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ORIGINAL ARTICLE

Analgesic efficacy and outcome of transversus-abdominis plane block versus low thoracic-epidural analgesia after laparotomy in ischemic heart disease patients

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Abstract
Background Tranversus-abdominis plane (TAP) block is a novel technique alternative to central neural blockade in providing analgesia to the anterior abdominal wall. As such, we compared the analgesic efficacy of TAP block with low thoracic-epidural analgesia (TEA) in ischemic heart disease patients after abdominal laparotomy.
Methods Forty-four American Society of Anesthesiologists physical status (ASA) III patients, 59–75 years of age and undergoing elective upper abdominal surgery under general anesthesia, were assigned randomly to receive either continuous low TEA or intermittent administration of local anesthetic in TAP block. Supplemental analgesia was provided with intravenous morphine with patient-controlled-analgesia. Morphine consumption and pain intensity using verbal rating scale (VRS) at rest and coughing over the first 48 h were recorded.
Results Whereas all patients in the TAP group required morphine, 16 (72.2 %) patients in TEA group received morphine postoperatively ($p = 0.021$). Morphine consumed on day 1 and day 2 was 11.5 mg (7.5–12.3 mg) and 7mg (4.5–8 mg) for the TEA group, while in the TAP group, it was 18 mg (16–19 mg) and 11 mg (10–13 mg), respectively ($p < 0.001$). Time for first request of morphine was 311.2 ± 18.5 min in the TEA group versus 210 ± 22.2 min in the TAP group ($p < 0.001$). VRS at rest and cough were lower in the TEA group compared with the TAP group at 1, 6, 12, 18, 24, 36 and 48 h ($p < 0.001$). Incidence of hypotension and ephedrine administration were significantly higher in the TEA group than in the TAP group ($p = 0.007$).
Conclusion Low TEA reduced morphine consumption and provided a higher analgesic efficacy compared with TAP block after laparotomy in ischemic heart disease patients.

Keywords TAP block · Epidural analgesia · Ultrasound

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Introduction

Patients with ischemic heart disease scheduled for abdominal surgery are undoubtedly vulnerable for perioperative complications [1]. The choice of analgesic technique in cardiac patients with the substantial possibility of hemodynamic instability is not a simple task. Transversus-abdominis plane (TAP) block, a new regional technique providing analgesia to the anterior abdominal wall and parietal peritoneum, was first described in 2001 [2]. Over the last decade, ultrasound (US)-guided TAP block has gained much popularity for better localization and deposition of local anesthetic with improved accuracy and success rate [3, 4]. On the other hand, the epidural analgesia is still considered to be the golden standard technique, with reduced perioperative cardiopulmonary complications, pulmonary embolism and blood loss [5]. In ischemic heart disease patients, improper pain control exposes these patients to postoperative morbidity and mortality.

There are infrequent reports comparing the efficacy of the TAP block with the thoracic epidural analgesia following upper abdominal surgery [6]. Moreover, the role of TAP block for control of pain of visceral origin has not been widely evaluated before. Therefore, this study was designed to compare morphine consumption and analgesic efficacy between low TEA and TAP block in the first 48 h after upper abdominal surgery in patients with ischemic heart disease.

Methods

After approval of our scientific and research committee, written informed consent was taken from 44 American Society of Anesthesiologists (ASA) physical status III patients (ages 59–75 years) undergoing elective upper abdominal surgery between March 2011 and August 2012. During the preoperative visit, conveyance of the details of procedures to each patient, demographic data recording and airway assessment were carried out by a senior anesthetist. Patients with proven coronary artery disease had at least one of the following criteria: history of myocardial infarction more than three months in duration, positive exercise electrocardiography (ECG) test, stable angina pectoris (defined as chest pain lasting for a few minutes, associated with ECG changes and relieved with rest or medication) or presence of pathological Q on ECG.

