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The effect of using the injection pressure monitoring device on the accuracy of the ultrasound guided transversus abdominis plane block

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Abstract

Background: The ultrasound-guided Transversus Abdominis Plane (TAP) block is utilized for postoperative pain relief after inguinal hernia repair and appendectomy procedures. The implementation of an injection pressure monitoring device is believed to improve the accuracy of local anesthetic placement within the TAP plane. This study aims to determine whether monitoring the injection pressure of local anesthetic affects the precision of TAP blocks.

Patient and Methods: Thirty patients aged between 18 and 65 years with ASA physical status classes 1 and 2 were enrolled 10 undergoing elective inguinal hernia repair and the remaining patients for emergency appendectomy. Following surgical completion, all participants received an ultrasound-guided TAP block using a mixture of 20 mL bupivacaine (0.5%) mixed with normal saline (0.9%). Injection pressure was monitored via a disposable pressure manometer while continuous ultrasound imaging tracked pain scores alongside vital signs including pulse rate and blood pressure during postoperative recovery.

Results: The findings indicated that all intramuscular injections required low pressures (< 15 psi), whereas intrafascial injections necessitated intermediate pressures (15-20 psi). Postoperative pain assessments showed that at zero hours post-injection (immediately after surgery), 86.7% of patients reported no pain while 13.3% experienced mild discomfort (scores of 1-3). One hour later and again at three hours post-surgery, 80% reported no pain with similar mild pain levels observed in the remaining cohort. At six hours post-procedure: 56.7% reported no pain while 36.7% noted mild discomfort.

Conclusion: For effective analgesia during TAP blocks administered through intrafascial injection requires an intermediate pressure range of 15-20 psi; conversely for intramuscular injections a pressure below 15 psi suffices. Utilizing injection pressure monitoring significantly enhances the localization accuracy of anesthetic deposition thereby improving analgesic efficacy when combined with ultrasound guidance.

Keywords: Ultrasound Guided TAP Block, injection pressure monitoring, post-operative analgesia

Introduction

According to the International Association for the Study of Pain (IASP), pain is characterized as "an unpleasant sensory and emotional experience linked with actual or potential tissue damage." Notably, several individuals may experience pain despite lacking harmful stimuli thus categorizing pain into acute or chronic forms becomes clinically significant acute being primarily nociceptive in nature whereas chronic often entails psychological influences alongside nociception.

Acute pain manifests most frequently as post-traumatic or postoperative sensations but can also arise from acute medical conditions like myocardial infarction or renal colic instances. Commonly employed tools for measuring pain include numerical rating scales (NRS), Wong-Baker FACES scale among others where a score of '0' denotes no discomfort escalating to '10' indicating extreme agony.

Transversus abdominis plane blocks are performed by injecting a local anesthetic into the neurovascular space between internal oblique and *transversus abdominis* muscles a procedure first articulated by Rafi followed by randomized controlled trials conducted by McDonnell which validated its clinical application enhanced through various ultrasound techniques popularized subsequently by Hebbard.

Based on data from the International Registry of Regional Anesthesia (IRORA), it has been established that over 99% of TAP blocks are executed under ultrasound guidance forming an integral component within multimodal approaches for managing postoperative discomfort across multiple surgical interventions including colorectal surgeries as well as gynecological procedures.

The addition of injection pressure monitoring through specialized disposable manometers offers clinicians real-time insights into syringe pressures throughout anesthesia administration facilitating safer practices particularly when navigating complex anatomical structures this method allows for easier communication regarding pressures experienced when performing procedures such as nerve blocks under less optimal visibility conditions associated with traditional methods.

Patients and Methods

This study is randomized prospective clinical trial was conducted at Baghdad teaching hospital, medical city, Baghdad, Iraq, which started in 1st of May 2017 until 30th December 2017.

Thirty patients were assigned randomly, twenty of them with emergent open appendectomy and the rest of them with elective inguinal hernia repair.

The patients were included in the study according to following criteria:-

- Age: 18-65 years.
- Patients of ASA class 1& 2.
- Patients were scheduled for emergent appendectomy and elective unilateral inguinal hernia repair.
- Vitally stable.

