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ORIGINAL ARTICLE**Analgesic Efficacy of Ultrasound Guided Transversus Abdominis Plane Block Versus Caudal Block for Inguinal Hernia Repair Surgery in Pediatrics: A Double-Blinded Randomized Comparative Study**Mohammed A. Refky¹, Doaa M. Farid¹, Ayat A. Amer¹, Mohammed A. Mekawy^{1*}.¹Department of Anesthesia and Surgical Intensive Care, Faculty of Medicine, Zagazig University, Zagazig, Egypt

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ABSTRACT

Background: caudal epidural block (CEB) is the most preferred modality for pediatric regional analgesia because of its effective somatic and visceral pain control, though transversus abdominis plane (TAP) block is an evolving regional anesthetic technique for abdominal wall. Our study aims to compare the analgesic effect of (CEB) versus (TAP) block in pediatrics undergoing inguinal hernia repair surgeries. **Patient and Methods:** The study enrolled 44 children, aged 3 to 7 years, scheduled for unilateral inguinal hernia repair surgery. Children were divided into 2 equal groups. Group A received ultrasound guided (CEB), while group B received ultrasound guided (TAP) block. We used a multimodal approach of pain control including regional block, intraoperative fentanyl when needed, standard postoperative paracetamol, and rescue ibuprofen when needed. Hemodynamic stability, fentanyl needs, time for first analgesic request, pain scores by Children's Hospital of Eastern Ontario Pain Score (CHEOPS), and ibuprofen requirements were recorded. **Results:** Both (CEB) and (TAP) groups showed hemodynamic stability, meanwhile there was no need for fentanyl among all patients in both groups, and the time for first analgesia in CEB and TAP groups, was (4.59±0.59) and (7.48±1.35) hours respectively. Furthermore, the ibuprofen requirements and pain scores were statistically significantly higher in (CEB) group than (TAP) group (P-value < 0.05). **Conclusion:** Both TAP block and CEB provide effective analgesia in children undergoing inguinal hernia repair surgery with TAP block superiority over CEB as evidenced by longer time for first analgesic request, decreased analgesics needs, and lower pain scores.

Keywords: caudal; TAP; ultrasound; pediatric; surgery.

INTRODUCTION

Regional anesthesia, including peripheral and central neuro-axial blockade, can be used for pain control in a wide scale of surgeries. The supremacy of regional anesthesia is coming from its ability to decrease the detrimental stress response to pain, which is three to five times greater in children than in adults. It can also provide better postoperative

analgesia, thus lowers the needs for systemic analgesics with its side-effects [1].

Caudal epidural block (CEB) is the most common regional anesthesia technique employed in pediatric lower abdominal procedures because of its effective control of both somatic and visceral pain with a low complication rate (0.7 per 1000). In addition to significant reduction of intraoperative analgesic

requirements and upper airway complications, it provides 4-6 hours of postoperative analgesia [2,3].

However, there is a trend toward the use of peripheral nerve blockade wherever applicable due to its lower incidence of complications than neuron-axial techniques and ability to overcome some specific contraindications that preclude the use of (CEB) (i.e. impaired hemostasis, bacteremia and anatomic neuro-axial abnormalities). Also, the use of ultrasound allowed real-time visualization of anatomical structures, guiding the blocking procedure itself and showing the spread of the local anesthetic solution injected [4,5].

An increased understanding of abdominal wall anatomy has led to the introduction of Transversus Abdominis Plane (TAP) block, which is a regional anesthetic technique that provides analgesia to the abdominal wall after abdominal surgeries, as it aims to block the segmental nerves T9-T12 and L1 within the plane between the transversus abdominis and the internal oblique muscles. Complications related to TAP block are unusual, especially when performed under ultrasound guidance, with no long-term serious consequences [6,7].

The TAP block has not been compared extensively enough, in the term of clinical trials, with (CEB) which is still the most preferred modality for regional analgesia management in pediatric patients. The aim of the current study was to compare the analgesic efficacy of ultrasound-guided (CEB) versus ultrasound-guided TAP block in pediatrics undergoing inguinal hernia repair surgery. The primary outcome was to compare the time for first analgesic request. The secondary outcomes were comparative assessment (CEB versus TAP) of hemodynamic stability, severity of pain (assessed by pain score) and rescue analgesia requirements.

