographies, scientific meeting abstracts, and surgical and anesthesia journals were also performed.

Inclusion criteria

Studies were included if they met each of the following: 1) randomized allocation to PCA *vs* NCA; 2) adult patients undergoing coronary artery bypass surgery or valvular repair; and 3) reporting at least one pertinent clinical or economic outcome.

Data extraction

Two authors independently identified trials for inclusion and extracted information on demographics, interventions, and outcomes. Two reviewers independently assigned each trial a Jadad quality score that evaluates randomization, blinding, and completeness of follow-up (maximum score, 5).[6] Disagreements were resolved by consensus.

Endpoints

The primary postoperative outcome was defined as mean VAS. Secondary clinical outcomes included postoperative nausea and vomiting, severe sedation, respiratory depression, severe pain, pruritis, constipation, pulmonary complications, hypotension, patient dropouts, patient satisfaction, and all-cause mortality. Economic outcomes included intensive care unit (ICU) length of stay, hospital length of stay, and hospital costs. Visual analogue scores represent a 10-cm scale from 0 to 10, where 0 represents no pain and 10 represents worst imaginable pain. When mean VAS scores were provided graphically, the values for the mean and standard deviation were derived by interpolation when possible. Visual analogue score at 24 hr was defined as the mean VAS over the first 24 hr postoperation. Visual analogue score at 48 hr was defined as the mean VAS during the interval of 24 to 48 hr postoperation. If the mean VAS was not available for the 24- or 48-hr timeframe, the VAS for the time peri-

TABLE I Characteristics of included trials

Author	*n*	*JADAD*	*Surgery*	*Intervention*	*Comparator*	*Country*
Pettersson 00	48	3	CABG	*iv* ketobemidone 1.0 mg q 6 min lockout 30 mg in 4 hr	Nurse administered *iv* ketobemidone (2-5 mg)	Sweden
Boulanger 02	40	3	CABG/Valve/ ASD	*iv* morphine 0.015 mg·kg^{-1} q 6 min	0.15 mg·kg^{-1} q 4 hr *sc*	Canada
Tsang 99	69	3	54 CABG, 11 valve, 4 combined	*iv* morphine 1 to 2 mg load q 15 min until VAS< 3 then morphine 1 mg q 6 min with 1 mg infusion	Same load, nurse could administer oral codeine if deemed insufficient	Canada
O'Halloran 97	66	3	Elective cardiac surgery	*iv* morphine 1 mg q 5 min lockout, no infusion, no limit	Nurse administered *iv* morphine infusion (0-3 mg·hr^{-1})	Ireland
Munro 98	80	3	61 CABG,17 valve, 2 combined	*iv* morphine 1 mg q 6 min 10 mg·hr^{-1} limit	*sc* NA morphine	New Zealand
Boldt 98	60	2	45 CABG, 15 valve	Piritramide 2 mg max 4 doses	Nurse administered piritramide	Germany
Gust 99	80	3	CABG	1.5 mg piritramide 10 min lockout	Nurse administered morphine	Germany
Coyle 90	52	3	CABG	Morphine 0.01-0.02 µg·kg^{-1} bolus 15-20 min lockout	Nurse administered morphine	USA
Myles 94	69	3	52 CABG, 11 valve, 6 combined	1 mg morphine 5 min lockout, no dose limit	Nurse administered morphine	Australia
Searle 93	60	4	CABG	0.1 mg·hr^{-1} hydromorphone 0.2 mg q 5 min bolus max 1.2 mg·hr^{-1}	Nurse administered morphine, demerol, codeine	Canada

CABG = coronary artery bypass graft; ASD-atrial septal defect.

od closest to 24 or 48 hr was used. Ventilation time was measured from end of surgery to time of tracheal extubation. Intensive care and hospital length of stay were measured from end of surgery to ICU or hospital discharge, respectively. Nausea and vomiting was defined as the presence of nausea and/or vomiting at any time point after surgery. Patient discontinuations were defined as patients discontinuing the study, for any reason, after randomization to treatment with PCA or NCA. Patient satisfaction scores were defined as per the study authors. Severe sedation was defined as difficulty in arousing a patient or unconsciousness. Patient satisfaction was defined by the authors, and included patients rating their treatment as "good" or "very good" on verbal or written questionnaires administered in hospital. Morphine sulphate consumption was calculated by converting narcotic doses into morphine equivalents according to the authors definitions or according to accepted equivalents (1 mg piritramide = 1 mg morphine sulphate, 1 mg ketobemidone = 1 mg morphine sulphate).