Exclusion criteria

- Patient refusal.
- Neurological or psychiatric disorder.
- Bilateral inguinal hernia.
- Female pregnant patient.
- Patients with contraindications or allergy to any drugs used in the study.
- Patients already in pain from another source.
- Patients already on analgesic drugs.

The study was approved by the Iraqi scientific council of anesthesia and intensive care, and the consent was obtained from all patients before included them in the study. A detailed history was taken from each patient; a clinical examination was performed pre operatively.

All the patients prepared properly to the operation, wide bore IV cannula inserted, lying in supine position, connecting to the monitoring (pulse rate (PR), noninvasive BP, SPO2&ECG). All patients received 50mg ranitidine, 10 mg metoclopramide, 8mg dexamethasone and 0.02mg/kg midazolam as pre-induction agent. Anesthesia was induced with 0.5mg/kg ketamine, sleeping dose of propofol up to 2 mg/kg, 1mg/kg tramadol, and tracheal intubation (with size 7.0-8.0 ID endotracheal tube) was facilitated with a muscle relaxants.

Anesthesia was maintained with halothane 0.6-1.0% in 100% oxygen. Neuromuscular blockade was maintained with a muscle relaxant. And Analgesia was maintained by 75mg Na⁺ diclofenac IM. Then the entire patient received

TAP block at end of the Operation before the muscle relaxants reversal administration, then received 2,5mg neostigmine +1.2mg atropine and recovered smoothly.

TAP block done under ultrasound guidance, using (Sonosite s-Nerve device), high frequency linear array probe (5.7-13.3 MHz) 45mm width. TAP block done under aseptic technique, after sterilization of the area, linear probe applied on the posterior abdominal wall called (petit triangle or lumbar triangle) above the iliac crest, bounded above and medially with tendon of Latissimus Dorsi & anterior edge of external oblique muscle below with the iliac crest, the bottom is the (internal oblique & transversus abdominal muscle) along with the mid axillary line.

On the screen of ultrasound, the skin, subcutaneous fat and three muscles identified (external oblique muscle, internal oblique muscle, and transversus abdominal muscle).

The needle used {Sono TAP cannula, 0.7x120mm (22G x 4 3/4")}, connected to a disposable injection pressure manometer (B. Braun) with a 20 ml syringe filled with 15 ml 0.5% bupivacaine +5ml 0.9%N/S fluid.

The needle passed through the abdominal wall layers toward the TAP, and after negative aspiration of fluid or blood, hydro dissection was confirmed by injection of local anesthesia and complete separation of the layer done with close monitoring to the injection pressure during the injection. With the continuous ultrasound view monitoring and tracking the pressure level, the pressure level was less than 15psi at the intramuscular, while at the intrafascial (TAP) the pressure was 15-20 psi.

Post-operatively, data, including pain score (NRS), the need for analgesia, pulse rate, blood pressure, were recorded at immediate post-operative period and considered as (0hr), then the same data were taken at (1hr, 3hr&6hr) post-operatively.

100 mg tramadol was given intramuscularly to relief pain, when the patients at moderate scale of NRS (NRS more than or =4).

Statistical Package for the Social Sciences (SPSS) version 23 was used for data entry and analysis. Suitable tables and graphs were used to describe the data. Comparison was done between different variables to reach the aim of the study.

