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An audit of patient controlled analgesia after appendicectomy in children

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Declarations:

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What is already known

- Patient controlled analgesia (PCA) is commonly used after appendicectomy in children.

What this article adds

- The duration of PCA was shorter with uncomplicated appendicitis and with the administration of intraoperative diclofenac, but was not affected by surgical approach.
- Intraoperative rectal diclofenac reduces first 24 hours postoperative PCA opioid consumption and mean pain score in first 12 hours post appendicectomy.
- There is no difference between open and laparoscopic appendicectomy postoperative mean pain scores.

It is feasible that children with uncomplicated appendicitis given intraoperative NSAID can be successfully managed without PCA.

Background: Patient controlled analgesia (PCA) is commonly used after appendicectomy in children

Aim: To characterise the analgesic use of children prescribed PCA after appendicetomy, in order to rationalise future use of this modality.

Methods: We retrospectively audited all cases of acute appendicitis over a 4-year period in a single paediatric hospital, recording demographics, surgical approach, pathology, analgesia use, pain scores, and duration of PCA. We pre-planned subgroup analyses for surgical approach, pathology, and intraoperative non-steroidal anti-inflammatory drug (NSAID) administration. We subsequently identified a patient subgroup who were unlikely to require PCA and conducted a (2 month) prospective audit of such patients (uncomplicated appendicitis with intraoperative NSAID) having non-PCA (oral) analgesia.

Results: Of the 649 patients undergoing appendicectomy for acute appendicitis, 85% were prescribed an opioid PCA, 8% received an opioid infusion (younger patients) and 7% received neither

PCA nor infusion. Of the 541 bolus only PCA patients, 49% had laparoscopic surgery, 36% had complicated appendicitis, and 49% received intraoperative NSAID (diclofenac). Mean (SD) duration of PCA was shorter with uncomplicated vs complicated appendicitis (21.9 ± 10.7 vs 32.8 ± 21.1 hours, $P < 0.001$, difference in means [95% CI]: 10.9 [7.7-14.1]) and, with intraoperative NSAID (23.2 ± 14.4 vs 28.4 ± 17.4 hours, $P < 0.001$, difference in means [95% CI]: 5.2 [2.5-7.9]). There was no difference in the time to PCA cessation between laparoscopic and open approach. Morphine consumption and pain scores were lower in the early postoperative period for those patients receiving intraoperative NSAID. In the prospective audit, 44 of 69 patients had uncomplicated appendicitis. 38 of these were prescribed oral analgesia and none required any parenteral opioid or acute pain service intervention postoperatively. Parental satisfaction level was high (>90%) with oral analgesia. **Conclusions:** It is feasible that children with uncomplicated appendicitis given intraoperative NSAID can be successfully managed without PCA.

Key words: appendectomy; appendicitis; analgesia, patient-controlled; acute pain; laparoscopy; child

Introduction

Patient Controlled analgesia (PCA) is commonly used following abdominal surgery, including the most common acute surgical emergency in children in developed countries, appendicitis (1,2,3,4). There is a perception that oral analgesia may not be a viable option in the immediate postoperative period in this setting. However, PCA is not without limitations. In order to be used in a safe and effective manner, additional resources are required including equipment and personnel. Patients require increased monitoring on the ward, both by nursing staff and by medical review, ideally by an acute pain service. Whilst PCA may be appropriate in children with moderate-severe pain or those with ongoing unavailability of the oral route, the advantages may be minimal in patients with less pain, or those able to tolerate oral analgesia.

The primary aim of this study was to characterise the analgesic use of children prescribed PCA after appendicetomy for acute appendicitis, in order to rationalise future use of this modality in our institution. In particular we aimed to assess the influence of surgical technique (laparoscopic vs open), pathology (uncomplicated vs complicated appendicitis), and intraoperative NSAID use on analgesic requirements to identify patients who might be suitable for oral analgesia postoperatively. The rationale for the second part of the study was to then prospectively audit patients identified as unlikely to require PCA and therefore manage them with oral analgesia alone.