Statistical analysis

Outcomes were analyzed as dichotomous variables, with the exception of VAS, cumulative morphine equivalents, patient satisfaction scores, sedation scores, ventilation time and length of stay which were analyzed as continuous variables when means and standard deviation were reported. For dichotomous variables, odds ratios (OR) and 95% confidence intervals (CI) (OR, 95% CI) were calculated. For continuous variables, the weighted mean difference (WMD; 95% CI) was calculated. If significant differences were found for proportions, it was planned to calculate the absolute risk reduction and number needed-to-treat.[7] Heterogeneity was explored using the Q-statistic, with $P < 0.10$ suggesting significant heterogeneity between trials. In addition, the I-squared value was calculated to define the proportion of heterogeneity observed between trials that could be explained by chance. For each outcome, the Mantel-Haentzel (fixed effect) or DerSimonian and Laird (random effects) model was used when the Q-statistic suggested lack or presence of heterogeneity, respectively.

When possible, data extraction and analysis was by intention-to-treat. Sensitivity analysis was planned to explore the potential effect of trial quality, and patients excluded in non-intent-to-treat trials using a worst-case scenario assumption.

Publication bias was explored through visual inspection of funnel plots for each outcome, in which the inverse of the estimated variance of the natural logarithm of the adjusted relative risk was plotted against the natural logarithm of the adjusted

TABLE II Baseline patient characteristics

Characteristic	*PCA*	*NCA*	*P*
Age (yr)	59.7 (8.7)	60.9 (8.5)	0.01
Female (%)	19	26	0.22
CABG surgery (%)	90	86	0.45
Length of ventilation (hr)	10.5	10.5	0.75

PCA = patient-controlled analgesia; NCA = nurse-controlled analgesia; CABG = coronary artery bypass grafting.

relative risk for each disease.[8] Statistical significance was defined as a two-tailed $P < 0.05$, or 95% CI that excluded values of no difference. Data were analyzed by use of Comprehensive MetaAnalysis® (Englewood, NJ, USA, 2002) and RevMan (v4.2, Cochrane Collaboration, 2004).

Results

A total of 96 citations were screened. Of these, a total of 16 trials were retrieved for in-depth consideration for inclusion in this study. Two trials were excluded because of non-cardiac surgery.[9,10] Three were excluded because of the use of a control arm which was not nurse administered.[11–13] One was excluded because of non-randomized trial design.[14] This left ten eligible trials, including nine papers[15–23] and one abstract[24] involving a total of 666 patients (Table I). The median Jadad score was 3 (range: 2–4).[6] Most baseline characteristics were similar between groups; however, the NCA group was older and had a greater number of female patients. (Table II). Four trials evaluated patients undergoing coronary artery bypass surgery exclusively, while six trials evaluated patients undergoing both CABG and valvular surgery. Overall, 88% of included patients underwent CABG. Clear evidence of publication bias was not found for any endpoint, although lack of power limited evaluation in some cases. Significant heterogeneity across trials was found for 24 and 48-hr VAS, 24 and 48-hr morphine equivalents, patient satisfaction scores, number of patients experiencing nausea or vomiting, number of patients with severe pain, and number of patients satisfied.

