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Blockade of thoracoabdominal nerves through perichondrial approach (TAPA) versus transversus abdominis plane block (TAP) for postoperative analgesia in pediatric abdominal surgeries: A randomized controlled trial

Ahmed M. El Aidy
Assistant lecturer of Anesthesia, Surgical Intensive Care and Pain Management, Faculty of Medicine, Mansoura University, Mansoura, Egypt
*Corresponding author email: a_m_elaidy88@mans.edu.eg

Amer A. Attia
Professor of Anesthesia, Surgical Intensive Care and Pain Management, Faculty of Medicine, Mansoura University, Mansoura, Egypt

Eiad A. Ramzy
Professor of Anesthesia, Surgical Intensive Care and Pain Management, Faculty of Medicine, Mansoura University, Mansoura, Egypt

Nevert A. Abdel Ghaffar
Assistant Professor of Anesthesia, Surgical Intensive Care and Pain Management, Faculty of Medicine, Mansoura University, Mansoura, Egypt

***Abstract*---**Background: Inadequate pain control after pediatric abdominal surgery complicates patient recovery and may lead to postoperative respiratory dysfunction. Multimodal analgesia using truncal blocks can be used to achieve better analgesic effect and improves patent outcome. This study aimed to compare the postoperative analgesic efficacy of transversus abdominis plane (TAP) block and thoracoabdominal nerves through perichondrial approach (TAPA) block in pediatric patients undergoing abdominal surgeries. Material and methods: A total of 100 pediatric patients undergoing elective abdominal surgery were randomly allocated equally into two groups intraoperatively where first group received transversus abdominis plane (TAP) block and second group received thoracoabdominal nerves through perichondrial approach (TAPA) block. Results: Patients in both groups showed statistically

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comparable (P > 0.05) stable hemodynamic characteristics during intraoperative period. Also, patients in both groups showed no statistically significant difference difference (P > 0.05) in the analgesic parameters including time to first analgesic request and postoperative pain score. Conclusion: Both TAP and TAPA blocks are equally effective in managing pain after abdominal surgery in pediatric population.

***Keywords*---**truncal blocks, pediatric abdominal surgery, postoperative pain, multimodal analgesia, TAP block, TAPA block, ultrasound.

Introduction

Postoperative pain management for pediatric abdominal surgery can reduce postoperative respiratory dysfunction (1). Truncal blocks have had a place within multimodal analgesia techniques in abdominal surgery. The application of a transversus abdominis plane (TAP) block has become routine in lower and upper abdominal surgery (2,3). There has always been a quest to discover a regional anesthesia technique that provides effective analgesia of the anterolateral portion of the upper abdomen (4). Blockage of thoracoabdominal nerves through perichondrial approach (TAPA) is a recently described novel regional anesthesia method which potentially provides effective and extensive sensorial block of the thoracoabdominal region (1). To the best of our knowledge, this is the first study that evaluated the analgesic efficacy of TAPA in pediatric patients. This randomized, double-blind, controlled study was designed to compare the postoperative analgesic efficacy of TAP and TAPA in children undergoing abdominal surgery using the number of patients who needed rescue analgesia in the first postoperative 24 h as the primary outcome.

Materials and Methods

This prospective randomized comparative study was conducted on 100 pediatric patients – based on sample size calculation which resulted in 46 patients with expected drop out so the result was 50 patients in each group – undergoing elective lower abdominal surgery at Mansoura University Children Hospital, after being approved by the local Institutional Research Board (proposal code: MD.20.05.323) and conducted between April 2020 to March 2021. The study was registered before the patient recruitment in the panafrican clinical trial registry system (clinical trial identifier: PACTR202110874021535). Written informed and verbal consent were obtained from the parents of all the included children prior to enrollment in this study.

Inclusion criteria were; Pediatric patients of either gender, aged between 1 and 7 years with American Society of Anesthesiologists (ASA) physical status I & II scheduled for elective pediatric lower abdominal surgery. Exclusion criteria were; parental refusal of consent, patients with hyperactive airway disease or respiratory disease, children with developmental delay, mental or neurological disorder, bleeding or coagulation diathesis, history of known sensitivity to the used anesthetics, infection or redness at the injection site. Eligible 100 pediatric patients were randomly allocated to one of two equal groups each contains 50 patients, they were randomized according to the computer-generated table of random numbers using the permuted block randomization method: Either TAP block group (group A), and TAPA block group (group B). In the morning of the day of surgery, the patients were visited by an anesthesiologist and both informed and verbal consents were obtained from their parents after explanation of the type of surgery, anesthetic method.