PATIENTS AND METHODS

After obtaining approval from institutional review board and a written informed consent from the parents of each patient, this double-blinded prospective

randomized comparative study was carried out at Zagazig University Hospitals (Zagazig, Egypt), where 44 children scheduled for elective unilateral inguinal hernia repair operations were included if they are aged 3-7 years and ASA (American society of anesthesiologists) physical status grade I-II. while children were excluded if parents refused the procedure, urgent cases, bilateral or complicated hernias and other contraindication of regional anesthesia (e.g. infection at injection site, coagulopathy and allergy to bupivacaine). All the patients received regional block technique before the surgery either in the form of caudal epidural block (CEB) or unilateral transversus abdominis plane (TAP) block. The work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Routine preoperative assessment was done to all patients by careful history taking, clinical examination and laboratory investigations. When patients were brought to the operating room, standard monitors were placed; pulse oximetry, non-invasive blood pressure cuff and ECG. After insertion of intra-venous line, all children received premedication in the form of atropine at a dose of 0.02 mg/kg. followed by a bolus dose of propofol (2 mg/kg) given over 30 seconds with administration of oxygen by face mask. Patients were then positioned and the block technique of choice by randomization (either TAP or caudal) was carried out. The ultrasound used was **SonoSite M-Turbo** (USA); the scanning probe was the linear multi-frequency 13-6 MHz transducer.

Randomization was done using computer generated number tables and concealed using sealed opaque envelope. Patients and data collectors were blind to group assignment. Once enrolled in the study, patients were randomly assigned into 2 equal groups and allocated to either ultrasound guided caudal block or ultrasound guided TAP block

In (group A: n=22), (caudal group), The patient is put in the left lateral position with the ultrasound monitor on the opposite side to the operator and under complete aseptic conditions the linear high frequency transducer is applied in a transverse plane to lower sacrum and scanned cranio-caudally until the level of the sacral hiatus is reached with direct visualization of the sacral cornua, the sacral hiatus in between the cornua and the sacro-coccygeal membrane over the hiatus (Figure 1-suppl). Then, the probe is turned 90° to lie in a sagittal plane to the midline over the sacral region where the dural sac can be visualized according to the degree of ossification and the sacral hiatus and the sacro-coccygeal membrane can be imaged (Figure 2-suppl). The needle is inserted in-plane, thereafter the needle is left for 10 seconds open to air to allow detection of blood or CSF followed by negative aspiration and injection of the local anesthetic using 0.25% bupivacaine, in a dose of (1 ml / kg) is done with displacement of the posterior dura anteriorly [8].

- In (group B: n=22), (TAP group), The patient is put in the supine position with the ultrasound monitor on the opposite side to the operator, and under complete aseptic conditions the linear high frequency transducer is applied in a transverse plane to the mid axillary line of abdomen, midway between the iliac crest and costal margin, with direct visualization of the three muscle layers of the abdominal wall (Figure 3-suppl). The needle is inserted in-plane anteriorly and slightly away from the probe and carefully advanced until it reaches the transversus plane with its tip visualized throughout the procedure, as it enters the transversus plane after piercing the fascial layer below the internal oblique muscle (Figure 4-suppl). After negative aspiration, injection of the local anesthetic using 0.25% bupivacaine, in a dose of (1 ml / kg) is done with direct visualization of the spread of local anesthetic solution in the plane separating between the two muscles [9].

The success of block was assessed after 15 minutes by a painful stimulation at the level of umbilicus. Movement of lower limbs or patient withdrawal or localization by hand of the stimulation site indicated failed block and patient was excluded from the study and completed the operation under conventional general anesthesia.

