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RESEARCH ARTICLE

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Effect of caudal nalbuphine on postoperative emergence agitation in pediatrics undergoing infra-umbilical surgeries: Randomized double-blind study

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ABSTRACT

Background Postoperative agitation is characterized by increased recovery time, irritability, and disorientation. This study hypothesized that adding nalbuphine to caudal bupivacaine could improve postoperative emergence agitation (EA). Methods Eighty children (2-12 years and ASA I-II) undergoing sub-umbilical abdominal surgeries were randomly allocated into two equal groups. Group-B received caudal bupivacaine 0.125 of 1 ml/kg plus 2 ml normal saline, whereas Group-N received caudal bupivacaine 0.125 of 1 ml/kg plus 0.2 mg/kg nalbuphine diluted in 2ml normal saline. We evaluated postoperative EA according to the pediatric anesthesia emergence delirium scale (PAED) on admission to the PACU and every 30 minutes for two hours postoperatively. Postoperative pain, sedation, rescue analgesia complications, and parents' satisfaction were also recorded. Results No statistically significant difference between both groups regarding the postoperative PAED scale at different times ($p > 0.05$), but inside each group, there was a significant decrease PAED scale at different times of assessment ($p < 0.001$) as compared to baseline data. Group-N had significantly better results concerning postoperative sedation and analgesia. No significant differences between study groups as regardingthe hemodynamic parameters. Group-N had a significantly prolonged time to 1st analgesic request, lower total rescue analgesia consumption, and more parents' satisfaction scores. No serious adverse effects were recorded during the study. Conclusion Adding nalbuphine to bupivacaine during pediatric caudal block had no significantly different effects on postoperative EA (PAED score). Both drugs decreased the incidence of EA with less severity in the nalbuphine group. Nalbuphine also decreases postoperative pain with more sedation.

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Caudal Block; Nalbuphine; Emergence agitation; Postoperative; Pediatrics

1. Introduction

Postoperative agitation, also known as emerging delirium, is characterized by increased recovery time in the post-anesthesia care unit (PACU), mental perplexity, impatience, and disorientation [1]. The largest incidence of agitation occurs within the first 30 min following emergence; its duration is often short, and recovery happens on its own. However, extended fits of agitation lasting up to 48 h have been reported [2]. It might cause issues with eating or sleeping, lethargy, and new-onset separation anxiety [3].

A conclusive reason for emergence agitation (EA) is not known. Numerous factors have been put up, including a child's personality, premedication, quick reawakening in a new setting, the presence of pain, stressful induction, airway blockage, noisy surroundings, the duration, or technique of anesthesia employed, and many others [4].

EA has been successfully treated with a variety of drugs, including ketamine, propofol, clonidine, midazolam, and fentanyl. However, these drugs could prolong anesthesia-induced drowsiness, slow awakening, and occasionally be linked to unpleasant side effects like nausea and vomiting [5].

A synthetic opioid receptor agonist and antagonist, nalbuphine has a plasma half-life of 5 h and begins to work within 2–3 min of IV infusion. Its duration of analgesia is 3–6 h. Its analgesic potency is comparable to morphine, although nalbuphine has less impact on the circulatory and respiratory systems, causing less frequent and intense blood pressure drops and respiratory depression. Nalbuphine was used by IV route only for decreasing emergence agitation in adults and pediatrics [6].

In patients having abdominal or lower-limb surgery, caudal epidural analgesia is a dependable and secure approach that can be utilized with general anesthesia for intraoperative and postoperative analgesia.

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Additionally, it is simple to perform on younger kids. The primary drawback of caudal anesthesia is its limited duration of effect following a single local anesthetic injection. Only 4–8 h of analgesia are provided by even long-acting local anesthetic medications like bupivacaine. Prolongation of caudal analgesia using a "single-shot" technique has also been achieved by the addition of various adjuvants [7].