Before induction of anesthesia, basic monitors were applied including electrocardiography, pulse oximetry and non-invasive BP. All baseline values were recorded. Anesthetic induction protocol was the same in the two groups. All patients received inhalational induction by face mask with 8% sevoflurane in 100% O2, and a peripheral intravenous cannula was inserted into a suitable peripheral vein. LMA connected to capnography was inserted after adequate jaw relaxation achieved by giving propofol (2mg/kg); its size was chosen according to the body weight of the child, fentanyl (1μg/kg) was given. Adequate LMA positioning was checked clinically by chest expansion, equal bilateral breath sounds, and the presence of CO2 wave on capnography with manual ventilation. Anesthesia was maintained with sevoflurane 2% and 50% air in oxygen.

The patients were randomly allocated to one of two equal groups (Table 1) using closed sealed envelope method by one of the anesthetists not included in the study, Each group contains 50 patients where they received the following protocol intraoperatively: In both groups, the patients were placed in the lateral position, and the surgical area was cleaned with povidone iodine, All blocks were performed by the same anesthesiologist after placement of laryngeal mask airway before surgery, A high-frequency ultrasound, using a linear probe covered with a sterile sheath was used.

- *Group A (TAP Block Group):* The probe was placed between the anterolateral abdominal wall and the iliac crest, the external abdominal oblique, internal abdominal oblique, and transversus abdominis muscles were identified, A 22-gauge needle was then inserted using the in-plane technique and was directed from anterolateral to posteromedial toward the TAP after making a negative aspiration test with 0.5mL normal saline to confirm the space with a hypoechoic image and hydrodissection, An injection of 0.5 mL/kg 0.2% bupivacaine was applied between the internal abdominal oblique and the transversus abdominis muscles.
- *Group B (TAPA Block Group):* The probe was placed on the costal margin at the 9th–10th costal cartilage level in the sagittal plane and angled deeply to view the lower aspect of the chondrium centrally, A 22-gauge needle was inserted using the in-plane technique. After making a negative aspiration test with 0.5mL normal saline to confirm the space with a hypoechoic image and hydrodissection, an injection of 0.5 mL/kg 0.2% bupivacaine was applied in two directions; between the chondrium's upper surface and the external oblique, and one between the chondrium's lower surface and the transversus abdominus muscle, both in the interfascial plane.

The operation started 7 to 10 minutes after the block had been applied, all patients were operated on with a standardized technique. any complications occurring during the procedure were recorded. All children received 0.5 mg/kg intravenous ketorolac for analgesia, maintenance fluid therapy was ensured using ringer solution. All patients were monitored for hemodynamic variables (heart rate; HR and mean arterial blood pressure; MAP). These variables were recorded at skin incision, during manipulation of the hernial sac, and at the end of surgery.

At the end of surgery, paracetamol (10mg/kg) was given, sevoflurane was discontinued, the LMA was removed semi-inflated to sweep secretions with it while the patient was still deeply anesthetized, careful suction was applied, then 100% oxygen was administered via face mask with careful observation for any upper airway obstruction, laryngospasm or breath holding. Thereafter, when patent airway and spontaneous respiration without assistance were confirmed, children were transferred to the PACU where their parents were present. Postoperatively; all patients were transferred to the internal ward, where frequent monitoring and assessment were done. Postoperative pain was assessed by FLACC pain score. It is scored in a range of 0 to 10 (0 = no pain and 10 = the worst imaginable pain). Pain was assessed upon arrival to PACU, one, two, four, six, 12, 24 hours after surgery.

- Intra-venous paracetamol (10mg/kg/6h) was given as a background analgesia.
- Intra-venous fentanyl (0.5μk/kg) was given as a rescue analgesia if FLACC score was ≥ 4, or upon the patient request.

Study measurements

Demographic data including age, sex, body weight, ASA and duration of surgery were recorded. The patients' hemodynamics including heart rate and non-invasive mean arterial blood pressure were recorded at baseline before the block, at skin incision, during deep tissue manipulation and at the end of surgery. The time of the first request for analgesia, the total analgesic requirements during the first 24 hours post-operatively, and the total number of patients receiving rescue analgesia were recorded. Satisfaction levels of the parents (or guardians) were given verbally as a level from 1 to 10, with the lowest level of satisfaction at a value of 1 and the highest level at 10.

