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Analgesic Effects of Ultrasound Guided Paravertebral Block Versus Transversus Abdominis Plane Block in Hepatic Patients Undergoing Laparoscopic Cholecystectomy: PVB vs TAP in Hepatic Patients

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***Abstract*---**Background: Several analgesic modalities after laparoscopic cholecystectomy were used in hepatic patients but with various complications. Bilateral ultrasound-guided transverse abdominis plane block (TAP) or thoracic paravertebral block (PVB) may provide safer techniques than others. The aim of this study is to delineate the more efficient and safer technique either TAP or PVB in hepatic patients. Methods: The research was conducted on sixty adult hepatic patients, ASA II or III, Child A or B, undergoing laparoscopic cholecystectomy. Patients were allocated randomly into one of two equal groups, to attain bilateral ultrasound guided either PVB (Group P) or TAP block (Group T). Results: Group P showed significant postoperative lower pain scores using visual analogue score at 2, 4, 6 and 24 h ($P < 0.01$) and less intraoperative desflurane and fentanyl consumption ($P < 0.001$) versus group T. In addition, group P exhibited less total postoperative pethidine requirement (23.3±25.4 mg vs. 38.3±21.5 mg, $P = 0.017$), fewer number of patients asked for postoperative analgesia (46.7% vs. 76.7%, P value = 0.017), longer duration to first analgesic demand (20.5±5.1 h vs. 15.1±8.4 h, $P = 0.021$), and compared to group T respectively. Regarding liver functions and haemodynamics, both groups were comparable at different intervals. Conclusions: PVB showed superiority over TAP regarding less postoperative pain scores, intra- and post-operative analgesic requirement with comparable effects on liver functions and haemodynamics during laparoscopic cholecystectomy so both of them can be used safely in hepatic patients Child A and B. It is recommended to compare them in lengthy procedures and using more specific and sensitive markers for early hepatic affection.

***Keywords*---**analgesia, hepatic patients, laparoscopic cholecystectomy, PVB, TAP, ultrasound.

Introduction

The incidence of gallstones in cirrhotic patients is double its prevalence in general population.[1] Hepatic patients undergoing non hepatic surgery have higher frequency of transfusion, infection, cardiac compromise, longer hospital stay with higher perioperative morbidity and mortality incidence. The type of surgical procedure and anaesthetic techniques affect perioperative outcome in these patients.[2] Systemic hypotension due to anaesthesia or visceral traction during abdominal surgery, as well as blood loss reduces hepatic arterial blood flow with variable degrees of hepatic affection.[3] Postoperative analgesia after laparoscopic cholecystectomy ensures early ambulation and shorter hospital stay.[4] Various analgesic modalities available like: a) intravenous Patient Controlled Analgesia

(PCA) using opioid has been successfully used in hepatic patients taking in consideration altered pharmacological effects as delayed drug clearance and prolonged half-life, b) intraperitoneal injection of local anaesthetics is inconvenient, c) thoracic epidural analgesia has potential risks of contamination, dural puncture, epidural haematoma, and muscle feebleness.[5]

The Era of using ultrasound guided blocks provides an attractive alternative to other techniques. Ultrasound-guided transverse abdominis plane block (TAP block) analgesia obtained by injecting local anaesthetic into the neurofascial plane of the anterior abdominal muscles.[6,7] Meanwhile, the ultrasound-guided thoracic paravertebral block (PVB), local anaesthetic is injected adjacent to the thoracic vertebra as the spinal nerve arises from the intervertebral foramina providing somatic and sympathetic blockade in numerous dermatomes at the same side.[8]
To our knowledge, no research studied the sparing effect of ultrasound guided TAP and PVB on liver functions thus the objective of this study is to determine which technique is more competent in declining postoperative analgesic requirements as well as the intraoperative analgesic and anaesthetic consumption maintaining haemodynamic stability and preserving hepatic homoeostasis.