This study hypothesizes that adding nalbuphine to caudal bupivacaine block improves postoperative emergence agitation in pediatrics undergoing infra-umbilical surgeries.

2. Materials and methods

This prospective randomized placebo-controlled double-blind study was conducted at Assiut University Hospital after approval from the Institutional Ethics Committee (IRB17101501 on 9 June 2021) and obtaining written informed consent from parents of all children scheduled for sub-umbilical abdominal procedures under general anesthesia. This study was registered in ClinicalTrials.gov before the enrollment of patients under the number NCT05245721 on 18 February 2022.

3. Patients

Eighty children between 2 and 12 years, ASA physical state I-II undergoing sub-umbilical abdominal surgeries were included. Exclusion criteria included parents' refusal, congenital anomalies at the spine or meninges, increased intracranial tension, infection at the site of injection, bleeding disorders, and history of allergy to any drug used in the study.

3.1. Randomization and blindness

Patients were divided into two equal groups (40 children in each group) after a random number sequence was generated by a computer program: Group B (control group) received caudal analgesia using bupivacaine 0.125 of 1 ml/kg plus 2 ml normal saline (NaCl 0.9%). Group N (nalbuphine group) received caudal analgesia using bupivacaine 0.125 of 1 ml/kg plus 0.2 mg/kg nalbuphine diluted in 2 ml normal saline (NaCl 0.9%). The research medicines were made in identically coded syringes by an anesthesiologist who was not involved in the study protocol or data collection. Access to these codes was only available to one anesthesiologist who prepared the syringes according to the study drugs used. To ensure double-blinding, the anesthetic technique and the outcome data were collected by an anesthesiologist not included in preparing study drugs or envelope coding. The surgeons and the parents were blinded to the drug grouping of all children as well.

4. Study protocol

4.1. Anesthetic technique

All procedures were carried out by the same surgical team under the same anesthetic protocol. All children underwent standardized general anesthesia (GA) with 6–8% sevoflurane for inhalational induction, a face mask of the appropriate size, and 100% O_2 flow. The electrocardiogram (ECG), pulse oximetry (SpO_2), non-invasive mean arterial blood pressure (MAP), end-tidal carbon dioxide ($EtCO_2$), and temperature probe were all used for intraoperative monitoring. After GA was induced, an intravenous (IV) cannula Gauge 22 was inserted. A properly sized endotracheal tube (ETT) was inserted and fastened, utilizing an Ayre's T-piece circuit for assisted ventilation to keep $EtCO_2$ at 35 ± 5 mmHg. GA was kept at 100% O_2 and 2–4% sevoflurane. Before making a skin incision, the appropriate antibiotic was intravenously delivered.

5. Caudal block

For a blind caudal epidural block, the patient was positioned in the lateral decubitus posture after ETT insertion. Under fully aseptic conditions, a needle is put in the sacral hiatus at a 45-degree angle to the sacrum and is redirected if it contacts the posterior surface of the sacral bone. One's own subjective experience of "give" or "loss of resistance" points to the sacrococcygeal ligament as a potential target [8], yet even with skilled hands, has a miss rate of up to 26% [9]. The "whoosh test," which involves injecting 2 ml of air while using a stethoscope to auscultate

the thoracolumbar area [10], has a sensitivity of 80% and a specificity of 60% [11].

After administering caudal analgesia for 20 min, the surgical incision began. If there was insufficient analgesia (detected by a 20% increase in heart rate (HR) and/or mean arterial pressure (MAP) above their baseline values), 1 µg/kg of IV fentanyl was administered, and the child was disqualified from the research. A 20% intraoperative drop in HR or MAP from baseline values was identified and promptly managed. After the surgery was finished, the patient was extubated after assuring good endotracheal and oropharyngeal suction, and the patient was sent to the PACU.