Statistical analysis

Analysis of data was performed using Statistical package for social science (SPSS) software, version 25 for Microsoft Windows (SPSS Inc., Chicago, iL, USA). Categorical data were reported as numbers and percentages and were analyzed using the chi-square test, or Fisher's exact test if the number of subjects in any contingency table cell was expected to be less than five. Continuous data were checked for normality using the Shapiro-Wilk test. Normally distributed data were presented as means (standard deviations) and were analyzed using an unpaired student t-test. Non-normally distributed data were expressed as medians (interquartile range) and were analyzed using Mann Whitney U test. A p-value of 0.05 or less was considered statistically significant.

Results

Basic demographic data of the studied groups regarding age, sex, body weight and ASA status were presented in (Table 1) with no significant statistical difference between the two groups. There was no significant statistical difference between the two groups regarding duration of surgery as presented in (Table 1). All of the recorded basal and intraoperative heart rates showed no significant statistical difference between the two groups (Table 2). MAP showed no significant differences between the two study groups, neither at baseline nor throughout the operative procedure (Table 3). Rescue analgesia was required in 48% and 42% of cases in Groups A and B respectively. The median time to the first analgesic request was 6 hours [2-24] and 6 hours [1-24] in same two groups respectively. On assessment of parent satisfaction with the pain management modality, it had median values of 7 [6-9] and 7 [5-10] in the same two study groups. All of the previous parameters related to the analgesic profile showed no significant difference between the two groups (Table 4). The two study groups expressed statistically comparable pain scores at PACU and after the operation as presented in (Table 5).

Discussion

Abdominal surgery is associated with varying degrees of incisional and visceral pain that benefits from optimal analgesia in the perioperative period. Effective postoperative analgesia is as important in pediatric patients as it is in adults, due to of the potential benefits of reduced complications, early ambulation, and a shorter hospital stay (5). In major pediatric abdominal surgery, the administration of central neuraxial techniques (epidural or caudal catheter) has become commonplace. However, in some circumstances, a central neuraxial block may be relatively contraindicated (e.g., coagulopathy, post spinal surgeries, and congenital spinal abnormalities) (6). Furthermore, in neonates and infants with increased sensitivity to narcotics (e.g., premature birth or sleep apnea), intravenous opiates may cause hypopnea and apnea. This may lead to the need for re-intubation and prolonged mechanical ventilation (7,8)

Interfascial plane block techniques are frequently used for post- operative analgesia (9) and its effectiveness is increased by ultrasound-guidance (10). There are many studies reporting effective analgesia with TAP blocks in infants, children, and adolescents undergoing any type of lower abdominal surgery (11,12), It provides analgesia to the parietal peritoneum as well as the skin and muscles of the anterior abdominal wall (13). Blockage of thoracoabdominal nerves through perichondrial approach (TAPA) is a recently described novel regional anesthesia method which potentially provides effective and extensive sensorial block of the thoracoabdominal region (1). TAPA block provides sensory block between the midaxillary line and the midabdominal/sternum in T5–T12 dermatomes (10).

The current study was conducted at Mansoura University Children Hospital aiming to compare postoperative analgesic effect of TAP and TAPA in pediatric abdominal surgery. To the best of our knowledge, no previous study has handled this comparison in the existing literature. On looking at preprocedural parameters, one could notice no significant difference between the two study groups. This indicates our proper randomization. Besides, this should nullify any bias that might have skewed results in favor of one group rather than the other one. Our findings showed that TAB block was successful in maintaining pain scores below four in most cases during the initial 24 hours after surgery. The first analgesic request was required after 10.17 hours, and rescue analgesia was successfully managed by a single dose of fentanyl (0.5μg/kg) given only once. Parent satisfaction had a mean value of 7.6 out of 10 on the used score.

The first report of substantial clinical efficacy emerged in 2006, when O'Donnell et al. coined the term 'transversus abdominis plane (TAP) block' and presented a case series of 12 consecutive radical prostatectomy patients (14). The following year, a randomized, controlled trial showed that TAP blocks improve pain scores and decrease opioid requirements in colon surgery as compared to standard care (15). Later in 2007, Hebbard et al. described an ultrasound-guided TAP block technique and then went on in 2008 to report a variant approach to the TAP block to specifically target upper abdominal dermatomes (16,17). Similar outcomes have been observed in pediatric studies (6,18,19), and analgesia after TAP block in pediatric patients is thought to last 15 to 24 hours (20). There are case series reporting the efficacy and safety of this analgesia technique in patients undergoing inguinal hernia surgery and appendectomy (21,22).