Materials and Methods

After Institutional Ethics Committee approval (Federal Wide Assurance Number: FWA00010609) and written informed consent, sixty hepatic patients were joined to this randomized prospective clinical study which was registered at ClinicalTrials.gov Identifier: NCT04208165. The authors complied with Declaration of Helsinki (2013) and relevant national laws & regulations. Patients ASA physical status II or III, child A or B, both genders, aged 20-65 years old scheduled for laparoscopic cholecystectomy via three ports were included in the study. Liver affections were verified by viral hepatitis markers and liver ultrasonography. They were assigned randomly via a computer-generated table into two equal groups of 30 patients each, receiving either bilateral ultrasound guided either PVB (Group P) or TAP block (Group T) before induction of general anaesthesia. The study was conducted from December 2019 till June 2020.

Severe coagulopathy, child C hepatic patients, those with ascites or encephalopathy, infection at the needle insertion site, allergies from amino-amide local anaesthetics, back surgeries and kyphoscliosis regarding the paravertebral group were excepted from the study. Midazolam 0.05 mg/kg as a premedication was given, then, ECG, pulse oximetry, noninvasive blood pressure, gas analyser, bispectral index (BIS), and TOF-Guard module for neuromuscular monitoring (Drägre Infinity Kappa version VF-5W, Germany) were connected to the participants.

In group P, bilateral ultrasound guided thoracic PVB were done while the patient was sitting. A linear transducer (6-15 MHz) was placed in plane longitudinally parallel to the spinous processes 3 cm from the midline directed cephalocaudal at the level of T7-8 to cover the desired dermatomes. The ribs and transverse processes were seen as hyperechoic and acoustic shadowing below them, then the transducer was moved a little caudad between adjacent ribs into intercostal space to recognise the thoracic paravertebral space (PVS). The PVS appeared as a wedge-shaped hypoechoic which is marked by the hyper echoic pleura underneath and the internal intercostal membrane on the top. Clear visualisation of the pleura continuously is very important. The movement of hyperechoic pleura with underlying hyperechoic air can be detected with respiration. (BRAUN Stimuplex D Plus 0,71*50 - 80 mm 22 G* 2'', 15°) was introduced and 0.5-1 ml local anaesthetic was injected with observing the downward displacement of the pleura then fifteen ml 0.25% bupivacaine (Marcaine® flacon, Astra Zeneca, Sweden) were given after negative aspiration to exclude intravascular injection into each side of the PVS.

In group T, ultrasound guided TAP was performed inserting the needle (BRAUN Stimuplex D Plus 0,71 50- 80 mm 22G) linear in plane technique to provide subcostal blockage. The probe was applied in the midaxillary line between the lower costal margin and the iliac crest in a transverse plane. On both sides, transverses abdominis and the overlying rectus abdominis muscles were identified adjacent to costal margin and xiphoid process. The needle was inserted medial to the probe about 2–3 cm directed from medial to lateral. After visualising the needle tip in the plane, fifteen ml of 0.25% bupivacaine were injected on each side in small increments along oblique subcostal line to extend from the xiphoid process towards the iliac crest.

General anaesthesia was induced by fentanyl (1.5- 2 μg/kg), 2% propofol (2-2.5 mg/kg) then muscle relaxation was achieved by 0.5 mg/kg atracurium. Tracheal intubation was performed, and ventilation was adjusted to keep end-tidal CO_2 at 30- 35 mmHg. The patients received 1 MAC (6.0 vol. %) desflurane volatile agent in 3 L/min 30-40% oxygen in air for ten minutes then reduced to 1 L/min through a closed circuit (Fabius GS, Drägre, Lübeck, Germany). Then the percentage of desflurane was adapted to maintain BIS value in the range between 40- 50. When the blood pressure and heart rate exceeded 20% of the baseline despite adequate level of anaesthesia adjusted by BIS, boluses of 0.5 μg/kg fentanyl were given. Decreased blood pressure and heart rate by 20% from baseline was managed by 5 mg ephedrine. Adequate muscle relaxation was preserved by applying additional doses of atracurium (0.15 mg/kg) according to TOF-guard monitoring.

