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Original Research Article

ORIGINAL RESEARCH ARTICLE

Anaesthetist prediction of postoperative opioid use: a multicentre prospective cohort study

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Abstract

Background: The Apfel simplified risk score includes four risk factors: female sex, non-smoking status, postoperative nausea and vomiting or motion sickness history, and postoperative opioid use. The score is calculated preoperatively, so postoperative opioid use must be predicted. We aimed to determine whether anaesthetists can predict patients' postoperative opioid use and dose.

Methods: Specialist anaesthetists from eight hospitals preoperatively predicted opioid use and dose in the post-anaesthesia care unit (PACU) and for the first 24 h postoperatively, which was compared with actual opioid use and dose. Opioid doses were converted to oral morphine equivalents (MEQ). Correlations between predicted and actual opioid use and dose were analysed with Spearman's rho and linear regression.

Results: A total of 487 anaesthetist–patient pairs were included. Anaesthetists overpredicted opioid use (398 [82%] predicted *vs* 251 [52%] actual patients requiring opioids in the PACU; 396 [81%] predicted *vs* 291 [60%] actual in the first 24 h) (Spearman's rho [95% confidence interval] 0.24 [0.16–0.33], $P<0.001$ in the PACU; 0.36 [0.28–0.44], $P<0.001$ in the first 24 h). Anaesthetists also overpredicted opioid dose (median [inter-quartile range] 12 [8–20] mg predicted MEQ *vs* 4 [0–18] mg actual MEQ in the PACU; 32 [18–60] mg *vs* 24 [0–65] mg MEQ in the first 24 h) (Spearman's rho 0.21 [0.13–0.29], $P<0.001$ in the PACU; 0.53 [0.40–0.60], $P<0.001$ in the first 24 h).

Conclusions: Specialist anaesthetists cannot accurately predict opioid use or dose in the PACU or the first 24 postoperative hours. The Apfel risk criterion for postoperative opioid use may be inaccurate in clinical practice.

Keywords: anaesthesia; opioid; postoperative nausea and vomiting; risk prediction; risk score

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Postoperative nausea and vomiting (PONV) is a common, distressing, and costly complication after surgery and thus, prevention is important.[1–3] The Apfel simplified risk score is commonly used to estimate risk and to guide antiemetic prophylaxis. It includes four risk factors: female sex, non-smoking status, history of PONV or motion sickness, and postoperative opioid use.[4] The presence of each risk factor increases a patient's risk of PONV by ~20%, with guidelines recommending on to two antiemetics for patients with one or two risk factors and three to four antiemetics for patients with three or four risk factors.[4,5] Although newer antiemetics have a more favourable side-effect profile than earlier-generation drugs, adverse effects can still be problematic. Neurokinin-1 antagonists and later-generation 5-HT_3 receptor antagonists can cause headache, constipation, and altered liver function.[6]

Despite its widespread use in clinical practice, the Apfel simplified risk score has limitations. Although it was initially developed using measured postoperative opioid doses, the Apfel score is intended to be calculated preoperatively.[4] Accurate estimation of risk is therefore reliant on the anaesthetist's ability to predict postoperative opioid use, an incongruity with usual risk prediction tools, which rely on information already to hand. Anaesthetists rely on accurate prediction to know how many antiemetics should be given prophylactically during the procedure, and to tailor postoperative 'rescue' prescribing. If prediction is poor, patients may receive insufficient prophylaxis with concomitant increased risk of PONV; conversely, excessive prophylaxis may expose patients to unnecessary drug side-effects, and health services to increased cost. Furthermore, postoperative opioid use is recorded as a binary variable in the Apfel risk score, despite evidence of a dose-dependent effect of opioids on the development of PONV.[7,8] Accurate prediction of opioid requirements is also important for appropriate postoperative analgesic prescribing, to ensure neither inadequate analgesia provision, nor that patients are prescribed (or discharged home with) excessive opioids. Recent work has demonstrated the issue of variability in prescribed *vs* consumed opioids after major surgery.[9]

It is thus important to know if anaesthetists can predict opioid requirements for their patients. However, the ability of anaesthetists to predict postoperative opioid use and dosing in surgical patients undergoing general anaesthesia is unclear. We therefore conducted a multicentre prospective cohort study across eight university-affiliated hospitals to determine if specialist anaesthetists can predict postoperative opioid use and dose.