General anesthesia was standardized for all patients in both groups and was established using propofol 2mg/kg intravenously administered with cisatracurium 0.1 mg/kg to facilitate tracheal intubation. Lungs were ventilated by a volume controlled mode (tidal volume: 8ml/kg, respiratory rate: 15 cycle/minute) to maintain normo-capnia. Anesthesia was maintained by isoflurane (1.2 %). At any time during operation if the heart rate (H.R) and/or mean blood pressure (MBP) increased by more than 20% of basal readings, intravenous fentanyl (1 µg/kg) was given. At the end of surgery, the inhalational agent was discontinued and the patients were reversed from muscle relaxant with (neostigmine 0.05mg/kg + atropine 0.02 mg/kg). Patients were extubated and transferred to recovery room. Postoperatively, all patients received paracetamol as a standard baseline analgesia (first rescue analgesia) in a dose of (15mg/kg) every 6 hours and the first paracetamol dose was given when patient complained of pain or asked for analgesia (a sign of fading of analgesic effect of regional block). The maximum permitted daily dose of paracetamol is 90 mg/kg/day [10].

After the operation, patients were admitted to the recovery room, vital signs were observed every 15 min. Then patients were discharged to the ward when they gained (modified Aldrete score) a score of ten (Table 1-suppl) [11]. When patients suffered from pain at a score above 6 on the Children's Hospital of Eastern Ontario Pain Scale (CHEOPS) (Table 2-suppl) [12], they received a dose of oral ibuprofen (10mg/kg) as a second rescue analgesia, only when needed. The maximum permitted daily dose

of ibuprofen is 40 mg/kg/day[13]. Pain was assessed immediately postoperative and then at 2, 4, 6, 12 & 24 hours after surgery using the (CHEOPS).

The data were collected during surgery, in the inpatient wards and after discharge by the telephone for 24 hours postoperatively. The data collector was an anesthesia resident (blind observer), who was not a part of the study team and evaluated the needs for analgesia both intra- and post-operatively.

The followings were measured in both groups:

- Hemodynamic parameters (H.R, MBP) were recorded preoperative (baseline), on skin incision and every 5 minutes till the end of surgery, then every 15 minutes in the recovery room.
- Number of patients who needed intraoperative extra-analgesia in the form of fentanyl.
- Assessment of post-operative pain by the CHEOPS pain score.
- Time for first analgesic request (It is the time from the end of block performance till the first patient's complain of pain postoperatively (in hours). And it is equivalent to the time for the first paracetamol dose.
- Number of patients who needed post-operative rescue analgesia, in the form of ibuprofen syrup, frequency of doses and total amount used in 24 hours.

By comparing mean and standard deviation of both techniques, postoperative first analgesic request in the (TAP) group was 7.41±/ 3 hrs, and in the (caudal) group was 5.07 ±/ 2.5 hrs[14]. So, the sample size was calculated to be (44 patient), 22 in each group using open Epi program, at confidence Interval of 95% and power of test 80%.

Data analyses was analyzed using IBM SPSS Statistics Version 22. Data was tested for normality using Kolmogorov-Smirnov test and Shapiro-Wilk test. Quantitative data was presented as mean and standard deviation. Qualitative data was presented as number and

percentage. Comparisons between the 2 groups for normally distributed numeric variables was done using the Student t test while non-normally distributed numeric variables was done by Mann-Whitney test. Comparisons between the 2 groups of categorical variables was done using Chi square test or fisher exact as appropriate. The probability value (p-value) ≤ 0.05 was considered statistically significant.

RESULTS

All the 44 patients participated in the study completed the study as shown in the CONSORT flow diagram (Figure 5-suppl). The patient's data including age, weight, sex ASA grade and duration of surgery did not show any statistical significant difference between the two groups (Table 1).

As regards patients hemodynamics, both (CEB) group and (TAP) group showed hemodynamic stability intra- and post-operatively with no statistically significant difference between them (P-value > 0.05) (Figures 1, 2, 3, 4).

There was no need for extra analgesia intra-operative (in the form of Fentanyl (1µg/kg I.V.) among all patients in the two groups.

As regards the time for first analgesic request (primary outcome), In group A (CEB group), it was (4.59±0.59) hours. While in group B (TAP group), it was (7.48±1.35) hours. By comparing the results via independent sample t test, there was a statistical significant difference between the two groups with (p-value < 0.001) (Table 2).