Collected parameters

Age, sex, height, weight, body mass index, ASA physical status, the Child–Turcotte–Pugh (CTP) classification involving preoperative bilirubin, albumin, prothrombin time (PT), ascites, and encephalopathy grade were recorded. Liver enzymes namely: alanine transaminase (ALT), aspartate transaminase (AST), and alkaline phosphatase (ALP) were measured preoperatively as baseline, then immediately after operation and after 24 hours to notice any hepatic affection. Concerning haemodynamic data: heart rate and mean blood pressure were checked before and after the block, after general anaesthesia induction and after intubation, then every ten minutes till end of the procedure. The total amount of intraoperative fentanyl dose was recorded, and total anaesthetic consumption was considered concerning the formula:[9]

$$\text{Total liquid (ml)= from t= 0 to t= end } \frac{\text{Fresh gas flow (litre/min) X vaporizor (\%) X1000}}{\text{Conversion factor}} \text{ dt}$$

The start time of end-tidal control (t= 0) till the time of switched off vapouriser at the procedure end (t= end). The quantity of vapour produced from each ml of volatile liquid detects the conversion factor which is 209 ml for desflurane calculated as follows:[10] Conversion factor =[volume at room temperature and pressure (24000 ml) × density of volatile liquid (g/ml)] / molecular weight (g). Overall volatile volume was measured by adding the product of used rate by the period of each time.

$$\text{Average volatile used (ml/h)} = \frac{\text{total volatile liquid used (ml)}}{\text{duration of volatile anaesthesia (h)}}$$

Pain severity was assessed by visual analogue score (VAS) where 0= no pain and 10= the worst imaginable pain at two, four, six, and 24 hours subsequent to surgical end. When VAS was exceeding three, boluses of 0.5 mg/kg intravenous pethidine were given. Duration to first analgesic requirement and total analgesic demands were documented. Postoperative pain score at two hours was the primary outcome while VAS score at four, six, and 24 hours, intraoperative anaesthetic and analgesic consumption, postoperative analgesic demand, number of patients asked for analgesia, time to first analgesic requirement as well as perioperative liver functions and haemodynamics were the secondary outcomes.

Statistical analysis

- Sample size
  Based on previous study[11] according to our primary outcome pain score 2 hours postoperatively comparing ultrasound guided TAP block versus PVB, a probability of type I error (α) = 0.05 besides power (1 - β) = 0.9. The difference detected between both groups = 1.4 and within group standard deviation = 1.0 so the minimum sample size required was 24 patients. Assuming a normal distribution of a specific score, the number per group is increased to be 30.
- Statistical analysis
  The data were evaluated with statistical package for social science 'IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, N.Y., USA)' and Microsoft Excel 2016. Normally distributed variables were recorded as mean ±SD. The frequencies and percentage aimed at categorical variables were used with 95% confidence interval. Statistically significant value was considered when *p* -value < 0.05. The Student's t-test was done to compare the means of normally distributed variables between groups. In addition to Paired-Samples t-test to compare different readings with the base line and ANOVA afterwards doing a Tamhanes as a post-hoc test in different time at the same group. Distribution of categorical variables between groups was determined by using x2 test or Fisher's exact test.

Results

Demographic data showed comparable results between the two groups concerning age, sex, height, weight, body mass index, as well as ASA physical status, Child score and operative time. (Table 1)

Table 1
Demographic data, ASA physical status, child score, and operative time

	Group P (n= 30)	Group T (n= 30)	*P*-value
Age (years)	41.9±4.0	40.8±4.4	0.31
Weight (Kg)	75.8±9.2	76.2±11.6	0.88
Height (cm)	164.3±5.7	164.9±7.7	0.73
BMI (kg/m)	28.1±2.9	28.0±3.2	0.88
Sex (M/F)	9/21 (30.0%/70.0%)	7/23 (23.3%/76.7%)	0.56
ASA status (II/III)	25/5 (83.3%/16.7%)	26/4 (86.7%/13.3%)	0.71
Child Score (A/B)	28/2 (93.3%/6.7%)	26/4 (86.7%/13.3%)	0.40
Operation Time (min)	90.6±12.3	89.9±9.7	0.79