Results

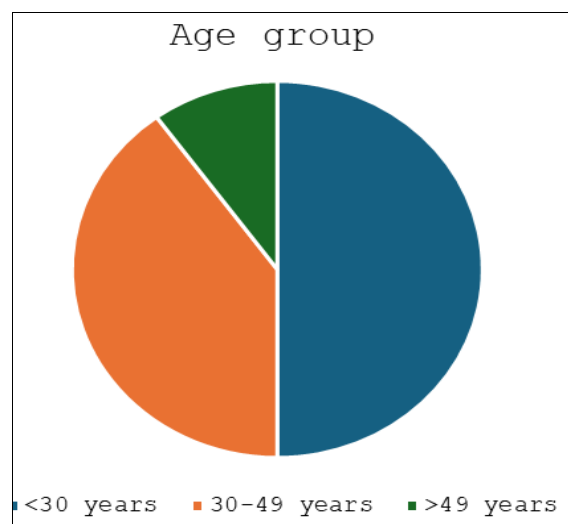


Fig 1: Distribution of study patients by age

Study patient's age was ranging from 18 to 65 years with a mean of 32.5 years and standard deviation (SD) of ± 13.62 years. The highest proportion of study patients was found in age group < 30 years (50%), (Figure 1).

Regarding weight, it was ranging from 50 to 90 kgs with a mean of 71.93 kgs and SD of ± 10.41 kgs.

Concerning gender, the highest proportion of study patients was male (73.3%) with male to female ratio of 2.75:1 (Figure 2).

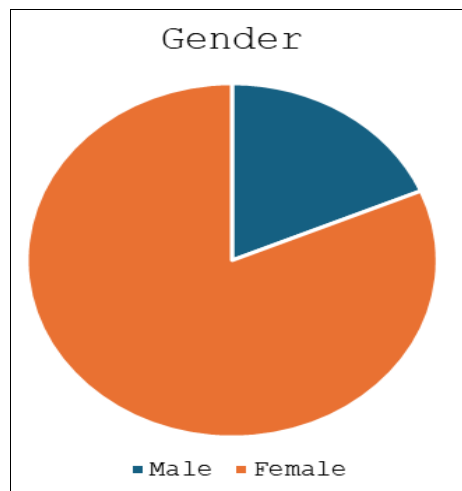


Fig 2: Distribution of study patients by gender

The distribution of study patients by operation type and site of TAP block is shown in Table 1.

We noticed that two thirds of the study patients (66.7%) were operated for appendicectomy, and 70% of the TAP block was in the right side of the body.

Table 1: Distribution of study patients by operation type site of TAP block

Variables		No.	Percentage (%)
Operation type	Appendicectomy	20	66.7
	Inguinal hernia	10	33.3
Site of TAP block	Right side	21	70
	Left side	9	30

The distribution of study patients by information about no of injection is shown in Table 2. The highest proportion of study patients was injected one intramuscular injection then injected intra facially (76.7%), while 16.7% of them injected two intramuscular injections then injected intra facially. Those who were injected directly into intrafascial site were 23.3%.

Table 2: Distribution of study patients by information about no of injections

Injections*	No.	Percentage (%)
One intramuscular injection + intra facial injection (IMUSG injection + IFUSG injection)	23	76.7
Two intramuscular injections + intra facial injection (IMUS guided injection + IFUS guided injection)	5	16.7
Just intra facial injection (IFUS guided injection)	7	23.3

*Some of patients might have more than one injection, so the total no of injections might exceed the no of patients

Regarding pressure of device used in injections, we noticed that all intramuscular injections were needed low pressure, while all intrafascial injections were needed intermediate pressure (Table 3).

Table 3: Pressure of device used in intramuscular and intrafascial injections

Variables	Pressure of device			Total
	Low < 15 Psi	Intermediate (15-20)Psi	High > 20 Psi	
Intramuscular injection	28	0	0	28
Intrafascial injection	0	30	0	30

Information about post-operative NRS is shown in Table 4. It was obvious that 26 patients (86.7%) had no pain and four patients (13.3%) had mild pain according to NRS at recovery (0 hour).

After one hour and after three hours, 24 patients (80%) had no pain and six patients (20%) had mild pain according to NRS After six hours, 17 patients (56.7%) also had no pain according to NRS, while 11 of them (36.7%) had mild pain.

Table 4: Information about post-operative NRS.

Time	NRS(score)							
	No Pain	Mild Pain			Moderate Pain			Total
	0	1	2	3	4	5	6	
At Recovery	26	4	0	0	0	0	0	30
After 1 hr.	24	4	2	0	0	0	0	30
After 3hr.	24	3	3	0	0	0	0	30
After 6 hr.	17	3	3	5	2	0	0	30

Figure 3 shows the distribution of study patients by postoperative need to analgesic drug (rescue dose of tramadol) Most of study patients didn't need analgesia post-operatively (93.3%).