Methods

After local human ethics committee approval, further retrospective analysis was performed on a previously collected patient database from a surgical audit in our tertiary referral institution (5). This database consisted of all 705 children who underwent appendicectomy between August 2006 and

February 2009 at the Women's and Children's Hospital, Adelaide, South Australia. The reasons for using this cohort of patients were firstly, that a single pathologist had stratified all patients with regards to their pathology into either 'uncomplicated' or 'complicated' appendicitis, and secondly to avoid duplication in data extraction (demographic data, surgical technique, length of stay had already been extracted and entered into an Excel database). Complicated appendicitis was defined as the presence of perforation or necrosis on histology, with correlations of intraoperative findings such as intraperitoneal pus or inflammatory mass (5).

All patient notes were recalled and data regarding anaesthesia and analgesia was extracted for those patients who underwent appendicectomy for acute appendicitis. This included preoperative, intraoperative and postoperative analgesia, use of regional anaesthesia/analgesia, antiemetic administration, duration of PCA and PONV. The following data was extracted from PCA charts up to 48 hours postoperatively in 6 hour epochs: total opioid dose, mean and median pain scores, nausea/vomiting scores, and administration of antiemetic. The PCA charts contained scales for scoring pain (0-10) and nausea/vomiting that are routinely used by nurses in our institution for all patients on PCA. As our inclusion criteria was appendicectomy for acute appendicitis, patients with a normal appendix, and those undergoing an interval or incidental appendicectomy, were excluded from further analysis.

After completion of the retrospective audit, an oral analgesia protocol was formulated to manage postoperative analgesia for uncomplicated (as defined by the surgeon intraoperatively) appendicitis. This included intraoperative non-steroidal anti-inflammatory drugs (NSAIDs) (diclofenac 1-2 mg·kg⁻¹ per rectum if age <12 years and weight <40 kg, or parecoxib 40 mg IV if weight ≥40kg) and antiemetics (ondansetron 0.1-0.15 mg·kg⁻¹ IV and/or dexamethasone 0.1 mg·kg⁻¹ IV), regular postoperative paracetamol (15 mg·kg⁻¹ IV or orally 6 hourly), postoperative NSAID (ibuprofen 5-10mg orally 6 hourly PRN) and PRN oral opioids (oxycodone 0.1-0.2 mg·kg⁻¹ 4 hourly and/or tramadol 1-2 mg·kg⁻¹ 6 hourly). Surgeons and anaesthetists were encouraged to prescribe oral analgesia instead of PCA but the ultimate decision was left to the discretion of the treating team. In addition we noted the use of any regional local anaesthetic techniques. After local human ethics committee approval, a 2 month audit was then conducted prospectively during December 2014 and January 2015 following this change in practice. This time period was chosen as it corresponded to a period of low elective operating and the availability of a clinical fellow. Outcome measures were: need for IV opioid analgesia, requirement of acute pain service (APS) review for unrelieved pain (as clinically determined by bedside nurse), PONV and parental satisfaction. APS made one routine review on the first day postoperatively. Each family of a child who had received oral analgesia protocol were contacted within one month following discharge via telephone to determine their satisfaction with the postoperative analgesia using a scale of 1-5, where 5 was 'completely satisfied' and 1 was 'completely dissatisfied'. The wording was standardised for assessing satisfaction with pain relief: "I would like you to think back to the pain relief after the appendix operation. Using a scale of 1-5 where 5 is completely satisfied and 1 is completely dissatisfied, how satisfied were you with your child's (or e.g. Mary's) pain relief in hospital following surgery?"

Statistical analysis

Continuous data were checked for normality using visual inspection of box-plots. Due to the large sample size, some variables which were non-normally distributed were still analysed using parametric statistical tests. Descriptive statistics were used to describe the patient and intraoperative characteristics for each PCA group. Independent samples t-tests were used to analyse group differences for opioid consumption, and Mann Whitney-U tests were used to analyse group differences for pain scores at each 6 hour epoch. Incidence of side effects were analysed using chi-square analysis. Total time of PCA was non-normally distributed; hence the data was transformed using log transformation. To assess the effects of procedure type, pathology and use of diclofenac on PCA duration, a factorial ANOVA was conducted. A simultaneous multiple regression analysis was used to assess the effect of PCA commencement time and timing of the pain round on PCA duration. A *P* value of <0.05 was considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 20.0. (Armonk, NY: IBM Corp.).