Data are presented as mean ±standard deviation or number (%). Group P: Paravertebral Block Group. Group T: Transverse Abdominis Plane Block Group. BMI: body mass index. ASA physical status: American Society of Anesthesiology physical status. $P > 0.05$ is not significant. Group P revealed statistically significant lower postoperative pain scores using VAS at 2, 4, 6 and 24 hours compared to Group T at each timing. (Table 2)

Table 2
Postoperative pain perception using VAS

	Group P (n= 30)	Group T (n= 30)	*P*-value
2 hours	1.1±0.3	1.4±0.5	0.007*
4 hours	1.6±0.5	2.0±0.6	0.006*
6 hours	2.2±0.5	2.6±0.7	0.006*
24 hours	3.1±1.1	4.2±1.8	0.006*

Data are presented as mean ±standard deviation. VAS: Visual Analogue Score. Group P: Paravertebral Block Group. Group T: Transverse Abdominis Plane Block Group. $^*P < 0.05$ is significant.

Group P exhibited statistically significant less intraoperative desflurane and fentanyl consumption versus Group T. Likewise, patients of Group P required significant lower postoperative dose of pethidine, fewer number of patients required analgesia, and longer time to first analgesic requirements compared to patients of Group T. (Table 3)

Table 3
Intraoperative fentanyl & desflurane consumption and postoperative analgesia

	Group P (n= 30)	Group T (n= 30)	*P*-value
Desflurane (ml/h)	36.4±1.1	41.9±2.5	<0.001*
Fentanyl (µg)	147.6±20.1	170.6±28.8	0.001*
Total postoperative pethidine dose (mg)	23.3±25.4	38.3±21.5	0.017*
Number of patients required analgesia	14 (46.7%)	23 (76.7%)	0.017*
Time to fist analgesic requirements (h)	20.5±5.1	15.1±8.4	0.021*

Data are presented as mean ±standard deviation or number (%). Group P: Paravertebral Block Group. Group T: Transverse Abdominis Plane Block Group. *$P < 0.05$ is significant.

Concerning liver enzymes (ALT, AST, and ALP), comparable results were detected among both groups and within each group at different timings, preoperatively, immediate postoperatively and after 24 hours. (Table 4)

Table 4
Perioperative liver functions

	Preoperative	Immediate Postoperative	24 hours postoperative	*P*- value intragroup
ALT (IU/L)				
Group P	20.7±3.2	21.0±3.2	21.3±3.1	0.69
Group T	20.2±3.5	20.5±3.5	21.3±3.6	0.51
P-value P vs. T	0.56	0.59	0.97	
AST (IU/L)				
Group P	30.2±2.5	30.4±2.6	30.7±2.5	0.69
Group T	30.0±2.7	30.4±2.8	30.9±2.6	0.36
P-value P vs. T	0.77	0.96	0.72	
ALP (IU/L)				
Group P	55.6±5.7	55.9±5.8	56.4±5.9	0.88
Group T	55.1±6.8	55.4±6.7	56.1±6.6	0.91
P-value P vs. T	0.78	0.76	0.85	

Data are presented as mean ±standard deviation. Number in each group is thirty patients. ALT: Alanine transaminase. AST: Aspartate transaminase. ALP: Alkaline phosphatase. Group P: Paravertebral Block Group. Group T: Transverse Abdominis Plane Block Group. $P > 0.05$ is not significant.

Concerning haemodynamic Parameters in the form of heart rate (HR) and mean arterial blood pressure (MBP) revealed comparable results among both groups before the block and throughout the operation till its end. HR raised twice significantly after the block and after intubation compared to base line in each group. Regarding mean arterial blood pressure, there was statistically significant rise after the block then significantly decreased intraoperatively compared to base line in the two groups with lower readings in group PVB than group TAP (Fig 1,2). However, these haemodynamic changes were within clinically acceptable range.