Patients were excluded if they had a history of sensitivity to local anesthetic, previous history of spinal surgery, a body mass index (BMI) $\geq$ 40/kg/m^2, or if ejection fraction was $<$ 20 % by an echocardiography. Anti-ischemic therapy was reviewed and clopidogrel was discontinued 7 days before surgery after cardiac consultation. Patients were randomly allocated to receive either low thoracic epidural analgesia (TEA group = 22 patients) or bilateral TAP block with catheter insertion (TAP group = 22 patients), according to a computer-generated sequence. All patients were connected to an O_2 face mask and premedicated with midazolam 0.05 mg/kg IV in divided doses just before surgery. All patients were monitored intraoperative with five-lead ECG, non-invasive arterial pressure, pulse oximeter, and capnography. An arterial line and right internal jugular venous catheter were inserted for blood gas analysis and central venous pressure (CVP) measurements. All patients received general anesthesia with fentanyl 1.5 μg/kg, etomidate 0.3 mg/kg and cisatracurium 0.15 mg/kg. Anesthesia was maintained with sevoflurane 1–2 % in 50 % O_2 in air mixture and infusion of fentanyl at a rate of 0.5 μg/kg/h. Fluid plan was adjusted to maintain CVP between 8–12 cm H_2O with lactated Ringer's solution, and blood loss was replaced to maintain hemoglobin level above 10 g/dl. Before the induction of anesthesia, a 20-G epidural catheter (Perifix, B Braun, Melsungen AG, Germany) was inserted for the TEA group patients by a senior anesthetist not involved in the study, under a septic precaution in lateral position at level T9–T10, midline approach with low resistance technique with saline using an 18-G, 8 cm Tuohy needle (Perifix, B Braun, Melsungen AG, Germany). In the TAP group, bilateral TAP block was performed by another senior anesthetist also not involved in the study, with the patient in supine position and using the same Tuohy needle under ultrasound (US) guidance after the end of surgery. A linear high frequency (6–13 MHz) US probe (Sonosite, Bothell, WA) after sheathing under a septic precaution was placed midway between the iliac crest and costal margin, and was moved medially in the oblique direction towards the costal margin until the tranversus-abdominis muscle was identified posterior to the rectus-abdominis muscle. The Touhy needle was inserted medially in line with the US probe into the fascial plane of transversus-abdominis muscle, and the same epidural catheter was threaded on either sides of the abdomen. Upon insertion of the catheter, 5 ml saline was injected to distend the transverses-abdominis plane. Before a patient's emergence from anesthesia, 10 ml of 0.125 % bupivacaine was injected in increments in the catheter of those in the TEA group, followed by 6–8 ml/h of the same concentration prepared by a dedicated nurse. In the TAP group, 20 ml of 0.25 % bupivacaine was injected in increments in the catheter on each side, then 15 ml of same concentration was injected every 8 h on each side by another dedicated nurse not sharing in the study. After recovery from anesthesia, patients were shifted to the intermediate care unit, and received a standard postoperative patient-controlled analgesia (PCA) with morphine after testing the sensory level with pin prick and ice pack. The PCA pump (Graseby 3300, Graseby Medical Ltd, Watford, UK), was programmed to deliver 1 mg morphine bolus per press with a lockout interval of 10 min. Day 1 and day 2 morphine consumption as well as time to first request of morphine analgesia were recorded. All patients were asked to give a score for their pain at rest and upon coughing, and pain severity was measured at 1, 6, 12, 18, 24, 36 and 48 h postoperative, using the verbal rating scale (VRS; 0 = no pain, 10 = worst pain).

Patients were also assessed according to a sedation scale (awake and alert = 0; quietly awake = 1; asleep but arousable = 2; deep sleep = 3) at 4, 12 and 24 h.

Before discharge to the surgical ward, patients were asked to rate their satisfaction for postoperative analgesia according to a satisfaction score (poor = 0; fair = 1; good = 2; excellent = 3).

Oxygen saturation (SPO2), arterial blood pressure and heart rate were recorded every 15 min in the first 2 h, and then hourly in the postoperative period. Postoperative events like arrhythmias were recorded and treated. All data were recorded by an anesthetist not sharing in the study. When mean blood pressure dropped below 70 mmHg, the epidural analgesia was held, the patient received 100–200 ml isotonic saline (0.9 %), and IV bolus of ephedrine (3 mg per dose) was given.

The primary outcome was to measure morphine consumption at day 1 and day 2 and to record the time to first request for morphine, while the secondary outcome was to measure pain at rest and upon coughing according to VRS.