Methods

This multicentre prospective cohort study was approved by the Melbourne Health Office for Research as a quality assurance project on 11 May 2021 (Project number QA2021022) and was subsequently approved at each participating site. The consent of the participating anaesthetist was implied by willingness to answer the study questions; patient consent for use of routinely collected data was not required. The study conforms with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[10]

Specialist anaesthetists at eight metropolitan and regional hospitals affiliated with the University of Melbourne, Australia, who were anaesthetising adult patients (≥18 yr) for noncardiac surgery under general anaesthesia, were eligible for inclusion between May 2021 and July 2022. Anaesthetists were included a maximum of three times each, providing that each anaesthetic was with a different surgical unit. Each surgical unit was represented no more than 10 times in total at each site. For combined surgical cases, the primary unit was chosen. Anaesthetists-in-training such as residents, registrars, and fellows were excluded in order to restrict to specialist-level experience across all participants. Anaesthetists who expected their patient to require intensive care unit admission postoperatively or to remain sedated and intubated after surgery were also excluded.

Anaesthetists were identified opportunistically from rosters and operating suite schedules and were approached on the day of surgery. The anaesthetists completed the preoperative survey after their preoperative assessment and before induction of anaesthesia. They were asked to predict postoperative opioid use (yes or no) and opioid dose for their patient, from PACU admission to PACU discharge and from PACU admission to 24 h postoperatively. Data about the patient's actual postoperative opioid use and doses were also recorded. We also collected patient age, sex, weight, height, and American Society of Anesthesiologists (ASA) physical status scores.

Statistical analyses

All opioid doses were converted to oral morphine equivalents (MEQ) using the Faculty of Pain Medicine, Australian and New Zealand College of Anaesthetists, opioid dose equivalence calculation table.[11] Data were summarised using median (inter-quartile range [IQR]) for continuous data and number (percent) for categorical data, with predicted *vs* actual opioid doses presented in 2×2 contingency tables. Predicted and actual opioid use and dose were compared using linear regression after visualisation using scatter plots of observed *vs* predicted variables, with accuracy summarised using root mean square error (RMSE) and bias (with 95% confidence intervals [CIs]). Correlations between predicted and actual opioid use and dose were also calculated using Spearman's rho (95% CI). Stata 14.0 (StataCorp LLC, College Station, TX, USA) was used for statistical analyses.[12]

Results

In total, 503 anaesthetist–patient pairs were recruited for participation in the study (Fig 1). After exclusions, 487 anaesthetist–patient pairs were included in the analysis. Fourteen surgical specialties were included, 359 (74%) of the cases were elective (Table 1). The median (IQR) age of the patients was 56 (40–68) yr; 251 (52%) were male and 236 (48%) were female.

In both the PACU and the first 24 postoperative hours, anaesthetists overpredicted opioid use (398 [82%] predicted to use opioids *vs* 251 [52%] actual use of opioids in PACU; 396 [81%] predicted *vs* 291 [60%] actual use in the first 24 postoperative hours, Tables 2 and 3), with weak correlation (Spearman's rho [95% CI] 0.24 (0.16–0.33) in the PACU and 0.36 (0.28–0.44) in the first 24 h). Anaesthetists also overpredicted opioid dose (median [IQR] 12 [8–20] mg predicted MEQ *vs* 4 [0–18] mg actual MEQ in the PACU; 32 [18–60] mg *vs* 24 [0–65] mg MEQ in the first 24 postoperative hours), with weak-moderate correlation (Spearman's rho 0.21 (0.13–0.29) in the PACU, 0.53 (0.40–0.60) in the first 24 postoperative hours). Linear regression analysis of PACU opioid dosing demonstrated differential bias (95% CI)=10.47 (9.24–11.70),