6. Assessment parameters

6.1. Primary outcome

The effect of nalbuphine caudally on postoperative emergence agitation according to the pediatric anesthesia emergence delirium scale (PAED) on arrival to the PACU and every 30 min for 2 h postoperatively. This scale is made up of five items (behaviors). The answers to each item on the scale had been converted into

scores. The scores were added together to provide a total score with a maximum score of 20, and the degree of agitation was correlated with the total score. The higher the score, the more agitated the kid was [12].

7. Secondary outcomes

Heart rate (HR) and mean arterial pressure (MAP) were measured before induction of anesthesia, after caudal block by 5, 10, 15, 30, 45, 60, 90, and 120 min.

Postoperative sedation was assessed immediately after recovery, after 30, 60, 90, and 120 min using Richmond Agitation-Sedation Scale (RASS) [13]. The patient was observed: if the patient was alert and calm (score 0)? Did the patient have behavior that was consistent with restlessness or agitation (score +1 to +4) using the listed criteria? If the patient was not alert or sedated (score −1 to −5)?

Postoperative pain was assessed in PACU for 24 h using the Modified Children's Hospital of Eastern Ontario Pain Scale (modified CHEOPS) [14]. Children having the modified CHEOPS ≥ 5 received 15 mg/kg of IV paracetamol as an additional analgesia.

The duration until the first dosage of rescue analgesia and the total amount administered during the first 24 h postoperatively were noted.

A 5-point Likert scale [15] was used to assess the parents' satisfaction regarding the entire procedure at the end of the postoperative 24 h. It ranged from (1 = very satisfied, 2 = satisfied, 3 = neither satisfied nor dissatisfied, 4 = dissatisfied, 5 = very dissatisfied). When all children were well with good feeding, they were sent home.

Complications: Any adverse effects from the drugs used during the current study or from the regional technique itself were reported and managed immediately.

7.1. Statistical methods

7.1.1. Power calculation

The computation of the sample size was based on the prior literature, where the incidence of postoperative EA in children ranged from 10% to 80% [2,16,17] and intervention that could cause a 50% reduction of its incidence was noteworthy. With a power of 90% and type I error of 5%, each group needed 36 patients (0.05% and 90% accuracy). However, the number of children in each group was increased up to 40 to prevent potential sample loss (dropouts) during the trial.

7.2. Statistical tests

The researcher checked, coded, and ran analyses on the data using IBM-SPSS/PC/VER 24's Statistical Package for Social Sciences. Descriptive statistics: Means, standard deviations, medians, ranges, and percentages were calculated. Test of significances: Chi-square test was used to compare the difference in frequency distribution among different groups. Shapiro–Wilk test was used to