Table III outlines the results for clinical and economic outcomes. For the primary endpoint of mean VAS at 24 hr there was no difference between the PCA group and NCA group (WMD -0.19, 95% CI -0.61 to 0.24). However, mean VAS score was significantly reduced at 48 hr (WMD -0.73, 95% CI -1.19 to -0.27) in the PCA group compared with NCA, and cumulative morphine equivalent consumption was significantly increased at both 24 hr (WMD 6.84 mg, 95% CI 0.97 to 12.72 mg), and 48 hr (WMD 10.46 mg 95% CI 2.02, 18.9 mg). No significant differences were found for resource utilization outcomes including ICU length of stay (WMD 0.05 days, 95% CI -0.19 to 0.29), and hospital length of stay (WMD -0.27 days, 95% CI -0.81 to 0.27), and costs were not reported in any study. Similarly, no significant difference was found for nausea and vomiting (OR 0.93, 95% CI 0.36 to 2.4), severe sedation (OR 0.83, 95% CI 0.29 to 2.35), respiratory depression (OR 1.4, 95% CI 0.39 to 5.08), severe pain (OR 0.71, 95% CI 0.18 to 2.90), patient discontinuations (OR 0.74, 95% CI 0.36 to 1.5), patient satisfaction (OR 3.32, 95% CI 0.57 to 19.48), and all-cause mortality (OR 1.45, 95% CI 0.17 to 12.08). Patient satisfaction scores and sedation scores did not differ significantly between groups (Figures 1–15, available as Additional Material at www.cja-jca.org). No studies reported on the following outcomes: pruritus, constipation, pulmonary complications, and hypotension. Sensitivity analyses by study quality were not possible since the studies had similar quality scores, and worst-case scenario sensitivity analysis was not possible due to inadequate information on dropouts.

Discussion

In cardiac surgical patients, PCA increased narcotic consumption by approximately 7 mg at 24 hr postoperatively and 10 mg at 48 hr postoperatively compared with NCA. This resulted in a net 22% reduction in VAS pain scores (0.7 points on the VAS) at 48 hr in the PCA group compared with NCA. While this reduction appears small, it is hardly surprising as VAS scores in these cardiac surgical patients were low overall, with averages between 2 and 3 in both groups. Studies on the subjective importance of improvement in VAS scores suggest that relative reductions may be more important than absolute changes, with reductions of 35% or higher being indicative of "much improved".[25–27] Similarly, others have suggested that a 33% decrease in pain represents a reasonable standard for determining that a change in pain is meaningful from the patient's perspective.[28] While this meta-analysis suggests an improvement in VAS of only 22% at 48 hr, our 95% CI were too broad to rule out a meaningful reduction in VAS with PCA (i.e., the 95% intervals include the possibility of a 37% improvement in VAS at 48 hr). This was associated, not surprisingly, with an increase in narcotic consumption of over 25%. Given that PCA patients consumed significantly greater narcotic equivalents to achieve greater (albeit, small) pain relief, these results suggests that a relative under-dosing of narcotics may occur with NCA, leading to under-treatment of postoperative pain.

TABLE III Results

PCA *vs* NCA – Continuous outcomes *Outcome*	*n (N)*	*PCA*	*NCA*	*WMD (95% CI)*	*Heterogeneity P value*	I^2	*P for overall effect*
VAS, 24 hr	498 (7)	3.1	3.0	-0.19 (-0.61, 0.24)	0.01	66	0.39
VAS, 48 hr	572 (8)	2.8	3.3	-0.73 (-1.19, -0.27)	< 0.00001	80	0.002
Morphine equivalents (mg), 24 hr	487 (7)	29.5	22.73	6.84 (0.97–12.72)	< 0.00001	86	0.02
Cumulative morphine (mg) equivalents, 48 hr	366 (5)	32.4	24.7	10.46 (2.02, 18.9)	< 0.00001	88	0.02
Patient satisfaction score	171 (3)	4.8	4.1	0.75 (-0.20, 1.66)	0.0004	87	0.12
Length of ICU stay, days	129 (2)	2.33	2.40	0.05 (-0.19, 0.29)	0.72	0	0.69
Length of hospital stay, days	150 (3)	7.10	7.30	-0.27 (-0.81, 0.27)	0.60	0	0.33
Sedation score	111 (2)	1.42	1.73	-0.28 (-0.61, 0.06)	0.2	38	0.11
PCA *vs* NCA – Discrete outcomes *Outcome*	*n (N)*	*PCA*	*NCA*	*WMD (95% CI)*	*Heterogeneity P value*	I^2	*P for overall effect*
Death, all cause	171 (3)	1.0	0	1.45 (0.17–12.08)	0.92	0	0.7
PONV	330 (5)	26.1	27.5	0.93 (0.36–2.40)	0.10	49	0.9
Severe sedation	228 (3)	6.0	9.6	0.83 (0.29–2.35)	1.0	0	0.7
Respiratory depression	317 (4)	2.8	2.2	1.40 (0.39–5.08)	0.93	0	0.6
Severe pain	181 (3)	21.5	23.9	0.71 (0.18–2.90)	0.15	33	0.6
Patients satisfied	210 (3)	52.3	45.2	3.32 (0.57–19.48)	0.08	61	0.2
Discontinuations	371 (6)	16.9	14.7	0.74 (0.36–1.5)	0.8	0	0.08