In another study by Karnik et al., the authors compared ultrasound-guided bilateral TAP block with local infiltration during pediatric laparoscopic surgeries and found that TAP block is superior to local infiltration for intra- and immediate postoperative analgesia in pediatric laparoscopic surgeries (23). In another study carried out by Bergmans et al., a prospective service evaluation was done to assess the quality of pain control after preoperative TAP block in 100 children undergoing abdominal surgery and concluded that TAP block may eliminate the need for intravenous (IV) opioids (24). All of the previous studies agree with our findings regarding the efficacy of TAB block in pain control after pediatric abdominal surgeries.

In the same context, other authors confirmed the efficacy of TAP block in pediatric abdominal operations. Their findings suggest that a TAP block provides analgesia equivalent to that provided by a caudal block and there is no significant difference between these 2 methods in terms of analgesic consumption; TAP blocks could be used an alternative to caudal blocks in patients undergoing lower abdominal surgery for reducing both pain scores and 24-hour morphine consumption (15,25). When it comes to the efficacy of TAPA block in our study, it yielded an excellent analgesic profile which was comparable with the TAP block. Both groups expressed statistically comparable pain scores, first analgesic request, rescue analgesic need, and parent satisfaction. The TAPA block provides its analgesic effect via large sensorial block between Th5 and Th12 dermatomes by blocking the lateral cutaneous and anterior cutaneous branches before they enter the interfascial plane between the abdominal muscles. (9)

Tulgar and his colleagues performed this on three adult patients, two of them underwent laparoscopic cholecystectomy, while the remaining case underwent laparoscopic incisional hernia repair. All three patients were ASA 2 and all were administered Paracetamol 1 g and tenoxicam 20 mg IV perioperatively. NRS was < 3/10 for 13h in patients 1 and 3 and for 9h in patient 2 with no additional analgesia. (1). Tanaka et al. reported efficacy of the same management technique in a 29-month-old pediatric patient who underwent open nephrectomy for Wilms tumour. No rescue analgesic drugs were needed. His Wong-Baker Faces Pain Rating Scale (range 0–10) score remained ≤2/10 until the 24th hour after surgery, indicating little to no postoperative pain, and notably, according to his mother, he was able to complain of pain in daily life. Finally, he moved to the pediatric ward in order to receive chemotherapy on postoperative day 7. This case has demonstrated that TAPA leads to successful and effective postoperative analgesia in pediatric abdominal surgery (26).

ErtÜRk and Ersoy compared the postoperative analgesic efficacy of TAPA and m-TAPA blocks in patients who underwent laparoscopic cholecystectomy. The TAPA group had significantly longer block application times than the m-TAPA group. At 1 and 12 hours, NRS scores were lower in the TAPA group. However, the mean NRS scores, total tramadol use, and use of additional analgesics were comparable between the groups. TAPA and m-TAPA block methods reduced NRS scores by alleviating pain after laparoscopic cholecystectomy procedures, thereby reducing the need for additional analgesics. Block times for TAPA were significantly longer than those for m-TAPA. However, both block applications were completed in a short period, smoothly and safely (10). The first report of TAPA being used as the sole surgical anesthesia technique stated its efficacy after failed erector spinae block in a 58-year-old male with end-stage chronic obstructive pulmonary disease presented with acute cholangitis and pericholecystic abscess. A total of 30 mL of local anesthetic (20 mL bupivacaine %0.5 and 10 mL lidocaine 2%) was administered to both the upper and lower aspects of the chondrium. After 30 min, sensorial block at Th6 to Th11 dermatome levels was determined with pinprick test. A seven cm incision was performed at the anterior subcostal region to reach the pericholecystic area. The surgery lasted 35 min with no complications. There was no need for additional sedatives during surgery (9).