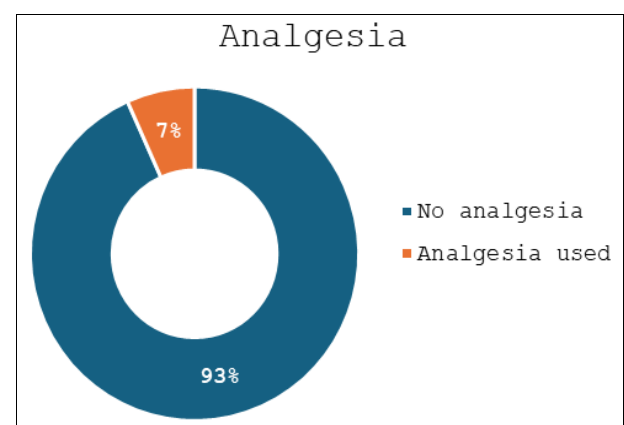


Fig 3: Distribution of study patients by postoperative need to analgesia

The mean of post-operative pulse rate of patients is shown in Figure 4. In this study, the mean of pulse rate was at lowest rate at recovery and after one hour (79 and 78 respectively), then it begun to increase to reach (81) after three hours and (86) after six hours.

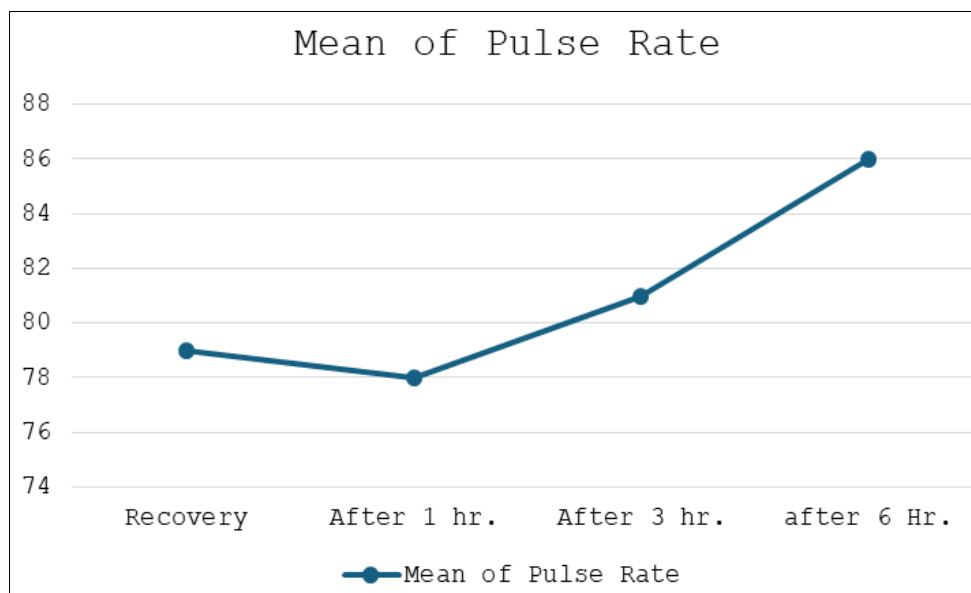


Fig 4: Mean of post-operative pulse rate of patients

Figure 5 shows the mean of post-operative systolic and diastolic BP. We noticed that the highest mean of systolic and diastolic BP was after six hours (123 mmHg and 81

mmHg respectively), while they were approaching to be the same and not changed at recovery, after one hour and after three hours.