PCA = patient-controlled analgesia; NCA = nurse-controlled analgesia; VAS = visual analogue scale; ICU = intensive care unit; WMD = weighted mean differences; CI = confidence intervals; OR = odds ratios; PONV = postoperative nausea and vomiting.

Nevertheless, the reductions in nursing-administered analgesics could also occur for reasons other than inadvertent under treatment. Restrictions on nurses' ability to administer narcotics in these trials may have been the result of the orders written (restrictions on dose and administration intervals), difficulty with timely administration, or both. In current practice, the trend toward more rapid turnover of cardiac patients may place further limitations on nursing time and may potentially favour PCA utilization.

In the real world setting, the potential differences in narcotic utilization and resulting pain relief between NCA and PCA might be even greater than suggested by this analysis, given that the increased attention paid to the NCA group as a direct result of being observed in a randomized controlled trial (Hawthorne effect) may have predisposed the results toward more conservative differences in narcotic utilization between PCA and NCA. The lack of differences observed between NCA and PCA within the first 24 hr postoperatively may be expected given that these patients traditionally have 1:1 or 1:2 nursing care which allows for effective pain management through nurse administered narcotics, with less chance for differential treatment between groups during this time period.

Significant heterogeneity was present for cumulative morphine equivalents at 24 and 48 hr and for VAS at both 24 and 48 hr. This is expected as the practice patterns for anesthesia and opioids given interoperatively were variable, and since differing opioids (with uncertainty of exact morphine equivalency) were used within the PCA regimen. In addition, some studies allowed concomitant *prn* or scheduled use of adjunctive non-steroidal anti-inflammatory agent (NSAID) analgesics or acetaminophen. Also, some of the heterogeneity in VAS may be attributable to the differing practices across institutions in measuring VAS, whether at rest, provoked by cough, or after movement.

Postoperative pain control in cardiac surgical patients has become increasingly important with the shift from high dose intraoperative narcotic being the standard, to more moderate doses becoming the norm to facilitate fast-track coronary bypass surgery.[29] While reduced intraoperative narcotic facilitates early tracheal extubation and cost-savings, it has led to a concern about the potential for increased pain following surgery. Numerous pain management techniques have been examined to improve pain scores without prolonging intubation. In particular, NSAIDs have been studied to reduce postoperative pain and mitigate potential narcotic-induced side effects. While they seem effective in reducing total morphine consumption and VAS pain scores, NSAIDs also bring risks including renal dysfunction, sternal wound infec-

tion, and bleeding.[30] Intrathecal morphine has been used preoperatively to treat postoperative pain. Doses have ranged widely and while some studies suggest no ventilatory depression other studies have suggested a risk of hypoventilation and delayed weaning.[31–33] Thoracic epidurals have also been tried with good success; however, concerns over epidural hematomas have precluded their widespread acceptance.[34,35]

Unfortunately, incomplete reporting of adverse events prevented adequate analysis of risks associated with PCA use. Since the absolute increase in narcotic use in the PCA group was small (7 mg over 24 hr), it would be unexpected to find significant differences in narcotic-induced adverse effects between groups even with adequate reporting and/or trials of greater sample size.

Comparison with other surgical literature

There exist no other systematic reviews or meta-analyses of PCA *vs* NCA randomized trials in cardiac surgery. A previous systematic review of miscellaneous surgical patients included randomized studies of PCA *vs* NCA (*iv, im, sc* narcotics) and found improvements in VAS and patient satisfaction with PCA.[2] There has been widespread adoption of PCA in the treatment of postoperative pain, as it not only improves patient comfort but also improves resource utilization.[9,10] The disparate findings between this paper and previous studies may relate both to the type of surgery, degree of postoperative pain and timely administration of *iv* analgesia by nurses caring for patients in the ICU following cardiac surgery.