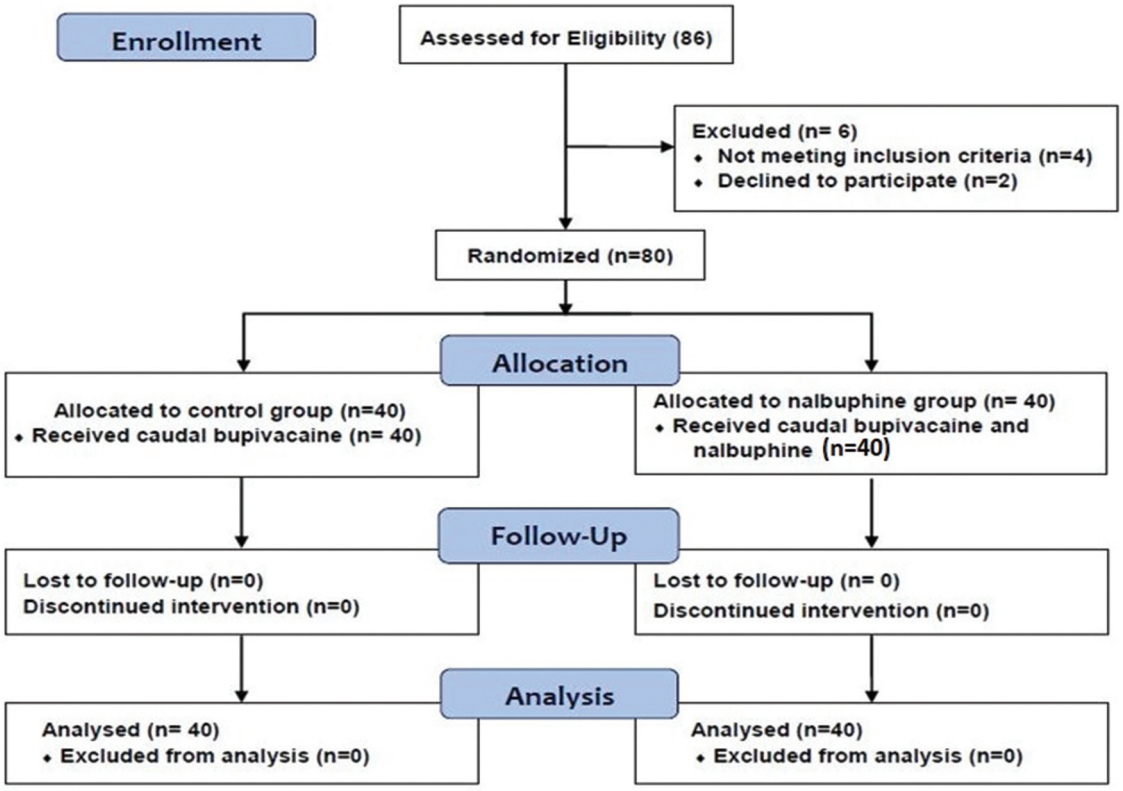

Figure 1. concort flow chart of the study groups.

Table 1. Demographic and clinical data of the studied groups.

Variable	Group B ($n = 40$)	Group N ($n = 40$)	P-value
Age/years	4.75 ± .5	4.60 ± .4	= 0.807[a]
Sex			= 0.431[b]
• Male	32 (80%)	29 (72.5%)	
• Female	8 (20%)	11 (27.5%)	
Anthropometric Measures			
• Weight/kg	16.90 ± 6.3	16.28 ± 6.1	= 0.653[a]
• Height (cm)	104.05 ± 15.2	103.73 ± 12.4	= 0.917[a]
• BMI	15.08 ± 1.7	14.57 ± 1.6	= 0.182[a]
ASA			
• ASA-I	37 (92.5%)	39 (97.5%)	= 0.308[c]
• ASA-II	3 (7.5%)	1 (2.5%)	
Type of Operation			= 0.897[d]
• Hernia	13 (32.5%)	5 (12.5%)	
• TA Pull-through	4 (10%)	23 (57.5%)	
• Hypospadias	23 (57.5%)	8 (20%)	
• Undescended Testis	0 (0%)	4 (10%)	
Duration of Anesthesia/minutes	87.01 ± 14.6	82.38 ± 1.9	=.464[a]
Duration of Operation/minutes	75.73 ± 15.1	7.75 ± 13.9	=.444[a]

Data were presented as mean ± SD, number of patients, and percentages.
p value < 0.05 was considered as significant.
[a]Independent t-test was used to compare differences in means between groups.
[b]Chi-square test was used to compare differences in frequency between groups.
[c]Fisher's exact test was used to compare differences in frequency between groups.
[d]Monte Carlo exact test was used to compare differences in frequency between groups.

test for data normality. Student t-test/Mann–Whitney U-test was calculated to test the mean/median differences in continuous variables between groups. The two-way repeated measure ANOVA test was calculated to test the mean differences of the data that follow a normal distribution and had repeated measures (between groups, within groups, and overall difference). P-value <0.05 was considered significant.

8. Results

The current study was conducted at Assiut University Hospitals between March 2022 and October 2022. Among the 86 pediatric patients scheduled for infra-umbilical surgeries, 6 patients were excluded (4 did not meet the inclusion criteria and 2 declined to participate). Finally, 80 patients continued the follow-up and analysis. The CONSORT Flow chart of the study participants was shown in (Figure 1).