Postoperative sedation, hemodynamic status, incidence of O_2 desaturation, time elapsed for recovery of bowel habit, time for ambulation, as well as patients' satisfaction with analgesia, were recorded. ECG was recorded 6 h postoperatively, and cardiac markers were requested if there was any new ischemic changes or chest pain. Postoperative morbidity and mortality were also recorded.

Statistical analysis

The required sample size was calculated using IBM© SPSS© Sample Power© (IBM© Corp., Armonk, NY). The primary outcome measure was the cumulative morphine consumption by PCA in the first 48 h after surgery.

A previous study reported that the mean (SD) 48-h consumption of morphine after abdominal hysterectomy was 26.8 (19.8) mg in patients receiving TAP block [7]. Thus, it was estimated that a sample size of 22 patients in each study group would have a power of 84 % to detect a reduction in morphine consumption by two-thirds of that reported by such study. The test statistic used was the unpaired *t* test, and type I error was set at a two-sided error of 0.05.

Statistical analysis was done on a personal computer using IBM© SPSS© Statistics version 21 (IBM© Corp., Armonk, NY). The Kolmogorov–Smirnov goodness of fit test was performed to test the normality of numerical data distribution. Normally distributed numerical data are presented as mean and standard deviation, whereas skewed data are presented as median and interquartile range. Qualitative data are presented as number and percentage. For normally distributed numerical data, the independent-samples Student *t* test was used to compare the difference in the means between the two study groups. For skewed numerical data, the Wilcoxon rank sum test was applied. The Pearson Chi square test was used for comparison of the two groups as regards differences in categorical data. Fisher's exact test was applied in place of the Chi square test if > 20 % of the cells in any contingency table had an expected count of < 5.

All *P* values are two-sided. $P < 0.05$ is considered statistically significant.

Results

A total of 44 patients with ischemic heart disease were included in the study and no patient was excluded. The two groups were comparable with respect to age, sex, BMI, comorbidities, preoperative ECG, left ventricular ejection fraction, surgical procedures, duration of surgery and postoperative ECG changes ($p > 0.05$), as shown in Table 1. Sixteen patients in the TEA group received morphine, compared with 22 patients in the TAP group ($p = 0.021$), as shown in Table 2. Morphine consumption on day 1 and day 2 was significantly lower in the TEA group [11.5 mg (7.5–12.3 mg) and 7 mg (4.5–8.0mg)] in comparison with the TAP group [18 mg (16–19 mg) and 11 mg (10–13 mg)], ($p < 0.001$), as shown in Table 2 and Fig. 1. The time for the first request for morphine was significantly longer in the TEA group (311.2 ± 18.5 min)

Table 1 Demographic and operative data

Variable	TEA group ($n = 22$)	TAP group ($n = 22$)	*P* value
Age (years)	66.3 (5.4)	66.4 (4.8)	0.930
Male/female	10/12	11/11	0.763
BMI (kg/m^2)	31.2 (3.0)	30.7 (3.5)	0.584
Comorbidities			0.455
Dyslipidemia	5 (22.7 %)	9 (40.9 %)	
Hypertension	8 (36.4 %)	3 (13.6 %)	
DM	3 (13.6 %)	3 (13.6 %)	
CRD	0 (0 %)	1 (4.5 %)	
Hypertension plus DM	3 (13.6 %)	4 (18.2 %)	
Hypertension plus CRD	3 (13.6 %)	2 (9.1 %)	
Preoperative ECG			0.858
Extrasystoles	4 (18.2 %)	5 (22.7 %)	
Old MI	8 (36.4 %)	9 (40.9 %)	
Myocardial ischemia	10 (45.5 %)	8 (36.4 %)	
Ejection fraction (%)	35 (5.6)	35.2 (5.9)	0.896
Surgical procedure			
Large bowel surgery	7 (31.8 %)	6 (27.3 %)	1.000
Small bowel surgery	5 (22.7 %)	6 (27.3 %)	
Gastrectomy	5 (22.7 %)	4 (18.2 %)	
Abdominal Hernia	5 (22.7 %)	6 (27.3 %)	
Operative time (min)	195.7 (19.7)	202.2 (23.9)	0.331
Intraoperative ECG changes			0.511
Nil	14 (63.6 %)	10 (45.5 %)	
PAC	3 (13.6 %)	4 (18.2 %)	
PVC	5 (22.7 %)	8 (36.4 %)	