Results

Of the 705 patients within the original surgical cohort, 649 underwent appendicectomy for acute appendicitis (Figure 1). Patient demographics, intraoperative analgesia and time to discharge home are presented in Table 1. The majority of children received pre- or intra-operative paracetamol. Morphine was the primary intraoperative opioid used (91% of cases). Almost all patients (98%) received local anaesthetic infiltration by the surgeon and none received transversus abdominis plane (TAP) blocks.

For postoperative analgesia, 85% of children with acute appendicitis were prescribed an opioid PCA, 8% an IV opioid infusion (younger patients), and 1% intermittent IV morphine boluses. The remaining 6% received oral analgesia (oxycodone/NSAID) postoperatively. All patients were prescribed regular paracetamol four times per day (IV or oral). All opioid PCA was prescribed via the IV route with only three patients (0.5%) receiving a concurrent background infusion. Of the 541 'bolus only' PCA patients that were included in further analysis, 49% had laparoscopic surgery, 36% had complicated appendicitis, and 49% received intraoperative NSAID (diclofenac 1-2 mg·kg⁻¹ per rectum).

Duration of PCA was significantly shorter with uncomplicated appendicitis (compared with complicated appendicitis) and with intraoperative diclofenac (compared with no diclofenac) (Table 2). There was no difference in duration of PCA with laparoscopic versus open surgical approach. Extinction curves of PCA use over the first 48 hours postoperatively are shown in Figure 2.

Morphine was prescribed in 93% of PCAs and fentanyl was used in the remainder. For the statistical analyses, fentanyl consumption values were scaled to arbitrary 'morphine equivalent' units, using a 100:1 conversion factor (6). Opioid PCA consumption was significantly lower in the first 24 hours

when diclofenac was administered intraoperatively (Table 3). There was no difference in opioid consumption between surgical approaches.

Mean pain scores were low in all patient groups whilst PCA was in progress (Figure 3). There was no difference in pain scores with surgical approach. Mean pain scores were statistically significantly lower for the first 12 hours in patients receiving intraoperative diclofenac, and in the first 6 hours with complicated appendicitis. Incidence of PONV (nausea and/or vomiting) whilst on PCA was 32% (174/541) whilst incidence of vomiting was 9% (49/541).

There was a small but significant negative correlation between the commencement time of the PCA and overall PCA duration, ($r = -.170$, $p < .001$), indicating that PCAs commenced later in the day were of shorter duration than PCAs commenced earlier in the day. A simultaneous multiple regression analysis with commencement time of PCA entered as the independent variable and duration of PCA entered as the dependent variable, indicated that PCA commencement time explained a small, but significant 2.9% of variance in PCA duration ($R^2 = .029$, F change (1, 539) = 16.05 ($p < .001$).

In the second (prospective) audit, 69 patients underwent appendicectomy during the two month study period. Forty-four patients had uncomplicated appendicitis and 38 of these patients (31 laparoscopic and 7 open) were prescribed the oral analgesia protocol (with all receiving local anaesthetic infiltration by the surgeon and none having regional blocks). There were 28 boys and 10 girls and the age range was 5-17 years (mean 11 years). Intraoperative or pre-operative antiemetics were administered to 95% of patients (36/38, 9 single agent, 27 double agent) and PONV (nausea and/or vomiting) was experienced by 24% (9/38) with an incidence of vomiting of 11% (4/38). NSAIDs were given pre-operatively or intraoperatively to 71% of patients (27/38). No patient prescribed the oral analgesia protocol required conversion to IV opioid analgesia or acute pain service review for inadequate analgesia. Median (interquartile range) time from end of surgery to discharge home was 24 (22, 44) hours. Of the 38 families, 31 were contactable via telephone after discharge. There was a high level of parental satisfaction with 24, 6, and 1 parents reporting satisfaction scores of 5, 4 and 3 respectively. Six patients (1 laparoscopic and 5 open) were potentially suitable but did not receive the oral analgesia protocol. There were 4 boys and 2 girls and the age range was 7-17 years (mean 12 years).