9. Demographic and clinical data of the studied groups

Both study groups had no statistically significant differences regarding age, sex, weight, height, and body mass index BMI (Table 1).

Table 2. Postoperative PAED agitation scale comparisons between groups.

		Group B ($n = 40$)	Group N ($n = 40$)	P-value
PAED Agitation Scale Score				
• Baseline		9.58 ± 1.1	9.45 ± .9	=.582 a
• 30-min		5.48 ± .5	5.60 ± .5	= 0.268[a]
• 60-min		1.50 ± .5	1.53 ± .5	= 0.826[a]
• 120-min		.03 ± .2	.01 ± .01	= 0.320[a]
P-value[b]		<.001	<.001	$P = 0.595$[c]
PAED Category				
• Baseline	o No	22 (55%)	22 (55%)	
	o Agitated	13 (32.5%)	16 (40%)	= 0.450[d]
	o Severe	5 (12.5%)	2 (5%)	
• 30-min.	o No	40 (100%)	40 (100%)	NA
• 60-min.	o No	40 (100%)	40 (100%)	
• 120-min.	o No	40 (100%)	40 (100%)	

Data were presented as number of patients and percentage.
P values < 0.05 was considered as significant. NA=Not Applicable.
[a]Mean differences between Group Comparison.
[b]Mean differences within Group Comparison.
[c]Two-way Repeated Measure ANOVA was used to compare the mean differences over time.
[d]Chi-square analysis was used to compare the frequency among groups.

Table 3. Comparison of postoperative RASS score between study groups.

RASS Score	Group B ($n = 40$)	Group N ($n = 40$)	P-value[a]
• Baseline	−2.43 ± .5	−3.15 ± .8	<.001
• 30-min.	−.40 ± .1	−.78 ± .4	<.001
• 60-min.	0 ± 0	0 ± 0	NA
• 120-min.	0 ± 0	0 ± 0	NA
P-value[b]	<.001	<.001	$P < 0.001$[c]

Data were presented as mean ± SD. P values < 0.05 was considered as significant.
[a]Mean differences between Group Comparison.
[b]Mean differences within Group Comparison.
[c]Two-way Repeated Measure ANOVA was used to compare the mean differences over time.

Table 4. Comparison of postoperative m-CHEOPS score between groups.

m-CHEOPS Score	Group B ($n = 40$)	Group N ($n = 40$)	P-value[a]
Baseline	.45 ± .1	.35 ± .1	=.368
30-min.	1.40 ± .5	1.08 ± .4	=.022
60-min.	2.75 ± .7	2.40 ± .5	=.015
120-min.	3.33 ± .5	3.33 ± .5	= 1.000
6 hours	5.08 ± .9	3.63 ± .5	<.001
12 hours	4.43 ± .5	5.08 ± .8	<.001
18 hours	4.18 ± .5	4.18 ± .5	= 1.000
24 hours	3.90 ± .4	4.00 ± .3	=.251
P-value[b]	<.001	<.001	$P = 0.027$[c]

Data were presented as mean ± SD. P values < 0.05 was considered as significant.
[a]Mean differences between Group Comparison.
[b]Mean differences within Group Comparison.
[c]Two-way Repeated Measure ANOVA was used to compare the mean differences over time.

Both groups showed insignificant statistical differences as regards the ASA status, type of operation, duration of operation, and duration of anesthesia (Table 1).

10. Postoperative PAED agitation scale comparisons between groups

There was no statistically significant difference between both groups regarding the postoperative PAED agitation scale assessment and its category at different times ($p > 0.05$), but inside each group, there was a statistically significant decrease in the postoperative PAED scale at different times of assessment ($p < 0.001$) as compared to the baseline data (on admission to the PACU) (Table 2).