Data are expressed as mean (SD) or number (%)

BMI body mass index, *DM* diabetes mellitus, *CRD* chronic renal disease, *MI* myocardial infarction, *PAC* premature atrial contraction, *PVC* premature ventricular contraction

Table 2 Analgesic consumption in the two study groups

Variable	TEA group ($n = 22$)	TAP group ($n = 22$)	*P* value
Need for morphine by PCA (*n*)	16 (72.7 %)	22 (100 %)	0.021
Time to first dose of morphine (min)	311.2 (18.5)	210.0 (22.2)	< 0.001
Morphine consumption (mg) on day 1	11.5 (7.5–12.3)	18 (16–19)	< 0.001
Morphine consumption (mg) on day 2	7 (4.5–8)	11 (10–13)	< 0.001

Data are expressed as number (%), mean (SD) and median (interquartile range)

PCA patient-controlled analgesia

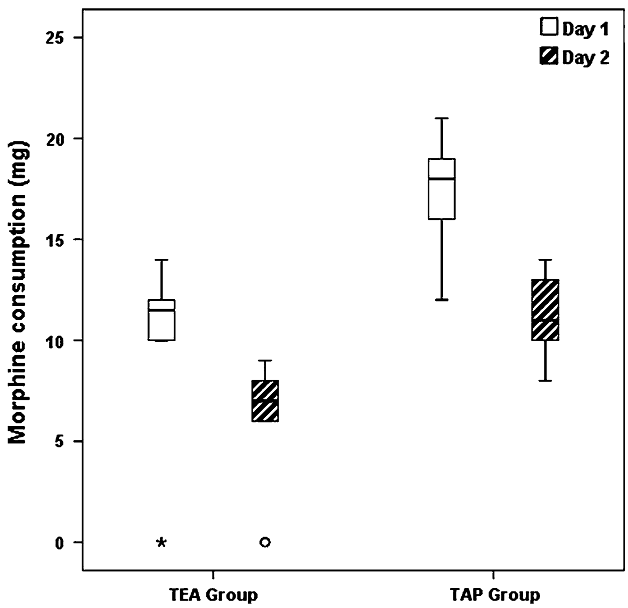

Fig. 1 Cumulative PCA morphine consumption on postoperative day 1 and day 2. *Box* represents interquartile range. Transverse *line across box* represents median. *Error bars* represent minimum and maximum values excluding outliers (*circles*) and extreme observations (*asterisks*). *TEA* thoracic epidural analgesia, *TAP* transversus abdominal plane

than in the TAP group (210 ± 22.20 min), ($p < 0.001$) as shown in Table 2.

The VRS at rest and upon coughing was significantly lower in the TEA group than in the TAP group at 1, 6, 12, 18, 24, 36 and 48 h, ($p < 0.001$), as shown in Table 3 and Figs. 2 and 3, respectively. Sedation score was significantly decreased in the TEA group compared to the TAP group at 4, 12 and 24 h after surgery ($p < 0.020$, < 0.030 and < 0.001, respectively, as shown in Table 4).

Incidence of hypotension was higher in the TEA group than in the TAP group, ($p = 0.007$) and the number of patients who received ephedrine was significantly higher in the TEA group (45.5 %) than in the TAP group (9.1 %), as shown in Table 4.