As regards the need for post-operative rescue analgesia, we found that the requirements of ibuprofen rescue analgesia were statistically significantly higher in group A (CEB) group than in group B (TAP) group (P-value < 0.05) (Table 2). In Group A (CEB group), nine patients needed rescue analgesia and mean total amount was 254.44±58.97 mg/24 hours, whereas, In Group B (TAB group), only four patients needed rescue analgesia in the form of a single dose and mean total amount was (187.5 ± 29.86 mg /24 hours (Table 2).

By comparing the CHEOPS pain score of the two groups immediately postoperative and then at 2, 4, 6, 12 and 24 hours postoperatively, it revealed that there was a significant difference between group A (CEB group),

which had statistically significantly higher pain scores compared to group B (TAP group) at certain time-points of assessment (p value < 0.001) (Table 3).

• **Table (1):** The patient characteristics and duration of surgery and recovery in all study groups:

	Group A Caudal block (n= 22)	Group B TAP block (n= 22)	P value
Age (years)	4.3 (± 1.3)	4.4 (± 1.2)	> 0.05 (NS)
Weight (Kilogram)	17 (± 3.5)	18 (± 3.3)	> 0.05 (NS)
Sex			
Male	16 (73 %)	12 (55 %)	> 0.05 (NS)
Female	6 (27 %)	10 (45 %)	> 0.05 (NS)
ASA grade	I (100%)	I (100%)	> 0.05 (NS)
Duration of surgery (minutes)	29.54 (± 3.05)	27.72 (±6.31)	> 0.05 (NS)
Duration of recovery (minutes)	120	120	> 0.05 (NS)

- Data are expressed as Mean (± standard deviation) or Number (percentage).
- (TAP)= Transversus Abdominis Plane
- (ASA)= American society of anesthesiologists
- P value <0.05 is significant
- (NS)= not significant

Table (2): Post-operative needs for analgesia of all patients in both groups:

		Group A Caudal block (n= 22)		Group B TAP block (n= 22)		Test*	P value
		N	%	N	%		
Time for first analgesic request in hours (Mean± SD)		4.59 (±0.59)		7.48 (±1.35)		-9.192*	<0.001 (S)
Need for Ibuprofen syrup frequency	Once	4.0	18.1%	4.0	18.1%	3.611**	0.05 (S)
	Twice	5.0	22.7%	0.0	0.0%		
	Sum	9.0	41.0%	4.0	18.1%		
Number of patients who did not need Ibuprofen		13.0	59.0%	18.0	81.8%		
Total amount of Ibuprofen syrup (mg) in 24 hours (Mean±SD)		254.44 (±58.97)		187.50 (±29.86)		2.116*	0.02 (S)

Data are expressed as number and percentage or mean ± standard deviation

Time for first analgesic request (It is the time from the end of block performance till the first patient's complain of pain postoperatively (in hours). And it is equivalent to the time for the first paracetamol dose.

- (TAP)= Transversus Abdominis Plane

- (*) independent sample t test
- (**) Chi square test
- P value ≤ 0.05 is significant (S)

Table 3: Post-operative (CHEOPS) pain score for patients in both groups:

Post-operative pain score (CHEOPS)	Caudal group (N=22)	TAP group (N=22)	test*	P -value
	Median (min-max)	Median (min-max)		
0hrs (immediately post-operative)	6.00(4.0-6.0)	5.00(5.0-6.0)	126.147	<0.001(s)
2hrs	6.00(4.0-6.0)	5.00(4.0-6.0)		<0.001(s)
4hrs	4.00(4.0-6.0)	4.00(4.0-6.0)		<0.001(s)
6hrs	6.00(5.0-11.0)	5.00(4.0-7.0)		<0.001(s)
12hrs	6.00(4.0-12.0)	4.50(4.0-9.0)		<0.001(s)
24hrs	6.00(4.0-11.0)	4.00(4.0-11.0)		<0.001(s)