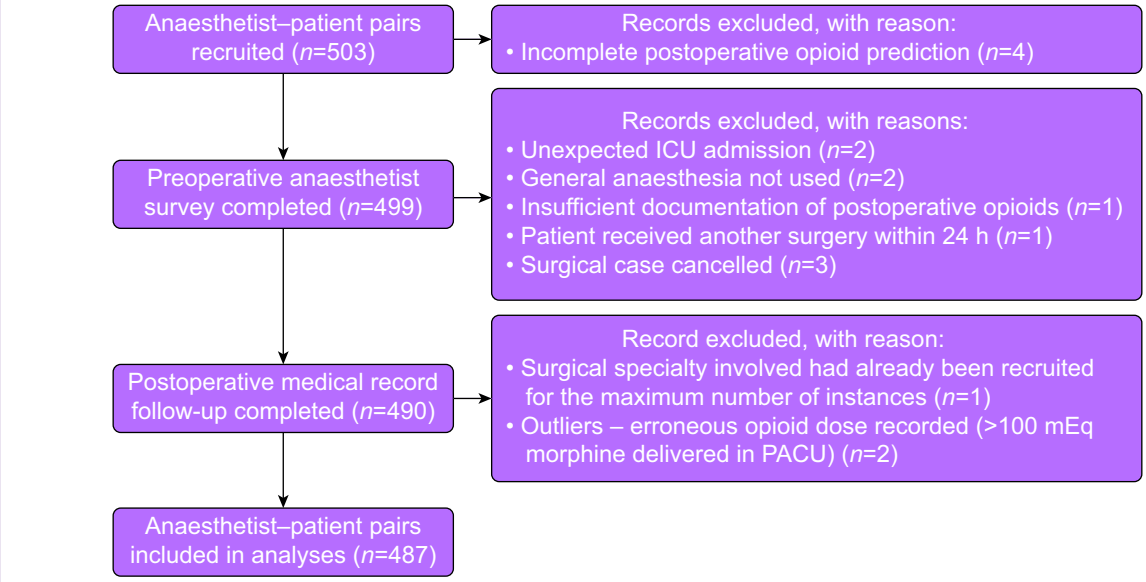

Figure 1. CONSORT diagram. CONSORT, Consolidated Standards of Reporting Trials.

Table 1 Characteristics of included anaesthetist–patient pairs. Values are number (proportion) or median (IQR). ASA,-=American Society of Anesthesiologists; IQR,=inter-quartile range.

Characteristic	*n* (%) or median (IQR)
Sex (*n*=487)	
Female	236 (48.5)
Male	251 (51.5)
Age, yr (*n*=487)	56 (40–68)
ASA physical status (*n*=487)	
1	80 (16.4)
2	199 (40.9)
3	194 (39.8)
4	14 (2.9)
Body mass index (kg/m^2) (*n*=413)	28.2 (24.2–33.2)
Surgical unit (*n*=487)	
Breast, oncology, and endocrine	50 (10.3)
Hepatobiliary and upper gastrointestinal	37 (7.6)
Colorectal	42 (8.6)
Emergency general surgery	22 (4.5)
Neurosurgery	37 (7.6)
Orthopaedics	63 (12.9)
Head, neck, and otolaryngology	34 (6.9)
Plastic	36 (7.4)
Urology	50 (10.3)
Vascular	32 (6.6)
Thoracic	24 (4.9)
Oral and maxillofacial	20 (4.1)
Trauma	5 (1.0)
Transplant and renal	4 (0.8)
Gynaecological	31 (6.4)
Surgical urgency (*n*=487)	
Elective	359 (74)
Emergency	128 (26)

Table 2 Two-by-two table for predicted *vs* actual opioid use in the PACU. Of those patients predicted to have used opioids in the PACU, 228/398 (57%) actually used opioids.

Predicted opioid use in the PACU	Actual opioid use in the PACU	
	Yes	No
Yes	228	170
No	23	66

Table 3 Two-by-two table for predicted *vs* actual opioid use in the first 24 h. Of those patients predicted to have used opioids in the first 24 h, 270/396 (68%) actually used opioids.

Predicted opioid use in the first 24 h	Actual opioid use in the first 24 h	
	Yes	No
Yes	270	126
No	21	70

proportional bias (95% CI)=0.17 (0.10–0.24) and an RMSE=11.10, also suggesting overprediction of PACU opioids, of a magnitude in the order of around 10 MEQ of morphine. Over the first 24 h, differential bias (95% CI)=32.22 (26.66–37.79), proportional bias (95% CI)= 0.31 (0.25–0.38) and RMSE=51.73, again suggested overprediction (Figs 2 and 3).

Discussion

In both the PACU and the first 24 h postoperatively, anaesthetists overpredicted whether their patients would receive