Table 3 Postoperative pain scores

Variable	TEA group ($N = 22$)	TAP group ($N = 22$)	*P* value
VRS at 1 h			
At rest	3 (3–4)	5 (5–5)	< 0.001
On coughing	3 (3–4)	6 (5–7)	< 0.001
VRS at 6 h			
At rest	2 (2–3)	4 (4–5)	< 0.001
On coughing	3 (3–4)	5 (5–6)	< 0.001
VRS at 12 h			
At rest	2 (2–3)	4 (4–5)	< 0.001
On coughing	3 (3–4)	5 (4–6)	< 0.001
VRS at 18 h			
At rest	2 (1–3)	4 (4–5)	< 0.001
On coughing	3 (2–3)	5 (4–5)	< 0.001
VRS at 24 h			
At rest	2 (1–3)	4 (3–4)	< 0.001
On coughing	3 (2–3)	5 (4–5)	< 0.001
VRS at 36 h			
At rest	2 (1–2)	4 (3–4)	< 0.001
On coughing	2 (2–3)	4.5 (4–5)	< 0.001
VRS at 48 h			
At rest	1 (1–2)	4 (3–5)	< 0.001
On coughing	3 (2–3)	4.5 (4–5)	< 0.001

Data are expressed as median (interquartile range)

VR verbal rating scale

Time elapsed to pass flatus was significantly shorter in the TEA group than in the TAP group (44.8 ± 6.4 versus 51.8 ± 8.9 h, respectively), ($p = 0.005$), while time to ambulation was longer in the TEA group than in the TAP group (62.5 ± 12.3 versus 48 ± 9 h, respectively), ($p < 0.001$) as shown in Table 4. Patient satisfaction for postoperative analgesia was significantly higher in the TEA group than in the TAP group [3 (2–3) versus 1 (0–2)], ($p = 0.001$), as shown in Table 4.

No chest pain or new major events were observed in postoperative ECGs, such as ST segment elevation or depression or bundle branch block. All arrhythmias reported in postoperative ECG were mainly atrial extrsystole that responded to intravenous verapamil 5 mg. Two cases in each group had a unifocal premature ventricular extrasystole, but no hemodynamic instability was recorded, as shown in Table 4. Only one patient in the TAP group had postoperative pulmonary edema, and O_2 saturation dropped to 83 % on day 2. This patient was connected to

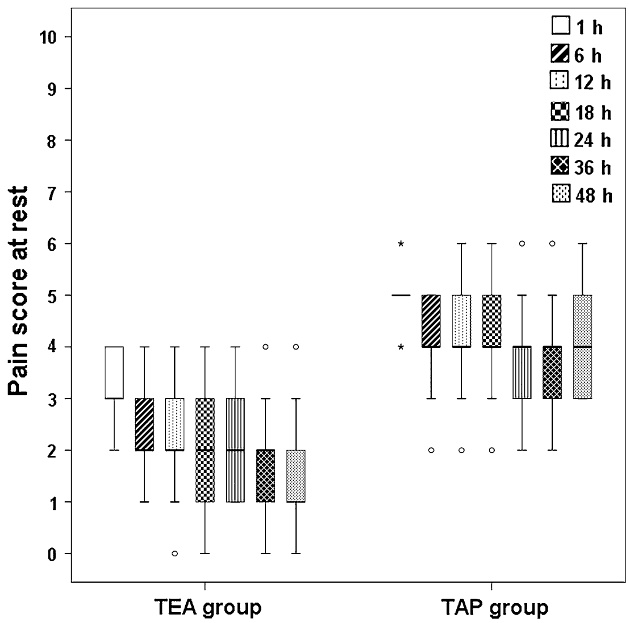

Fig. 2 Box plot showing pain scores at rest in both study groups. *Box* represents interquartile range. *Horizontal line across box* represents median. *Error bars* represent minimum and maximum values excluding outliers (*circled markers*) and extreme observations (*asterisks*)