- Data are expressed as median (range)
- (CHEOPS)= Children’s Hospital of Eastern Ontario Pain Score
- (TAP)= Transversus Abdominis Plane
- (*) Friedman test
- P value ≤ 0.05 is significant (S)

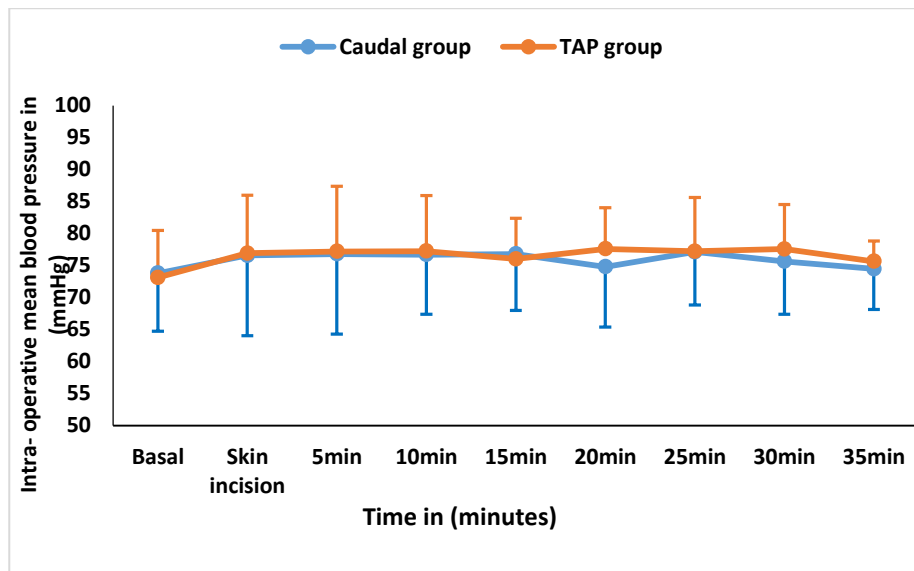


Figure (1): Intra-operative Mean arterial blood pressure (in mmHg).

- Data are presented as (Mean \pm SD)
- TAP= Transversus Abdominis Plane
- No significant difference between both groups was present (p-value > 0.05)

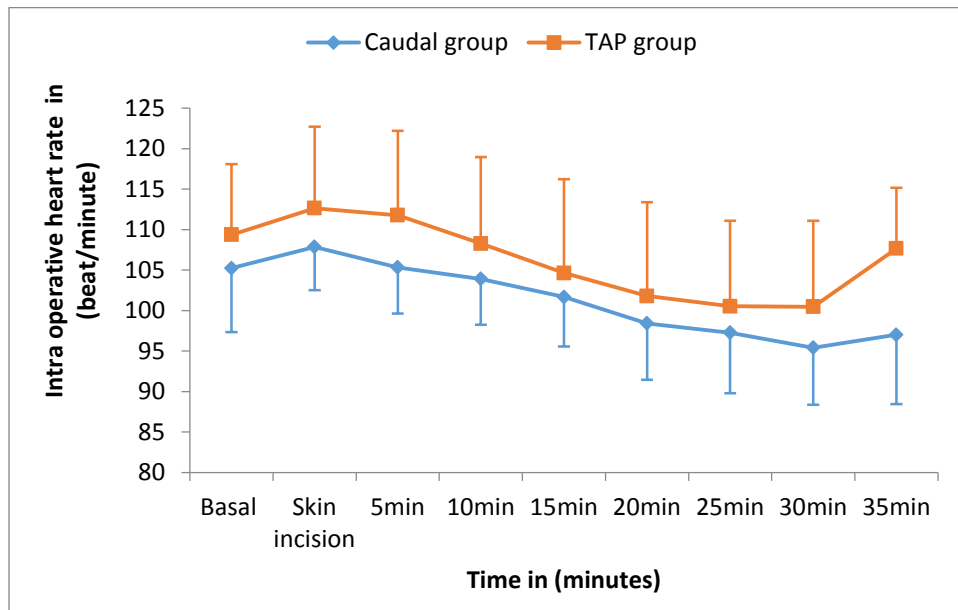


Figure (2): Intra-operative heart rate (in beat/min).