On arrival at PACU, there were 22 non-agitated patients in group B, and the same number was in group N, 13 agitated in group B and 16 agitated in group N, 5 severely agitated in group B, and 2 severely agitated in group N, with no agitated patients at other different times (Table 2).

11. Postoperative RASS score comparisons between groups

The nalbuphine group had significantly lower RASS scores (more sedated patients) at immediate postoperative (−3.15 ± 0.8 vs. −2.43 ± 0.5; $p < 0.001$) and after 30-min (−0.78 ± 0.4 vs. −0.40 ± 0.1; $p < 0.001$), but there were no statistically significant differences between both groups at 60 and 120 min postoperatively. Inside each separate group, there was a statistically significant improvement in postoperative RASS values at different times of assessment ($p < 0.001$) in both groups (Table 3).

Table 5. Distribution of study groups according to postoperative outcomes.

Variables	Group B ($n = 40$)	Group N ($n = 40$)	P-value
Time to Recovery/min	8.98 ± 1.1	9.23 ± 1.2	= 0.340[a]
Time to 1st Analgesia/h			
• Mean ± SD	7.08 ± 1.3	11.00 ± .8	<0.001[b]
• Median (Range)	7 [6] - [12]	11 [10] - [12]	
Total Analgesic Dose – paracetamol (mg)			
• Mean ± SD	625.01 ± 333.7	432.92 ± 225.3	= 0.020[c]
• Median (Range)	495 (210–1300)	390 (165–1125)	
Parents' Satisfaction			
• V. Satisfied	19 (47.5%)	28 (70%)	
• Satisfied	19 (47.5%)	10 (25%)	= 0.097[a]
• Neutral	2 (5%)	2 (5%)	

Data were presented as mean ± SD, number of patients, and percentages.
p value < 0.05 was considered as significant.
[a]Chi-square test was used to compare differences in frequency between groups.
[b]Independent t-test was used to compare differences in means between groups.
[c]Mann Whitney U test was used to compare Median between groups.

12. Postoperative m-CHEOPS score comparisons between groups

It was found that group N had significantly postoperative lower m-CHEOPS scores only at 30 min (1.08 ± 0.4 vs. 1.40 ± 0.5; p = 0.022), 60 min (2.40 ± 0.5 vs. 2.75 ± 0.7; p = 0.015), 6 h (3.63 ± 0.5 vs. 5.08 ± 0.9; p < 0.001). Group N had significantly higher m-CHEOPS score 12 h postoperatively (5.08 ± 0.8 vs. 4.43 ± 0.5; p < 0.001). Inside each group, there was a statistically significant difference in postoperative *m*- CHEOPS score values when compared to the baseline values (on admission to PACU) at different times of assessment with p < 0.001 (Table 4)

13. Postoperative outcomes between study groups

13.1. Time to recovery

There was no statistically significant difference between both groups regarding the time to recovery with a p-value of 0.340. It was 8.98 ± 1.1 and 9.23 ± 1.2 min in groups B and N, respectively (Table 5).

14. Postoperative analgesia-related factors

It was found that the nalbuphine group had a significantly prolonged time to first analgesic request postoperatively (11.00 ± 0.8 vs. 7.08 ± 1.3 h; p-value <0.001), with lower total rescue analgesic dose consumption (432.92 ± 225.3 vs. 625.01 ± 333.7 mg; p-value = 0.02) when compared to the control group (Table 5).

15. Parents' satisfaction

There was no statistically significant difference between the study groups ($p = 0.097$). There were 28 parents (70%) with very satisfying results and 10 parents (25%) with satisfied results in comparison to 19 parents (47.5%) and 19 parents (47.5%) in group B. Both groups had two (5%) neutral-satisfied parents. No parents were dissatisfied with the study results (Table 5).

There were no statistically significant differences between both groups regarding intraoperative and postoperative HR assessment at different study times ($p > 0.05$). Regarding intraoperative MBP, there were no statistically significant differences between both groups. Conversely, there was a significant increase in postoperative MBP at different times of assessment ($p < 0.05$). No serious adverse effects were recorded during the whole study's observational periods resulting from the used techniques or the study drugs administered.