Data are presented as Mean ± SD, § *p* value <0.05 and §§ p value <0.01 vs. base line in PVB group. †† p value <0.01 vs. base line in TAB group. HR: heart rate. PVB: Paravertebral Block. TAP: Transverse Abdominis Plane Block.

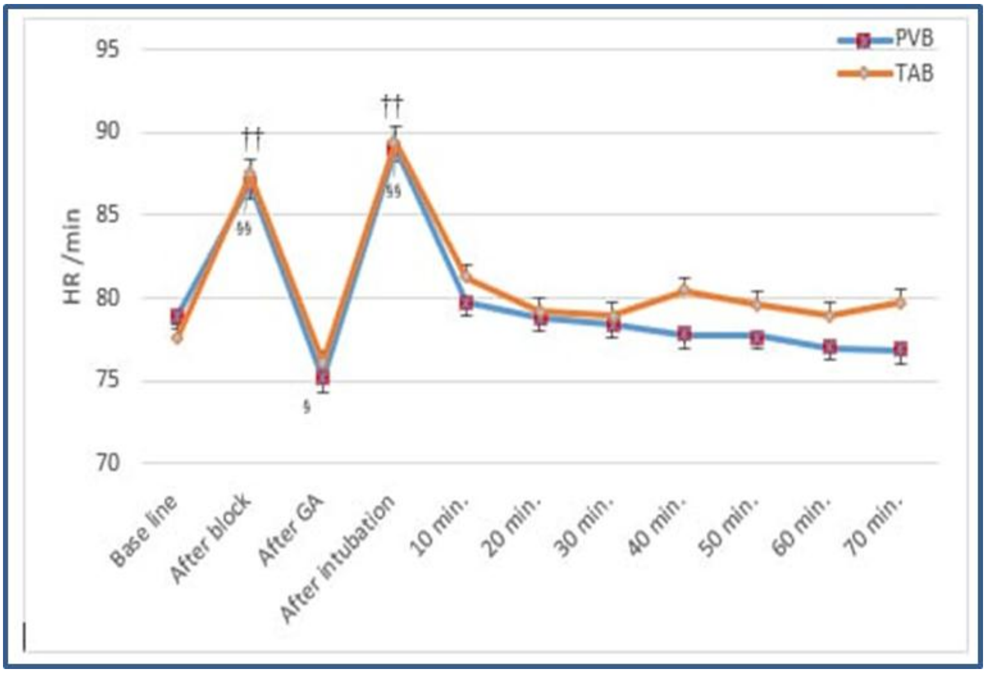

Figure 1. Mean values of heart rate changes.

Data are presented as Mean ± SD, § *p* value <0.05 and §§ p value <0.01 vs. base line in PVB group. † *p* value <0.05 vs. base line in TAB group. MBP: Mean blood pressure. PVB: Paravertebral Block. TAP: Transverse Abdominis Plane Block.