- Data are presented as (Mean ±SD)
- TAP= Transversus Abdominis Plane
- No significant difference between both groups was present (p-value > 0.05)

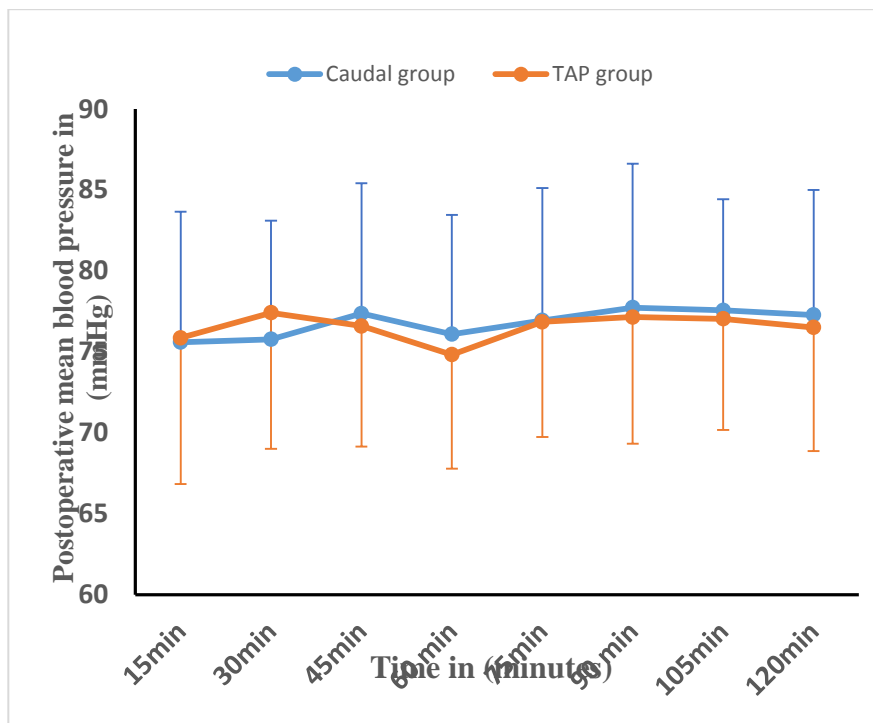


Figure (3): post-operative Mean arterial pressure (in mmHg).

- Data are presented as (Mean ±SD)
- TAP= Transversus Abdominis Plane
- No significant difference between both groups was present (p-value > 0.05)

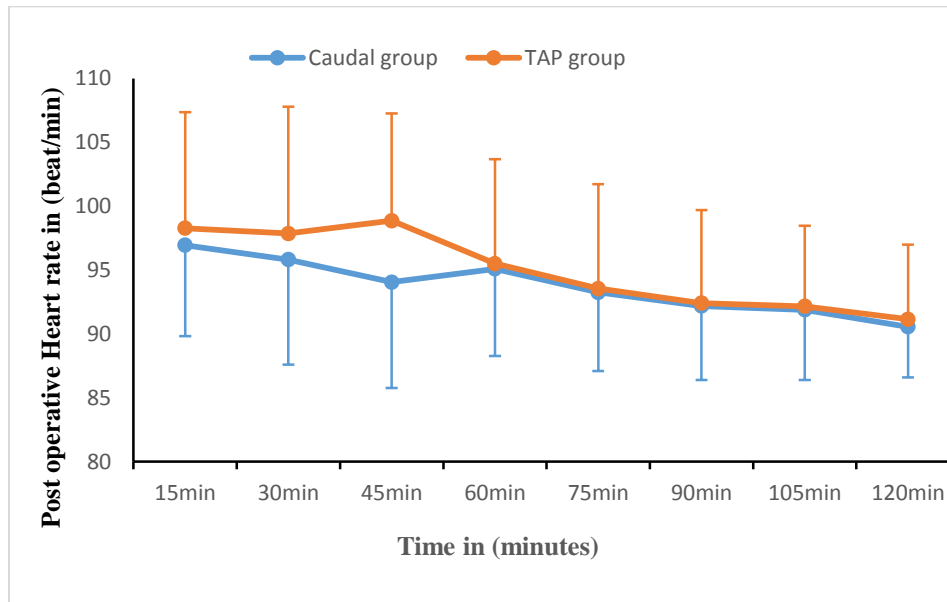


Figure (4): Post-operative heart rate (in beat/min).