16. Discussion

One of the most important regional blocks in pediatrics is the caudal block. The majority of surgeries conducted below the umbilicus, including urogenital, rectal, inguinal, and lower extremity surgeries, employ this technique. However, emergent agitation (EA) after anesthesia is very common in children. The bulk of EA in young children happens while they are just beginning to wake up from anesthesia [5,16]. Unending sobbing, anxiety, restlessness, hallucinations, and bewilderment are hallmarks of emergent agitation [18]. To the best of our knowledge, many studies have used caudal nalbuphine for postoperative analgesia in pediatrics with no or very few evidence about emergence agitation.

Even though EA is self-limiting, it can still cause problems for kids, including self-harm, bleeding and incision breakage, falling off the indwelling catheter, and tumbling off the bed. These issues may be challenging for medical professionals, and as a result, family members may feel extremely anxious [19,20]. Moreover, children with EA are more likely to experience behavioral changes during hospitalization, and these changes may last longer [21]. Treatment of EA also adds to the medical staff workload and patient medical expenditures [16].

Our results showed no statistically significant differences between both groups as regards the PAED agitation scale assessment and its category at different times. Inside each group, there was a statistically significant decrease in the postoperative PAED scale at different times of assessment as compared to the baseline data (on admission to the PACU)

Zhao et al. (2018) investigated the difference between saline and nalbuphine by intravenous route. It was conducted on 84 pediatric patients undergoing dental surgery to evaluate the efficacy and safety of intravenous nalbuphine 0.1 mg/kg for emergent agitation. They assessed the agitation using the AONO scale and similar to our findings, nalbuphine decreased the incidence of EA. They reported that the nalbuphine group was statistically significantly associated with decreased agitation. In contrast to our findings, they showed that higher score of EA was statistically significant associated with the saline group more than the nalbuphine group. This difference can be attributed to the difference in the route of administration as it was given by intravenous route, not the caudal route [22].

Similar to our findings, some researchers looked at how nalbuphine affected children having adenotonsillectomy-related emergence agitation (EA). Eight hundred patients between the ages of 3 and 9 who were undergoing elective adenotonsillectomy and were classified as I or II by the American Society of Anesthesiologists (ASA) participated in a multicenter, prospective, double-blind, randomized controlled

experiment. Participants were divided into two equal groups, the first taking Nalbuphine (0.1 mg/kg) and the second taking saline intravenously. They concluded that emergence agitation was significantly lower in patients taking nalbuphine [23].

We found that the nalbuphine group had significantly lower postoperative pain scores (m-CHEOPS score) when compared to the control group. Caudal nalbuphine had a significantly prolonged time to the first analgesic request postoperatively, with lower total rescue analgesic dose consumption during the first postoperative day.

Mohamed et al. carried out a similar study to assess the caudal anesthesia effects of bupivacaine alone versus nalbuphine. Forty patients scheduled for surgeries were divided into two groups: in group B, patients received a caudal injection of bupivacaine 0.25% in a dose of 1 ml/kg, and in group NB, they received a caudal injection of bupivacaine 0.25% 1 ml/kg with nalbuphine 0.1 mg/kg. They used the AIIMS pain discomfort scale to assess the difference in pain score between both groups. Similar to our findings, pain score was reported to be significantly lower in the nalbuphine group 4, 6, and 12 h postoperatively [24].

In our study, postoperative sedation was evaluated using Richmond Agitation-Sedation Scale (RASS). We found that the nalbuphine group was statistically significantly associated with lower RASS values (more sedation) compared to the other group, especially in the first 30 min postoperatively with no serious effects.