Discussion

The main findings of our retrospective study were that the duration of PCA was shorter with uncomplicated appendicitis and with the administration of intraoperative diclofenac, but was not affected by surgical approach. Intraoperative diclofenac was also associated with lower morphine PCA consumption and lower pain scores. In the prospective part of the study we found that patients with uncomplicated appendicitis, given intraoperative NSAID, could be successfully managed postoperatively with oral analgesia alone. In contrast to the retrospective audit period where only 6% of patients were managed with oral analgesia alone, over half of the patients (55%) in the prospective

audit avoided PCA or other forms of IV opioid analgesia. We have subsequently continued with this practice, which has reduced nursing and acute pain service workload, and has met with our surgeons' approval.

We found that surgical approach (laparoscopic vs open) resulted in no difference in PCA duration, opioid consumption or pain scores. The choice of surgical approach in our institution is largely based on individual surgical preference, and this accounts for the near even division of the cohort between the two approaches. The focus of many studies has been the difference in pain and analgesic requirements between open and laparoscopic approaches to appendicectomy (3,7,8,9). Research into the impact of surgical approach on postoperative outcomes has been contradictory. Foulds *et al* (4) demonstrated no difference between approaches when it came to length of stay, and yet a meta-analysis by Wei *et al* in 2011 (7), which included adult data, concluded that the laparoscopic approach resulted in less postoperative pain. Till *et al.* (3) found PCA opioid consumption was less after laparoscopic appendicectomy with a long overall mean PCA duration of 46 hours. Tomecka *et al* retrospectively audited 186 cases of paediatric laparoscopic appendicectomy, only 11.2% of whom received PCA, and reported that substantial pain was common after laparoscopic appendicectomy (10). In contrast, we found that pain was well controlled with PCA in our large retrospective audit and also with oral analgesia in our smaller prospective audit.

Not surprisingly, we found that patients with complicated appendicitis required their PCA for longer. Patients with complicated disease are known to have a longer time course of recovery, and are more likely to have a complication post operatively (4). It has been identified that one of the main determinants of length of stay post-appendicectomy is pathology (4), but the influence of pathology on pain and analgesic requirements has had limited investigation (11). We were surprised to find that the only difference in pain scores and morphine PCA requirements were in the first 6 hour epoch, where the complicated group had lower values. The reason for this is unclear but it is worth noting that the difference in mean pain scores was only 0.5 out of 10 (i.e. 1/10 vs 1.5/10), so this is unlikely to be of any clinical significance. Perhaps differences in pain before and after surgery allows patients to experience a greater level of relief when recovering from complicated appendicitis.

The greatest impact on postoperative morphine PCA consumption was associated with the intraoperative administration of diclofenac with statistically significant lower pain scores for the first 12 hours, however again this may be of limited clinical significance given that the difference in mean pain scores was only 0.5 out of 10 (Figure 3). Others have also reported a benefit with NSAIDs after appendicectomy (12,13,14). Our morphine PCA consumption in the first 24 hours is comparable to that of Lambert *et al.* (15) whose patients all received regular NSAID and used an average of 480 $\mu\text{g}\cdot\text{kg}^{-1}$. Our patients consumed 369 $\mu\text{g}\cdot\text{kg}^{-1}$ and 596 $\mu\text{g}\cdot\text{kg}^{-1}$ if they received intraoperative diclofenac, or not, respectively.

In the second (prospective) audit none of the 38 patients commenced on the oral regimen required conversion to a PCA or other IV opioid analgesia. This audit has closed the loop on practices within our institution, and resulted in the routine use of oral analgesia alone after uncomplicated

appendicitis. Currently, extending an oral regimen to patients with complicated pathology at operation is limited by postoperative fasting as directed by surgeons, but may be considered for future investigation.