- Data are presented as (Mean ±SD)
- TAP= Transversus Abdominis Plane
- No significant difference between both groups was present (p-value > 0.05)

DISCUSSION

The current study was aimed to compare the analgesic effect of ultrasound guided caudal block versus ultrasound guided TAP block in pediatrics undergoing unilateral inguinal hernia repair surgeries. This study demonstrated that both TAP block and (CEB) can provide effective analgesia in these children with TAP block superiority over (CEB) as evidenced by longer time for first analgesic request, decreased analgesics needs, and lower pain scores.

For caudal block, The higher (cephalad) vertebral levels can be reached if a sufficient volume of fluid is injected into the caudal epidural space, although formulae to calculate the dose required to reach a given dermatome level are not reliably predictive [15]. So, to make a low thoracic epidural block a large volume of local anesthetic is wasted to fill the area supplying the area (from L2 to S3). The average duration of caudal block using (0.25% bupivacaine) in children is 4 hours. This can be prolonged by the use of additives (as epinephrine or clonidine) [1]. In this study we

didn't use additives because we examined the efficacy of the sole technique while the local anesthetic solution composition and volume were standardized for both TAP and caudal blocks. While caudal block has an advantage of the ability to block both visceral and somatic pains, in this study (simple inguinal hernia repair) doesn't produce significant visceral pain so this advantage lost power here.

On the other hand TAP block is a plane block that aims at locating the local anesthetic near the nerves running in the transversus fascia plane (anterior branches of T6 to L1) that supply somatic sensations to anterior abdominal wall. The spread of local anesthetic in this plane is dependent on the site of injection and how much volume is injected[16]. In this study we tried to optimize the conditions for TAP block success by 1) choice of type of operation that produce no or minimal visceral pain. 2) choice of site of injection, lateral TAP block in which the spread of local anesthetic targets mainly dermatomes below the umbilicus (T10 to L1) 3) usage of large volume of local anesthetic (1 ml/kg of 0.25% bupivacaine) but

not exceeding the maximum dose. 4) choice of unilateral cases so that the whole volume is injected in one side and not divided on both sides. Under these conditions TAP block proved to provide analgesia superior to caudal block.

The current study agrees with the study of Küpeli and Özdamar [17], who investigated the contribution of (TAP) block supported by intravenous ketamine sedation in 60 children on intraoperative anesthesia and analgesia. They concluded that TAP block reduced the need for intraoperative anesthesia, provided hemodynamic stability, less pain scores, longer analgesia duration and less analgesics needs in the postoperative period.

In the current study both intraoperative and postoperative hemodynamic variables between the (TAP) and (caudal) groups were comparable and were not statistically significant and therapeutic interventions were not required. We attributed this to the effective analgesia in both groups which omitted the needs for opioids intra-operatively.

The current study also supported the study performed by Alsadek et al [18], who compared the effectiveness and safety of both Ultrasound guided (TAP) block and (CEB) in children. They concluded that both TAP block and (CEB) under ultrasound guidance proved to be safe with no recorded complications.

In accordance to the current study, Tobias [19] found that TAP block provided effective analgesia following lower abdominal procedures in children, when compared with the usual practice of caudal analgesia. Also, a study done by Frederickson et al, [20] supported our results and concluded that unilateral TAP block has been shown to provide effective analgesia for inguinal hernia repair in children.