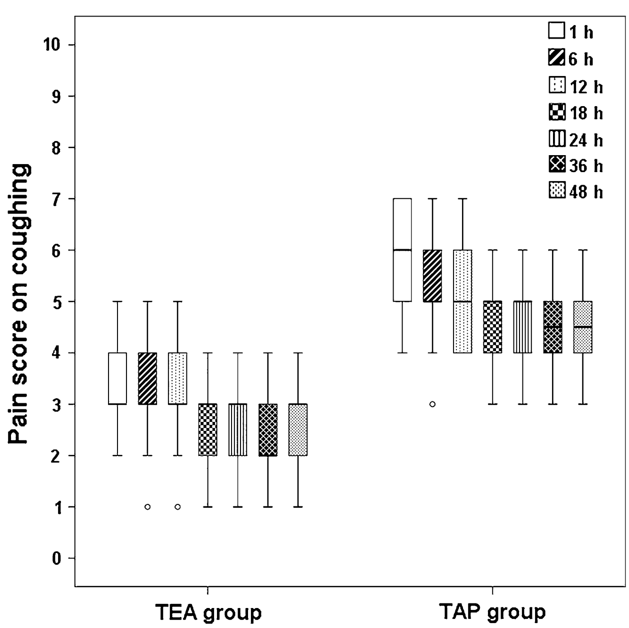

Fig. 3 Box plot showing pain scores on coughing in both study groups. *Box* represents interquartile range. *Horizontal line across box* represents median. *Error bars* represent minimum and maximum values excluding outliers (*circled markers*)

noninvasive ventilation using continuous positive airway pressure mode of 10 cm H_2O, and responded to IV bolus of furosemide 80 mg and nitrate therapy, but no rise in cardiac markers (creatine kinase-MB and troponin-I levels) were recorded. No cardiac mortality was recorded and all patients were discharged to home.

Table 4 Sedation scores and side effects

Variable	TEA group ($N = 22$)	TAP group ($N = 22$)	*P* value
Postoperative sedation score			
4 h after surgery	1 (0–1)	1 (1–2)	0.020
12 h after surgery	1 (1–1)	1 (1–2)	0.030
24 h after surgery	1 (0–1)	1 (1–2)	0.001
Incidence of hypotension	10 (45.5 %)	2 (9.1 %)	0.007
Need for ephedrine			0.007
Nil	12 (54.5 %)	20 (90.9 %)	
1 Dose	1 (4.5 %)	0	
2 Doses	5 (27.7 %)	2 (9.1 %)	
3 Doses	4 (18.2 %)	0	
Postoperative ECG changes			0.568
Nil	13 (59.1 %)	10 (45.5 %)	
PAC	4 (18.2 %)	3 (13.6 %)	
SVT	3 (13.6 %)	7 (31.8 %)	
PVC	2 (9.1 %)	2 (9.1 %)	
Time to passing flatus (h)	44.8 (6.4)	51.8 (8.9)	0.005
Time to ambulation (h)	62.5 (12.3)	48 (9)	< 0.001
Patient satisfaction score	3 (2–3)	1 (0–2)	0.001

Data are expressed as median (interquartile range), number (%) and mean (SD)

PAC premature atrial contraction, *SVT* supraventricular tachycardia, *PVC* premature ventricular contraction

Discussion

This study showed that in ischemic heart disease patients, both low TEA and TAP block provided a satisfactory control of postoperative pain with almost negligible postoperative morbidity after upper abdominal surgery. However, VRS values and morphine consumption were lower in the TEA group with a higher incidence of hypotension in comparison with the TAP group.

Ischemic heart disease is a major predictor of perioperative morbidity and mortality. Therefore, optimal management of perioperative analgesia has several benefits like reduction of stress response [8], morbidity [9] and improving myocardial outcome [10].

Several studies have evaluated the outcome of various anesthetic drugs and techniques on cardiac morbidity; however, there is no ideal myocardial protective technique [11–13].

Abdominal wall incision is a major component of pain experienced after abdominal surgery. The abdominal wall consists laterally of three muscle layers: the external oblique, the internal oblique, and the transversus-abdominis and their fascial sheathes, while the central abdominal wall includes the rectus-abdominis muscle and its fascial sheath. This muscular wall is supplied by afferent nerves that course through the transverses-abdominis neuro-fascial plane.

Efficiency of analgesic technique in patients with ischemic heart disease is always questionable. The preferred standard technique for postoperative analgesia is either epidural technique or PCA with opioids. In absence of any contraindication, regional anesthesia is an effective approach of choice for intraoperative and postoperative analgesia during abdominal surgeries. However, mismanagement of either technique in elderly patients with ischemic heart disease may precipitate serious cardiorespiratory complications. From an anesthetic point of view, epidural technique in particular has its side effects and potentially catastrophic risks, as well as a reported failure rate from 17 to 37 % [14–16]. Not only cases of sepsis, but also varying degrees of vasodilatation that could be detrimental in sympathetically driven circulation of cardiac patient, make central neuraxial anesthesia unsuitable. On the other hand, local anesthetic deposition in TAP is a simple technique that can provide analgesia to the anterior abdominal wall (dermatomes T7–L1) and has provided low pain scores and less morphine requirements [17]. This technique is reliable and safe, because the block is given under real-time ultrasound scanning, avoiding the risk of either peritoneal puncture or visceral damage as observed in previous techniques [18].