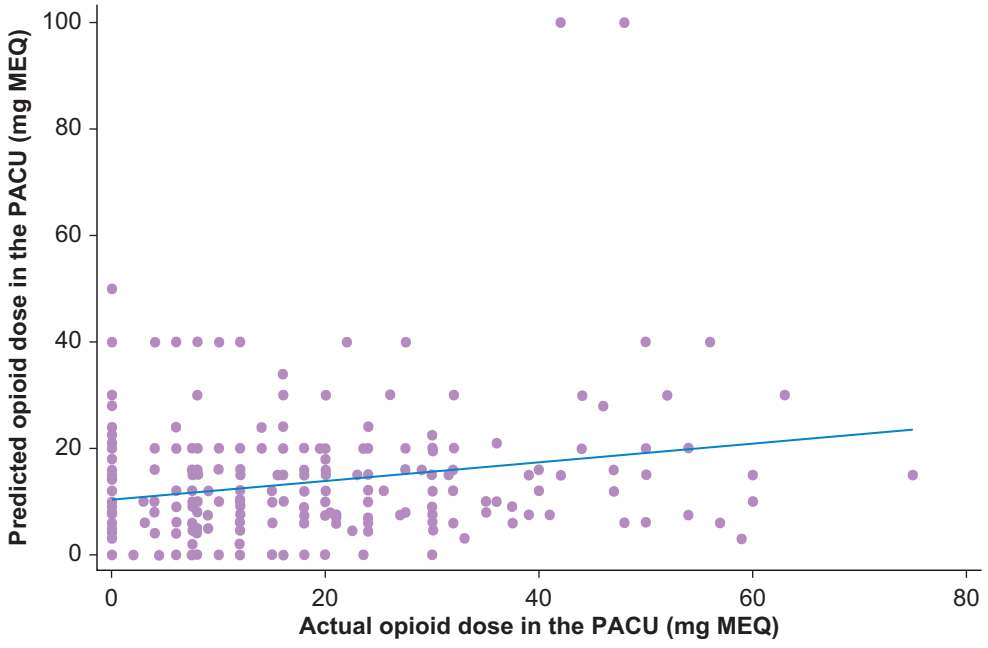

Figure 2. Scatter plot for predicted *vs* actual opioid dose in the PACU. Differential bias (95% confidence interval [CI])=10.47 (9.24–11.70) proportional bias (95% CI)=0.17 (0.10–0.24), root mean-square error (RMSE)=11.10.

opioids, with only weak correlation between predicted and actual opioid use. Opioid dose prediction was similarly poor, with weak dose correlation in the PACU and only moderate correlation for the first 24 h. Large RMSE for both PACU and first 24 h opioid consumption suggests the magnitude of this difference is considerable.

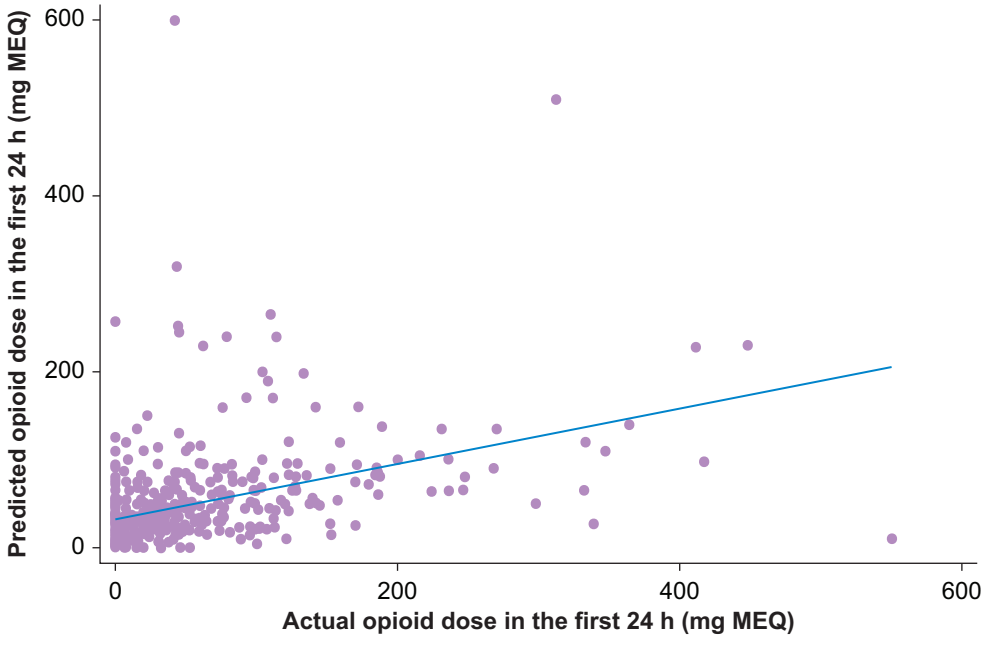

Figure 3. Scatter plot for predicted vs actual opioid dose in the first 24 h. Differential bias (95% confidence interval [CI])=32.22 (26.66–37.79), proportional bias (95% CI)= 0.31 (0.25–0.38), root mean-squared error (RMSE)=51.73.