The current study ensured the effectiveness of both TAP and caudal blocks as intra-operative analgesia as there was no need for extra analgesia intra-operatively in the form of fentanyl among all patients in the two groups. However post-operatively, analgesia of TAP block was superior to caudal analgesia. The mean time for first analgesic request in TAP

group (7.48 ± 1.35) hours was statistically significantly longer than that of caudal group (4.59 ± 0.59) hours. These results agree with similar results of a study done by Kanojia and Ahuja [14], who compared TAP block and caudal block regarding the duration and quality of analgesia postoperatively in 60 children undergoing lower abdominal surgery. They found that time to rescue analgesia in group TAP was (7.41 ± 0.78) hours whereas, in group Caudal was (5.07 ± 0.69) hours and this difference was statistically significant.

In accordance to the current study results, Poovannan et al. [21] compared the efficacy of ultrasound guided TAP block and the (CEB) for post-operative analgesia and they found that the duration of analgesia was higher in the TAP group (9hrs 44minutes) compared to the caudal group (4 hours 5 minutes). They concluded that TAP block increases the duration of post-operative analgesia without producing any adverse effects when compared to (CEB).

Another study done by Sahin et al. [22] compared the analgesic efficiencies of three different regional block techniques using 0.25% levobupivacaine solution with 1/200,000 adrenalin, namely CEB (0.7 ml/kg), ultrasound guided TAP block (0.5 ml/kg) and ilio-inguinal/ ilio-hypogastric block (0.3 ml/kg) in ninety children scheduled for unilateral lower abdominal surgery. Sahin et al. concluded that there was no significant difference between the caudal and TAP groups in terms of both time to first analgesic request and the CHEOPS pain scores at certain time points.

The current study results are against Sahin et al. results as we proved the superiority of TAP block analgesia over caudal analgesia with statistically significantly longer time to first analgesic request. Also, when we compared the pain score (the CHEOPS) of the two groups (caudal and TAP groups), we found that there was significant difference between the (CEB) group, which had higher pain scores and the (TAP) group, which had lower scores, at certain time-points of assessment (p value < 0.001). The controversy between us and Sahin et al. results may be due to the use of different drugs

and doses in both studies. Also the blocks in Sahin's study were done by three anesthetists with different experience periods in regional anesthesia while in our study all blocks were done by the same anesthetist.

In the current study we used ibuprofen syrup (10 mg/kg/ dose) as a rescue analgesia when CHEOPS pain score was > 6. When both TAP and (CEB) groups were compared together, there was a significant difference (with TAP group lower than caudal group) as regard rescue analgesia requirements. The number of children not requiring any rescue analgesia in the first 24-hours postoperatively were statistically significantly higher in the (TAP) group (group-Caudal: n=13 versus group-TAP: n=18; p<0.05). This indicated the superior analgesia of TAP block over caudal analgesia. These results are reinforced by similar results of a study done by Sethi et al.[23]who compared the quality of pain relief and rescue analgesia requirements in children scheduled to undergo unilateral lower abdominal surgery under general anesthesia and were randomly allocated to receive either CEB (0.75 ml/kg of 0.25% bupivacaine) or ultrasound-guided TAP block (0.5 ml/kg of 0.25% bupivacaine). They found that The number of children not requiring any rescue analgesia in the first 24-hours postoperatively was statistically significantly higher in the TAP group (8 patients) than in CEB group (2 patients). Our study results agreed with this and even showed much more percent of patients who did not require rescue analgesia. We explained this difference in results by the larger volume of local anesthetic injected in our study with superior efficacy of analgesia.

This study has some limitations:

- The first limitation is that only a small number of patients were enrolled, there are likely to be different results in larger series
- The second limitation is that the current study follow-up time in hospital was limited to 6 hours since all cases were scheduled as day-cases, further follow-up to 24 hours were done by phone communication with parents.

CONCLUSION

Both ultrasound guided transversus abdominis plane block and caudal epidural block provide effective analgesia in children undergoing inguinal hernia repair surgery with transversus abdominis plane block superiority over caudal block as evidenced by longer time for first analgesic request, decreased analgesics needs, and lower pain scores.

Conflict of Interest: No any financial or personal relationships with other people or organizations that could inappropriately influence the current study.

Financial Disclosures: No any specific financial interests, relationship and affiliations relevant to the subject of the manuscript.

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