Strengths and limitations

The results of this analysis must be interpreted in light of the strengths and limitations of the included trials. The rigour of this analysis, as evidenced by comprehensive searches for randomized trials in any language and the adherence to QUOROM recommendations, suggests that this represents a complete summary of best available evidence.

It is important to note that the highly selected population found in these trials, which was generally younger and had fewer overall coronary vessel grafts than the national average in the United States[36] may impact the generalizability of the findings. In addition, a number of the trials were performed in the early 1990s, suggesting the surgical and anesthetic techniques may be less relevant to predominant practice today. The prolonged ventilation time in the trials (nearly 12 hr in each group), and the prolonged ICU stay (over two days in each group) highlights the fact that most trials predated the fast-track era. A number of advances in anesthesia, including multimodal analgesia, have resulted in reduced pain postoperatively. Thus, any differences observed between PCA and NCA may be overpowered by recent advances.

Despite the fact that only randomized trials were included in this meta-analysis, both the number of females and age appear to be unevenly distributed between groups. Whether the excess number of females included in the NCA group compared with the PCA group impacted the results of this meta-analysis remains indeterminate. While there has been some empirical evidence of gender differences in perception of pain in other surgical trials,[37] research in this area is very preliminary. That the preponderance of females in the NCA group, which may have biased results in favour of PCA, cannot be ruled out at this time. While patients in the NCA group were statistically significantly older, it is unlikely that clinically the 1.2 yr difference would have a large impact on the results.

The heterogeneity observed between trials is not unexpected; given the diverse anesthetic and surgical practice patterns and institutional protocols that would variably impact outcomes such as length of ventilation and length of stay. In addition, the intervals during which VAS was measured differed (i.e., some trials reported average VAS from 0–24 hr, while others reported average VAS from 12–24 hr) across studies, and it is not surprising that significant heterogeneity was found. Nevertheless, since our analysis examined the difference in VAS between groups, the differing definitions should not materially impact the overall conclusions.

Since few studies contributed data to the outcomes of interest related to narcotic adverse effects, this meta-analysis remained underpowered to detect clinical significant differences between PCA and NCA. Notwithstanding this lack of power, this meta-analysis represents the best state of knowledge for PCA in postcardiac patients. Future studies should focus on increasing the power to detect important differences in VAS in today's context of fast-tracked cardiac surgery, and patient-reported outcomes such as satisfaction should be evaluated. Also, the relative risk of adverse events with PCA *vs* NCA, and the costs should be examined in future studies. The paucity of studies evaluating PCA in the contemporary surgical and anesthetic context is surprising given the widespread use of PCA worldwide. Clearly, sufficient eligible patients exist to allow for adequately powered studies.

While this analysis delineates the landscape of existing evidence, it also serves to highlight gaps that remain. Most notable is the lack of adequate numbers

of randomized trials evaluating PCA compared with NCA that report on clinically relevant narcotic adverse effects. Also notable, is the lack of research on patient subgroups likely to benefit more from PCA, which may include younger patients, fast-tracked patients, and those with preexisting chronic narcotic use. Finally, valid economic analysis of PCA compared with NCA should be undertaken in order to determine whether the resource allocation required is worthy of the outcomes achieved.

Conclusions and implications

Overall, the use of PCA reduced 48-hr VAS scores by 25% (absolute VAS difference 0.7) while increasing narcotic cumulative consumption by approximately 7 mg at 24 hr. Whether this modest benefit is sufficient to warrant recommending PCA over NCA requires further understanding of patient preferences and cost-effectiveness. Future trials should focus on high-risk populations likely to require more intensive analgesic regimens, and should be adequately powered to evaluate the impact of PCA on narcotic-induced adverse effects and patient satisfaction. In addition, cost-effectiveness studies will be required to determine whether the routine use of PCA should be advocated in place of NCA in postcardiac surgical patients.

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