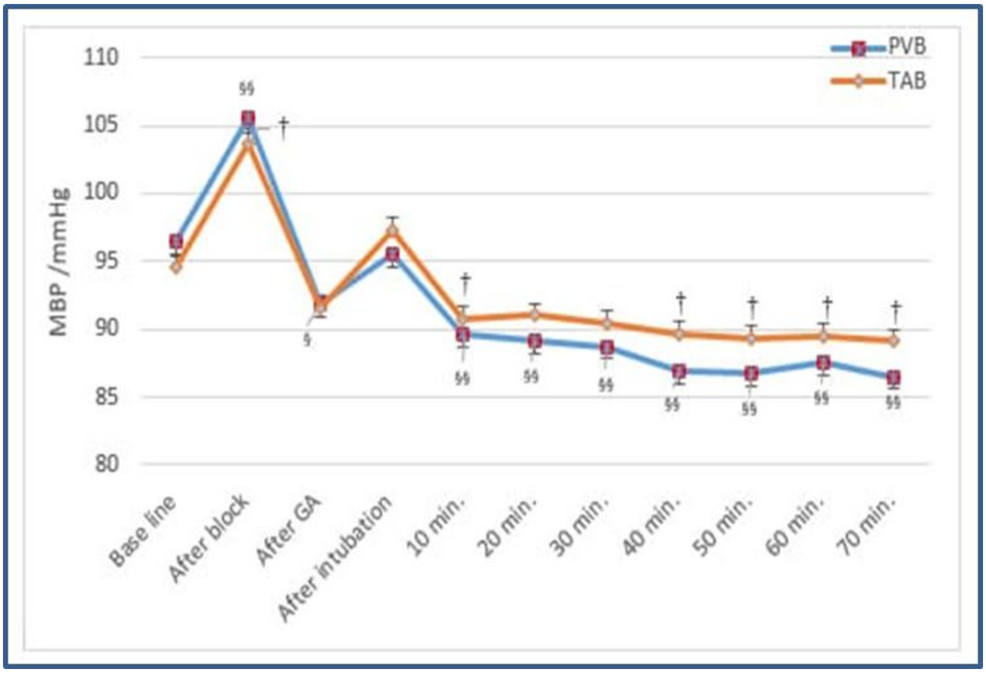

Figure 2. Mean values of mean blood pressure changes

Discussion

This study was carried out to delineate the efficient block whether Paravertebral Block (PVB) or Transverse Abdominis Plane Block (TAP) regarding pain scores, intra- and postoperative analgesic requirements, and anaesthetic consumption, taking in consideration their effect on liver functions and haemodynamic parameters and their safety in hepatic patients.

In this study, patients receiving PVB revealed significantly lower *pain scores* using visual analogue score (VAS) at different postoperative timings up to 24 hours compared to TAP group patients. Both blocks were considered safe being performed under ultrasound guidance. These results agree with Melinkov et al.[11] who compared blind thoracic PVB versus ultrasound-guided TAP block, and control groups in major gynaecological cancer surgery. They reported that both blocks significantly decreased pain scores at all recorded timings compared to the control group with superiority of PVB over TAP block. However, they considered TAP block more controllable and safer alternative being done under ultrasound guidance than PVB attained blindly in their study. Elsayed and Eldahshan[12] also went with our results when compared ultrasound guided TAP and PVB in patients underwent upper abdominal surgeries (incisional hernia, open cholecystectomy). They found significant lower pain scores in PVB group at the end of operation and up to 24 h after that.

On the other hand, Kamhawy et al.[13] exhibited comparable results among both ultrasound- guided thoracic PVB and TAP block regarding postoperative VAS except at 21 h and 24 h postoperatively when patients receiving PVB displayed significantly better scores at cough. This discrepancy may be due to the different surgical approach where cholecystectomy was conducted via open technique and small sample size in their study.

Aydin and Aydin[14] also investigated the effectiveness of single-dose unilateral preoperative versus postoperative ultrasound-guided PVB and control groups in non-hepatic patients undergoing elective laparoscopic cholecystectomy. They compared the outcomes of the block timing on intraoperative opioid dose and pain score. They found that no additional intraoperative opioid dose was needed in patients receiving preoperative PVB apart from the induction dose. They also recorded that patients receiving either preoperative or postoperative PVB showed significantly lower VAS scores versus the control group with superior analgesic spare of preoperative block patients than those of postoperative block only within the first 2 hours postoperatively.

In the current study, PVB group showed significant fewer number of patients demanding *postoperative analgesia*, longer duration to first analgesic dose and less total postoperative analgesic requirements than TAP group. These results are supported by previous studies conducted in open cholecystectomy,[13] major gynaecological surgery,[11] and upper abdominal surgeries.[12]

Our results go in accordance with those of Jindal, et al.[15] who compared ultrasound‑guided thoracic PVB with oblique subcostal TAP block in patients scheduled for open cholecystectomy. They revealed that patients in PVB group had lower pain score from 8 to 24 hours after surgery, less postoperative tramadol consumption, and reduction in the incidence of postoperative nausea and vomiting as opioid related adverse events than patients of TAP block group. Although, they noted PVB required longer time to be performed than TAP block yet statistically non-significant.