This study has a number of limitations. In the first study, being retrospective in nature, the choice of surgical approach and intraoperative NSAID use was by the individual clinician. Factors such as severity of operative findings could have influenced clinician decisions to administer NSAIDs which may have biased the results. However, diclofenac use was evenly distributed across groups and there was no correlation between intraoperative diclofenac use, pathology and surgical approach. We extracted data as to whether patients were prescribed regular paracetamol but, on reflection, did not check for administration of every prescribed dose. However our APS nurses are very diligent in training surgical ward staff to administer the regular paracetamol doses that have been charted. During the retrospective audit our patients did not receive postoperative NSAID whilst on PCA but oral NSAIDs were commonly commenced on cessation of PCA. The timing of PCA cessation was at the discretion of the acute pain service and/or surgical team and pain score data was no longer charted after this point in time. Analgesic management of appendicectomy patients in our institution has also evolved in the period of time since this data collection began. In particular, parecoxib has recently become available for intravenous use in our hospital, increasing the frequency of intraoperative NSAID administration. Some may feel that it is preferable to record the number of PCA presses (good and bad) and that this would have described analgesia more effectively than total opioid dosage over 6 hour time epochs. Unfortunately our PCA charts do not record unsuccessful presses but only volume delivered per hour. In addition there is a lack of functional activity scores in both the prospective and retrospective groups and some patient data was incomplete or missing.

In the second (prospective study) not all suitable patients received oral analgesia protocol, as the decision was left to the treating clinician. Although the number of patients who received PCA was small, there may have been factors leading a clinician to choose that method of analgesia, potentially biasing our results. For example, clinicians were encouraged to prescribe oral analgesia for all patients with simple appendicitis, but we noticed that only 7/12 patients who had open procedures received the oral analgesia protocol compared to 31/32 patients who had laparoscopic procedures. Further studies would be desirable to verify the effectiveness of oral analgesia after open procedures. Pain scores were not available for patients in the second study, as systematically recording pain scores is not our routine practice for patients receiving oral analgesia alone. The lack of APS contact as an outcome measure does not necessarily equate with adequate analgesia. However we consider that our paediatric surgical nurses are extremely diligent at detecting and acting upon inadequate analgesia. Unfortunately we only have satisfaction scores rather than pain scores as verification. TAP blocks were not used at all in the retrospective audit and even now are used infrequently in our institution. Previous studies have not shown any advantage of TAP blocks over parenteral opioids in laparoscopic appendicectomy (16), although there may be a benefit with open appendicectomy (17). However, the absence of a need for pain service intervention and a high level of satisfaction

demonstrated by our prospective audit in uncomplicated appendicitis, suggest that a TAP block may not be necessary in this context.

Implications for future research

There are several reasons to consider oral analgesia including facilitating sleep, less fluctuations in pain scores particularly if the patient hasn't pressed the button for several hours as well as potentially earlier discharge. These were not specifically measured in our study but may be useful aspects to include in future research. A future prospective audit that includes compliance with oral analgesia, pain scores at rest and with movement, and ongoing assessment at home, might be useful to ascertain when patients fully recover following appendicectomy. A comparative study of oral analgesia with PCA to see whether PCA allows better titrated analgesia when patients need it most (i.e. with movement and to facilitate it) may also be useful.

Conclusion

In conclusion, the duration of PCA after appendicectomy for paediatric patients appears to be influenced by the nature of the pathology and NSAID administration, rather than surgical technique (laparoscopic vs open). Patients who have uncomplicated appendicitis, as judged intraoperatively by the surgeon, can be prescribed oral analgesia alone postoperatively, with a high degree of parental satisfaction and low analgesia failure rates. It is feasible that children with uncomplicated appendicitis given intraoperative NSAID can be successfully managed without PCA.

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Ethics

Institutional ethics approval was obtained for this study from the Women's and Children's Health Network Human Research Ethics Committee, 72 King William Road, North Adelaide 5006, Australia.

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Conflict of interest

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The authors report no conflicts of interest.

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Table 1 Patient characteristics, intraoperative analgesia and hospital length of stay for the retrospective audit.