However, for surgery deep to the parietal peritoneum, like bowel resection due to either ischemic events or tumors, TAP block is obviously insufficient for visceral pain control and thereby systemic analgesic supplements will be required.

The above results of this study are consistent with previous studies that reported analgesic benefits of TAP block in abdominal surgeries [19–21]. However, McMorrow and his colleagues reported that TAP block in 80 parturients after caesarean section did not improve postoperative analgesia compared with spinal morphine [22]. However, McMarrow mentioned several limitations, such as that blind technique in the absence of ultrasound did not guarantee correct placement of the needle, and did not demonstrate loss of dermatomal distribution to test the block. Another contradictory result to our data has been reported by Castello and his colleagues [23], despite performing TAP block under real-time ultrasound guidance. However, the last two studies did not raise the question of whether this failure was attributed to efficacy of block for intraperitoneal versus extraperitoneal surgeries, performance of the technique, or statistical level.

There is some argument regarding the extent of sensory blockade under TAP block. Although Mc Donnell et al. [17] reported a T7–L1 spread of block after a single injection; Tran et al. [24] reported that spread of local anesthetic under ultrasound guidance failed to spread above T10, alleging that the block is suitable for lower abdominal surgery. However, McDonnell et al. [17] reported statistically significant reduction in morphine requirements after large bowel resection in patients receiving TAP block with 20 mL of 0.375 % levobupivacaine ($p < 0.05$). Moreover, Hebbard et al. [25] reported that subcostal TAP block provided postoperative analgesia after upper abdominal surgery in a series of 20 patients.

On the other hand, TEA can provide optimal analgesia for abdominal wall structures as well as deep visceral pain. However, it is unquestionably contraindicated in sepsis, hemodynamic instability or anticoagulative medications, which necessitate importance of another safe and reliable technique. In the present study, all the cases were elective and the decision for the course of epidural analgesia was predicted to be safe.

A few studies have compared continuous TEA with bilateral TAP block with catheter, but not in cardiac patients. Niraj et al. [6] reported that rescue analgesia with tramadol was significantly higher in TAP block (400 mg) than TEA (200 mg) ($p = 0.002$), which is consistent with our result of high morphine consumption in the TAP group. However, the values of visual analogue scores in their groups were statistically insignificant, and these were not reflected by patient satisfaction.

Delayed postoperative recovery of bowel motility after abdominal surgery is often related to bowel manipulation, inhaled anesthetics and systemic opioids. In our study, the earlier passage of flatus in the TEA group than in the TAP block group could be explained on the basis of lower opioid consumption [26, 27]. By contrast, the incidence of hypotension, risk of orthostatic hypotension and delayed ambulation are drawbacks of the epidural blockade [28], which passively influence accelerated postoperative recovery in comparison with TAP block. However, in the present study, low levels of TEA refined hypotensive episode response to conventional treatment.

There are several limitations in the present study. First, being a non-double–blinded study carries risk of some bias. However, this was too difficult to avoid, because of the medical staff's understanding of the nature of this study. Second, it may be argued that those ischemic heart disease patients are more vulnerable to hypotension after TEA. However, in presence of low levels of TEA, hypotensive episodes were transient and easily controlled with either fluid therapy or small doses of ephedrine. Third, although

TEA delayed postoperative ambulation, we might have had a satisfactory outcome if we reduced the concentration of bupivacaine on the 2nd day.

In conclusion, this study demonstrated that low TEA provided better postoperative analgesia, less morphine consumption and earlier recovery of bowel activity without serious impact on hemodynamic compared with TAP block. Meanwhile, TAP block could be a potential alternative analgesic approach if an epidural approach was contraindicated.

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Conflict of interest None declared.

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