Our findings showed that both block techniques have a statistically comparable analgesic profile after abdominal surgeries in the pediatric population. Either of the two procedures is recommended to be applied in such population according to the physician experience and preference. Another point to be discussed is the number of patients requiring rescue analgesics. It was 92% and 98% in Groups A and B respectively. The high incidence of this need does not necessarily reflect the weak analgesic profile of the blocks. First of all, the applied pain score was a subjective one, which could have some fallacies in our study. Also, both blocks are effective in managing parietal pain, not the visceral one, and that could explain their extra need for analgesic. Finally, all pain episodes were managed by a single dose of fentanyl (0.5μg/kg) given only once, and that could also refer to the analgesic effect of the block. Our study has some limitations. It included a relatively small sample size that was collected from a single institution. Therefore, more studies including more cases from different pediatric surgical centers should be conducted in the near future.

Conclusion

Based on the results of our study, it could be included that both TAP and TAPA blocks are equally effective in managing pain after abdominal surgery in the pediatric population

Declarations

Conflict of interest

The authors declare no competing interests.

Ethical approval

Ethical approval was obtained from Institutional Research Board with code number (MD.20.05.323).

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Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon request.

Registration of research studies

Panafrican clinical trial registry system (clinical trial identifier: PACTR202110874021535)

Disclosure of interest

The authors repot no financial or non-financial conflicts of interest in this work.

Consent for publication

Written informed consent was taken from all patents before enrollment in this study.

Provenance and peer review

Not commissioned, externally peer reviewed.