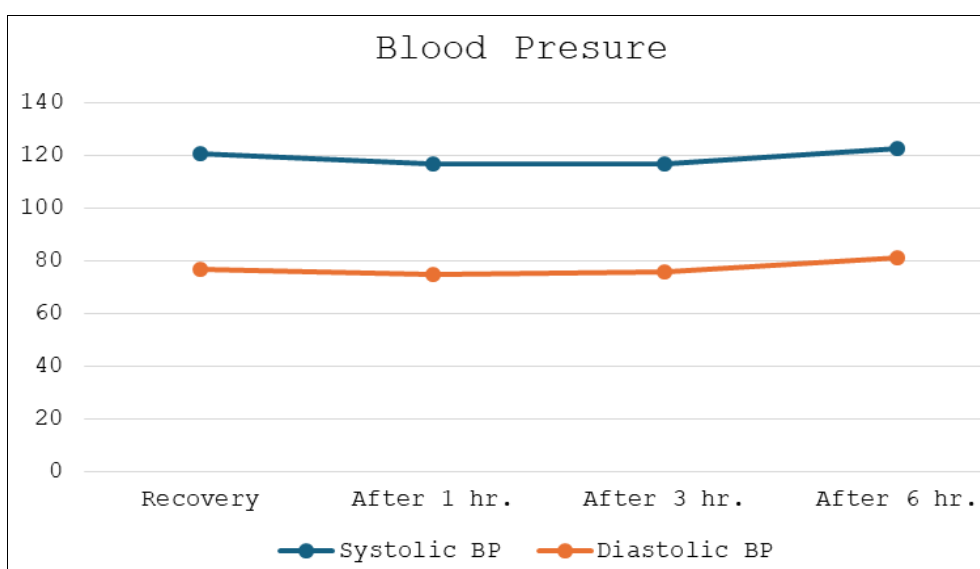


Fig 5: Mean of post-operative systolic and diastolic BP

Discussion

Open appendectomy and inguinal hernia repair are common surgical operations, they are frequently performed operation and their postoperative pain may delay the return to the normal activity and delay the hospital discharge. Various techniques have been employed to provide postoperative analgesia by regional anesthetic technique or traditional analgesic technique (opioids, NSAIDs or combinations).

In this study, TAP block as a postoperative analgesia modality has been applied, and it is performed under ultrasound guided technique with close monitoring of injection pressure while the passage of the needle toward the plane. That has implemented with the viewing of the ultrasound and watching pressure of the injection.

The outcomes show the highest proportion of studied patients were injected one intramuscular injection then injected intra facially (76.7%), while 16.7% of them injected

two intramuscular injections then injected intra facially. Those who were injected directly into interfacial site were 23.3%.

Also regarding pressure of device used in injections, we noticed that all intramuscular injections were needed low pressure less than 15psi, while all interfacial injections were needed intermediate 15-20 psi pressure. So we need an intermediate pressure in a target (intra facial injection) site of the block.

In addition the intra muscular injection was associated with low injection pressure less than 15 psi. Moreover, opening injection pressure and pressure throughout the injection procedure remained between 15-20 psi during administration of the 20-ml local anesthetic used for the blockade. The study findings have important clinical implications, most importantly on halting the injection process when opening injection pressure reached less than

15 psi, commencement of injection was possible only when the needle tip was advanced into interfascial site. Therefore, limiting opening injection pressure to 15-20 psi reliably detected intrafascial site and allowed injection when the needle tip was positioned in intrafascial. This is particularly germane to clinical practice because the ultrasound guidance alone does not appear to be a fail-accurate monitor to prevent inadvertent injection. Ultrasonography requires technical skill, adequate sono-anatomy, and high-quality ultrasonography equipment. For these reasons, inadvertent injection of local anesthetic Drug intramuscularly can occur undetected by ultrasound.

Where Jeff C. Gadsden *et al.* [9], demonstrates High OIP (≥ 15 psi) consistently detected NNC, suggesting that injection pressure monitoring may be useful in preventing injection against nerve roots during interscalene block.

O rebaugh SL *et al* [10], demonstrates we did not commence injections when pressure within the monitoring system reached 15 psi. Thus we do not know whether breaching this pressure threshold to force injection would have resulted in neurologic consequences.