Another study was conducted by Akheela and Chandra. One hundred and eighty patients who were undergoing elective laparoscopic cholecystectomy under general anesthesia participated in this prospective, randomized research. Patients were split into two groups, A (nalbuphine) and B (fentanyl). They reported that the RASS score was significantly lower in the nalbuphine group. Following the administration of the study medicine, the RASS scores were correspondingly −2, −1, and 0 in 18.9%, 21.1%, and 60% of the patients in group A and 20%, 18.9%, and 61.1% of the patients in group B. There wasn't a significant difference. After extubation, 54.4% of patients in the nalbuphine group had a RASS score of −2, while none of the patients in the fentanyl group had reached this score. This difference between groups was statistically significant ($p < 0.0001$) [25].

Also, Mohamed et al. carried out the study to compare the effect of bupivacaine alone and with nalbuphine in caudal anesthesia. They reported that the sedation score was significantly higher in the nalbuphine group, indicating more sedation which is in agreement with our findings [24].

Our study showed no significant differences in hemodynamic parameters including heart rate and mean blood pressure between both study groups either intraoperatively or during the 2 h postoperatively.

A similar study was conducted by Murthy et al., a prospective, double-blind, randomized study. Sixty kids between the ages of 1 and 12 were divided into two groups at random; Group A received a caudal block with 0.2% ropivacaine 1 ml/kg along with 0.2 mg/kg of nalbuphine, and Group B received a caudal block with 0.2% ropivacaine 1 ml/kg together with 2 g/kg of dexmedetomidine. This study showed that there was no statistically significant difference in hemodynamic parameters between both groups. All patients were stable hemodynamically throughout the whole study period [26].

He et al. reported no statistically significant difference between both groups regarding oxygen saturation which is similar to our observations. They reported no statistically significant difference was found between both groups regarding hemodynamic parameters, which is similar to our findings [23].

Also, Mohamed et al. reported no statistically significant difference regarding hemodynamic parameters. They reported no statistically significant difference between the two study groups concerning HR and MAP at different times [24].

Akheela and Chandra showed that hemodynamic parameters were different from our findings. The starting HR was similar between the groups. Five minutes after the study drug was administered, HR in the group B (fentanyl) was considerably lower than in the group A (nalbuphine) ($p = 0.015$). Immediately upon intubation, HR was discovered to be greater in group A compared to group B ($p = 0.016$), which was statistically significant. However, HR was comparable between the groups thereafter ($p > 0.05$). Between the groups, the basal MAP was comparable. Although MAP decreased in both groups, it was noticeably lower in group B than in group A. Although both groups experienced a rise in MAP just after intubation, group A experienced a statistically significant ($p = 0.001$) greater MAP compared to group B. After that, the MAP values between the groups were comparable [25].

17. Conclusions

The addition of nalbuphine to bupivacaine during caudal block in children undergoing infra-umbilical surgeries who were maintained on isoflurane inhalational anesthesia had no significant different effects on emergence agitation score (PAED). Both drugs decreased the incidence of postoperative emergence agitation with less severity in the nalbuphine group.

Nalbuphine significantly decreases the postoperative pain with few sedation. No serious adverse effects were recorded during the whole study period with stable hemodynamic parameters in all participants.

The limitations of this study included that it was a single-center study that may have resulted in different findings than elsewhere. A larger sample size may be needed to validate our results. Also, the study didn't utilize different concentrations or volumes of the used drugs to determine the appropriate doses needed. The study didn't investigate the role of sevoflurane which is the most commonly used drug in pediatric anesthesia with a higher incidence of emergence agitation.

We recommend further studies with large sample sizes to compare findings, validate our results, and confirm the safety of the used drugs. We also recommend further studies including the comparison between different concentrations and volumes.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Mohamed F. Mostafa: The author participated in the design and conduct of the study, data collection, and writing the manuscript. H.A. Youssef: The author participated in the design and conduct of the study, data analysis, and critical supervision. Rehab okely: The author participated in the design and conduct of the study, data collection. Ahmed Aboulfotouh: The author participated in the conduct of the study, data analysis, and writing the manuscript.

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