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Figures

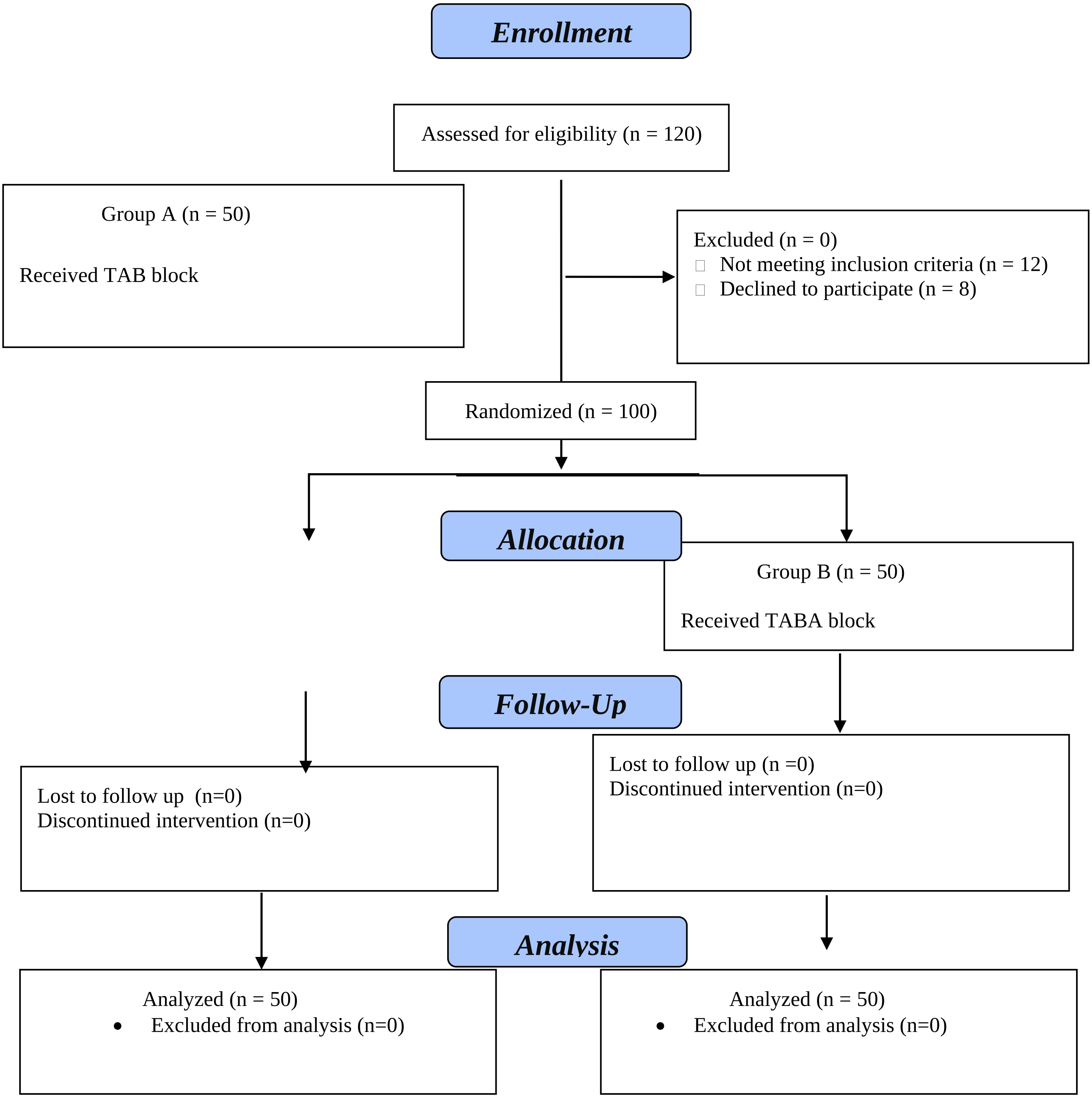

Figure 1. Consort flow diagram of the studied groups

Tables

Table 1
Basic demographic, clinical data and surgical data of the cases in the study groups. Data are expressed as mean ± SD and number %

*P value ≤ 0.05 is significant

		Group A (n=50)		Group B (n=50)		P value	CI
Age (years)		4.77 ± 1.32		4.64 ± 1.45		0.94	-0.5, 0.6
Gender	Male	30	60 %	23	46%	0.16	
	Female	20	40 %	27	54%		
Weight (kg)		16.54 ± 3.21		16.37 ± 3.03		0.85	-1.1,1.4
ASA	1	48 (96%)		47 (94%)		0.64	
	2	2 (4%)		3 (6%)			
Duration of surgery (minutes)		34.76 ± 6.11		34.56±6.10		0.87	-2.2,2.6

Group A: TAP block group
Group B: TAPA block group

Table 2
Heart rate (beat/min) of the cases in the study groups at different times. Data are expressed as mean ± SD

Heart rate	Group A (n=50)	Group B (n=50)	P value	95% CI
Basal	109.12 ± 8.99	106.80 ± 13.98	0.33	-2.4 , 7
Skin incision	112.08 ± 9.24	111.32 ± 14.07	0.75	-4 , 5.5
Surgical manipulation	111.44 ± 9.30	109.02 ± 14.56	0.32	-2.4 , 7.3
End of surgery	110.98 ± 10.09	107.36 ± 14.44	0.15	-1.3 , 8.6

*P value ≤ 0.05 is significant
Group A: TAP block group
Group B: TAPA block group

Table 3
Mean arterial blood pressure (MAP) (mmHg) of the cases in the study groups at different times. Data are expressed in mean ± SD

MAP (mmHg)	Group A (n=50)	Group B (n=50)	P value	95% CI
Basal	66.74 ± 5.23	66.42 ± 5.56	0.77	-1.8 , 2.5
Skin incision	65.32 ± 4.95	66.84 ± 5.03	0.13	-3.5 , 0.5
Surgical manipulation	63.82 ± 4.91	64.06 ± 4.97	0.81	-2.2 , 1.7
End of surgery	63.28 ± 5.10	62.64 ± 4.82	0.52	-1.3 , 2.6

*P value ≤ 0.05 is significant
Group A: TAP block group Group B: TAPA block group

Table 4
Postoperative analgesic profile and parent satisfaction in the studied groups. Data are expressed as median and range or percentage and frequency

	Group A (n=50)	Group B (n=50)	P value
Patients requiring rescue analgesia	24 (48%)	21(42%)	0.55
1st request of analgesia (hours)	6 [2 – 24]	6 [1 – 24]	0.09
Parent satisfaction	7 [6 – 9]	7 [5 - 10]	0.15

*P value ≤ 0.05 is significant
Group A: TAP block group
Group B: TAPA block group

Table 5
Postoperative follow up of FLACC score in the studied groups. Data are expressed as mean and standard deviation

FLACC	Group A (n=50)	Group B (n=50)	P value
PACU	1.92 ± 0.49	2.14 ± 0.78	0.1
One hour	2.44 ± 0.64	2.74 ± 1.14	0.11
Two hours	2.94 ± 1.08	3.00 ± 1.29	0.8
Four hours	3.24 ± 0.94	3.02 ± 0.68	0.18
Six hours	4.00 ± 1.14	3.78 ± 1.27	0.36
12 hours	4.02 ± 0.87	4.08 ± 1.10	0.76
24 hours	4.16 ± 0.62	4.18 ± 0.94	0.9

*P value ≤ 0.05 is significant.
Group A: TAP block group. Group B: TAPA block group.