Our findings imply that patients may potentially receive excessive PONV prophylaxis for their level of risk. The Fourth Consensus Guidelines for the Management of Postoperative Nausea and Vomiting recommend that patients with one to two risk factors should receive one to two antiemetics, and patients with three or four risk factors should receive three to four antiemetics.[5] Although some experts suggest that all patients should receive higher numbers of antiemetics,[13,14] their unnecessary use increases the cost of patient care, and unnecessarily exposes patients to side-effects.[5,6] This increased cost burden in less well-resourced settings should not be underestimated—a dexamethasone 4 mg ml^{-1} ampoule, for example, varies in cost more than nine-fold across the world, with ondansetron 2 mg ml^{-1} ampoules varying more than 16-fold in price.[15] The highest antiemetic drug prices are also often paradoxically observed in the poorest countries.[15] Our findings also imply that excessive opioid prescribing could be a potential problem (for example, overestimation of opioid consumption leading to unnecessary patient-controlled analgesia prescription, with attendant resourcing implications for postoperative pain rounds, and potentially delayed patient discharge). A further implication of systematic overestimation of opioid requirement may be unnecessary discharge opioid prescription and dispensation.

We have previously shown that the postoperative opioid criterion is poorly defined and reported in studies examining PONV.[16] In a systematic review of the literature, only 138 of 255 (54%) studies defined this criterion as 'anticipated' opioid use as intended, with an explicitly stated opioid threshold dose present in only seven (3%) studies.[16] Our study extends these findings, demonstrating that anaesthetists in clinical practice poorly predict both the requirement for and dose of postoperative opioids. Postoperative opioid dose is also not a component of the Apfel simplified risk score, despite the positive association between opioid dose and PONV.[6,7] As such, a known limitation of the Apfel simplified risk score is the dichotomous representation of postoperative opioid use[4]; a risk stratification model for PONV that includes postoperative opioid dose as a continuous variable may be of benefit.[16]

The strengths of our study include its multicentre design, incorporating eight metropolitan and regional hospitals and encompassing a wide range of noncardiac surgical cases. In addition to almost 500 anaesthetist–patient pairs, restricting assessments to a maximum of three per specialist means our results represent >150 discrete anaesthetists' predictions. Our results are thus widely generalisable, and likely representative of opioid prediction in modern anaesthetic practice. Limitations include that anaesthetists were not directed to perform any standard form of preoperative assessment, thus the information gathered by each anaesthetist before making their prediction may not have been uniform. This methodology, however, mirrors 'real world' practice in postoperative opioid requirement prediction. In addition, we required anaesthetists to predict opioid consumption before induction of anaesthesia (*vs*, for example, towards the end of a surgical case once intraoperative opioid requirements have become known, along with the patient's response to the surgical stimulus and the opioid). This, however, is again analogous to how the postoperative opioid Apfel risk criterion is intended for use in clinical practice, with an assessment of PONV risk made before commencement of anaesthesia. In addition, waiting until the end of surgery before prediction precludes the use of prophylactic strategies that must commence at the start of the case (e.g. dexamethasone or propofol total i.v. anaesthesia). A further limitation is that anaesthetists may have correctly identified a need for opioids that was subsequently not met in the PACU or the ward, because of a failure of administration. We consider this unlikely to have considerably affected our results, however, given that pain management is highly protocolised in the hospitals included in our study, with also a large magnitude of difference between predicted and actual opioid use. In addition, anaesthetists were also asked to predict according to the opioid they were prescribing, with some evidence that usefulness of conversion to oral MEQ decreases in proportion to the number of doses given. We also did not analyse multiple predictions per anaesthetist, to determine within-anaesthetist predictive power, nor did we make an *a priori* judgement about what would constitute 'good' prediction. A final limitation is we were unable to account for opioids used once the patient was discharged from the hospital, which may have affected the relationship between predicted and actual use for day cases. Patients discharged before 24 h, however, represented only a minority of included cases in our analysis.

In conclusion, specialist anaesthetists cannot accurately predict opioid use or dose, in the PACU or in the first 24 postoperative hours. The Apfel simplified risk criterion for postoperative opioid use may be inaccurate in clinical practice.

Authors' contributions

Study design: KT, KL, JD
Patient recruitment: KT, MBD, CL, MY, DG, XT, SL, BP, KC
Data collection: KT, MBD, CL, MY, DG, XT, SL, BP, KC
Writing up of the first draft of the paper: KT, ADS, KL, JD
Revisions to subsequent drafts of the paper: MBD, CL, MY, DG, XT, SL, BP, KC
Data analysis: ADS, KL, JD

Declarations of interest

The authors declare that they have no conflicts of interest.

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