Andrzej Krol *et al* [11], demonstrate significant differences between intraneural and perineural injection pressures in the median, ulnar, and radial nerves. Intraneural injection pressures show low specificity but high sensitivity suggesting that pressure monitoring might be a valuable tool in improving the safety and efficacy of peripheral nerve blockade in regional anesthesia.

By comparing with the 3 above listed studies, the conducted study is a first study that use the injection pressure monitoring in TAP block, and this study shows that the required an intermediate injection pressure between 15 to 20 psi to inject the local anesthetic drug into a target site of TAP block, while the other 3 listed studies and through the peripheral nerves block we should avoid the pressure above the 15 psi to prevent the intra neural injection.

Another result this study shows and regarding the postoperative pain assessment by NRS using, we noticed that 26 patients (86.7%) had no pain and four patients (13.3%) had mild pain according to NRS at recovery (zero hour). After one hour and after three hours, 24 patients (80%) had no pain and six patients (20%) had mild pain according to NRS. After six hours, 17 patients (56.7%) also had no pain according to NRS, while 11 of them (36.7%) had mild pain. Thus the TAP block provide effective pain relieving postoperatively and reduced numerical rating scale at most 0, 1, 3, 6 hour. And reduce the need to rescue dose of tramadol, where Most of study patients didn't need analgesia post-operatively (93.3%) in first 6 hours post-operatively.

Also Oscar David Aguirre-Ospina *et al*, shows in their study that the benefits of ultrasound-guided TAP block to reduce acute postoperative pain following unilateral hernia repair during the first hour and at 24 h postoperative, with a decreased use of opiates by patients though the need for opiates use is not totally abolished, in the intervention group (TAP receiving group) the pain score was 2 (SD: 1) (p: 0.03) at one hour.

Likewise, pain score at 24 h postop was 1 (SD: 1.2) but in our study the pain score at one hour was 80% of the patients (0) and this difference might be because the use of analgesic dose of ketamine at induction with administration of Tramadol and Sodium diclofenac intra operatively in this study.

Sooyoung Cho *et al* [12], show Ultrasound-guided TAP block using 20 ml of 0.5% levobupivacaine provided effective postoperative analgesia during the 12 postoperative hours after an open appendectomy, where the Control group received ultrasound transverses abdominis plane block with 20 ml of 0.9% normal saline. TAP block group whose received ultrasound transverses abdominis plane block with 20 mL of 0.5% levobupivacaine results shows VNRSr (Verbal Numerical Rating Scale at resting) state at 0hr is 2, at 1hr is 4, 3hr is 3.25 and 6hr is 2.5 but VNRSr (Verbal Numerical Rating Scale at coughing) state at 0hr is 3.5, at 1hr is 5, 3hr is 5 and 6hr is 4. We noticed that difference in the score in both situations because of stress condition (cough) exacerbate the pain. But in comparison with our study the pain score in both study is approximately in mild scales of the score.

Thus the conducted study and the last 2 listed studies confirmed that the ultrasound-guided TAP block provides good postoperative analgesia, reduces analgesic requirements, and provides good NRS scores with fewer complications following inguinal hernia surgery and appendectomy. Regarding to the pulse rate, the Systolic and the Diastolic blood pressure changes at 0hr, 1hr, 3h and 6hr post operatively, the results show no significant changes in these parameters because the entire of the patients on the same scales of NRS approximately.

Conclusions

- The use of the injection pressure monitoring device enhances the accuracy of local anesthetic deposition and hence the efficacy of analgesic effect of TAP block in addition to the use of ultrasound.
- The injection of the local anesthetic drug intra-fascially in TAP block need intermediate injection pressure 15-20psi and intramuscular injection need low injection pressure < 15 psi
- Ultrasound guided TAP block provides effective postoperative analgesia and reduce the systemic administration of opioid in appendectomy and inguinal hernia repair operations.

Recommendations

- Use TAP block as postoperative analgesia for all types of surgical operations those performed in the lower part of the abdomen.
- It is preferable to perform TAP block under ultrasound guide with monitoring of local anesthetic drug injection pressure by using injection pressure monitoring device.

Conflict of Interest

Not available

Financial Support

Not available

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