Recently, Vindal et al.[16] reported that TAP block guided laparoscopically was a good method that provided post-operative analgesia for patients undergoing laparoscopic cholecystectomy. It can deliver the drug inside the exact level under vision without the necessity for any special equipment or training. They revealed that it can decrease post-operative pain and analgesic consumption, aid early recovery and discharge from the hospital.

Shahmoradi et al.[17] concluded that preoperative TAP block done before open appendectomy is efficient to control postoperative pain and is accompanied with reduction of postoperative analgesic requirements compared to the control group. Also, Kitlik et al.[18] reported that TAP block reduced the 24 hours postoperative morphine consumption and postoperative visual analogue pain scores (VAS) both at rest and during movement in patients underwent living liver donors.

With reference to *intraoperative anaesthetic consumption,* PVB group showed significant less desflurane consumption guided by BIS when compared to TAP group. Previous studies did not compare the effects of both techniques on intraoperative anaesthetic consumption but the concept that regional analgesia can reduce inhalational anaesthetic consumption was supported by Kokulu et al.[19] who reported less desflurane consumption during laparoscopic cholecystectomy in TAP versus non-TAP group. Also, Lu et al.[20] stated that epidural anaesthesia using lidocaine decreased the end tidal desflurane needed by forty two percent when compared to general anaesthesia alone.

PVB group also showed significant less *intraoperative fentanyl* doses guided by haemodynamics when compared to TAP group. These results were confirmed by Melnikov et al.[11] who revealed significant less intraoperative fentanyl dose in the PVB group versus the TAP and the control groups during major gynaecological surgery. Meanwhile, less intraoperative sufentanil requirement was observed in TAP block group compared to non-TAP block during laparoscopic cholecystectomy.[19,21]

In this study, *liver function tests;* ALT, AST, and ALP were comparable at different recorded times, before operation, immediate and 24 hours postoperatively. This may be attributed to the short duration of the procedure and the usage of regional blocks ensuring less exposure to inhalational anaesthetics and hence preserving the postoperative hepatic functions. Salah and Algharabawy[22] compared ultrasound-guided TAP block combined with ilioinguinal- iliohypogastric nerve block versus ilioinguinal- illiohypogastric nerve block alone for patients undergoing inguinal hernia repair in patients with liver cirrhosis. They reported comparable results between both groups regarding pre and post-operative liver functions namely AST, ALT, INR, and Albumin.

Concerning *haemodynamic parameters*, HR and MBP raised twice after block and after intubation then decreased intraoperatively compared to base line in the two groups with lower readings in PVB group than TAP group. However, these changes were within clinically acceptable range without statistically significant difference among the two groups. These results go in accordance with Elsayed and Eldahshan[12] who revealed comparable readings of MBP in PVB group versus TAP group pre- and intra- operatively, as well as throughout the entire postoperative time in patients underwent upper abdominal surgeries. They revealed no significant postoperative increase in stress hormones; IL6 or serum cortisol level from baseline value up to 6 hours in both groups. This can explain the haemodynamic stability throughout the procedure. Also, Jindal et al.[15] informed that patients received either PVB or TAP block scheduled for open cholecystectomy showed stable haemodynamic parameters and no need for vasoactive drugs during the intraoperative period.

Limitation of this study that liver function tests performed to detect hepatic affection were the traditional ones while more sensitive and specific hepatic markers may be needed.

Conclusions

This study concluded that PVB is more effective and superior over TAP regarding less postoperative pain score, intraoperative anaesthetic, and analgesic consumption as well as postoperative pethidine requirement with comparable effect on liver functions and haemodynamics during laparoscopic cholecystectomy. Therefore, both techniques can be used safely in hepatic patients classified as Child A and B. It is recommended to perform further studies to compare both techniques in lengthy procedures as well more sensitive and specific markers may be required to reveal early liver affection in hepatic patients.

Conflicts of interest

The authors declare no conflict of interest.

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Ethics declaration:

Institutional Ethics Committee approval (Federal Wide Assurance Number: FWA00010609).

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