	PCA	Infusion	Other
Number of patients	541	51	46
Gender (male/female)	308/233	27/24	23/23
Age, years (mean $\pm$ SD)	12 $\pm$ 3	6 $\pm$ 2	11 $\pm$ 3
Weight, kg (mean $\pm$ SD)	47 $\pm$ 16	20 $\pm$ 6	42 $\pm$ 16
Surgery duration, mins (mean $\pm$ SD)	56 $\pm$ 25	51 $\pm$ 24	54 $\pm$ 23
Laparoscopic/open procedure	263/278	10/41	32/14
Uncomplicated/complicated pathology	345/196	24/27	35/11
Pre/intraoperative paracetamol	386 (71.3%)	33 (64.7%)	28 (60.9%)
Intraoperative diclofenac	264 (48.8%)	19 (37.3%)	19 (41.3%)
Intraoperative morphine	490 (90.7%)	44 (86.3%)	41 (89.1%)
Intraoperative fentanyl	225 (41.6%)	12 (23.5%)	14 (30.4%)
Time to discharge, hours median (IQR)	64(47-95)	105(58-147)	55(40-69)
Number of subjects discharged within:			
≤24 hours	30 (5.5%)	2 (3.9%)	5 (10.9%)
24–48 hours	186 (34.4%)	16 (31.4%)	23 (50%)
>48 hours	325 (60.1%)	33 (64.7%)	18 (39.1%)

Intraop Antiemetics

Tropisteron (Trop)	489 (90.4%)	45 (88.2%)	38 (82.6%)
Dexamethasone (Dex)	404 (74.9%)	33 (64.7%)	27 (58.7%)
Trop + Dex	386 (71.3%)	31 (60.8%)	26 (56.5%)
Trop + Dex + Droperidol	6 (1.1%)	0	1 (2.2%)

PCA = Patient Controlled Analgesia, SD=standard deviation, IQR = interquartile range.

Table 2 Time to PCA cessation in the retrospective group for the variables of surgical approach (laparoscopic vs open), pathology (complicated vs uncomplicated appendicitis), and intraoperative NSAID administration (diclofenac vs no diclofenac).

	Number	PCA duration (hours) Mean $\pm$ SD	Difference in means of PCA duration (95% CI)	Mean morphine PCA consumption in first 24 hours ($\mu\text{g}\cdot\text{kg}^{-1}$)
Laparoscopic	263	25.4 $\pm$ 16.2	0.9 (-1.8 - 3.6)	488
Open	278	26.3 $\pm$ 16.2	p = 0.553	483
Uncomplicated	345	21.9 $\pm$ 10.7	10.9 (7.7 - 14.1)	438
Complicated	196	32.8 $\pm$ 21.2	p < 0.001	570

Diclofenac	264	23.2 ± 14.4	5.2 (2.5 – 7.9)	369
No diclofenac	277	28.4 ± 17.4	p < 0.001	596

PCA = Patient Controlled Analgesia, SD = standard deviation, CI = confidence intervals.

Table 3 Morphine PCA consumption (mean ± standard deviation) in $\mu\text{g}\cdot\text{kg}^{-1}$ for each 6 hour epoch for those who had intraoperative diclofenac vs no diclofenac (retrospective group)

Time post-appendicectomy (hours)	Number of patients still on PCA	Morphine PCA consumption Mean ± SD ($\mu\text{g}\cdot\text{kg}^{-1}$)		P value	Difference in means (95% CI)
		Diclofenac	No diclofenac		
0-6	539	85 ± 113	130 ± 148	.006*	45 (23-67)
6-12	538	88 ± 98	133 ± 141	.003*	45 (25-65)
12-18	466	103 ± 112	132 ± 124	.026*	29 (8-50)
18-24	306	96 ± 94	157 ± 165	.002*	61 (32-90)
24-30	183	100 ± 105	117 ± 134	.432	17 (-18-52)
30-36	149	91 ± 92	118 ± 144	.962	27 (-11-65)
36-42	116	72 ± 76	101 ± 106	.124	29 (-5-63)
42-48	72	97 ± 111	82 ± 111	.773	15 (-44-74)

Figure captions:

Figure 1 Retrospective audit flow diagram.

Figure 2 Extinction curves of PCA use showing percentage of patients remaining on PCA up to 48 hours postoperatively.

Figure 3 Mean (SD) pain scores in six hour epochs postoperatively for the variables of surgical approach, pathology (uncomplicated ['simple'] vs complicated appendicitis), and intraoperative NSAID administration. Note that only patients still on PCA are included therefore the number of patients in each epoch reduces with time as patients progressively cease PCA (the number of patients on PCA in each epoch are obtainable from Figure 2 and not shown here to maintain simplicity). ** $P < 0.01$





