

# Contribution of Regional anaesthesia on health economics: cost effectiveness of preemptive TAP block in Laparoscopic cholecystectomy

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## Abstract

**Objective:** Regional anaesthesia can play a vital role as a supplement of general anaesthesia in laparoscopic cholecystectomy surgery. In this study we postulated that preemptive bilateral dual transversus abdominis plane (BD - TAP) block has the potential to reduce the requirement of volatile anaesthetic, muscle relaxant, postoperative opioid demand and shortening of hospital stay in laparoscopic cholecystectomy surgery, ultimately total cost.

**Method:** Total 40 patients ASA I - II undergoing laparoscopic cholecystectomy surgery were randomly assigned into two equal groups of 20 patients each. All patients received preemptive IV Paracetamol (15 mg/kg), IV Diclofenac (1 mg/kg) and BD - TAP block. Block was performed with bilateral Subcostal (medial to linea semilunaris) and lateral TAP injection with total 70 ml drug volume. Group A received a drug solution containing plain Bupivacaine 15 ml (0.1%), Lidocaine 35ml (1%), Dexamethasone 10 mg. Group B received a total 70 ml normal saline injection. Maintenance of anaesthesia was accomplished with low flow anaesthesia (0.5 - 1.0 L/min) accompanied by BIS monitoring, maintaining BIS index 45 - 55. All patients received Sevoflurane with N<sub>2</sub>O 60%. Muscle relaxation was guided by TOF monitoring and supplemental dose was adjusted by the TOF counting. Postoperative analgesia was maintained with IM pethidine in p.r.n dose and oral paracetamol in regular doses. Total opioid requirement, muscle relaxant and volatile anaesthetic used and duration of postoperative hospital stay were recorded.

**Result:** BD - TAP block reduced the Sevoflurane requirement, group A 5.5 (± 0.05) ml/ hr and group B 6.8 (± 0.9) ml/ hr (p < 0.05). It also reduced the requirement of Rocuronium in comparison to control group, group A 49.5 (± 2.85) mg and in group B 58 (± 4.21) mg (p < 0.05). Postoperative pethidine requirement, group A 135 (± 22.9) mg and group B 375 (± 46) mg (p < 0.05). It also facilitated rapid hospital discharge, group A 1.16 (± 0.5) days and group B 2.03 (± 0.5) days (p < 0.05).

**Conclusion:** In this study it is demonstrated that preemptive (BD - TAP) block in laparoscopic cholecystectomy surgery is associated with reduced requirement of volatile anaesthetic, muscle relaxant and postoperative opioid consumption. It seems that regional anaesthesia has a big contribution in modern health economics and national health policy should consider this issue.

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## Background:

Combined regional and general anaesthesia has been used in recent years for better perioperative outcome. The combined general and neuraxial anaesthesia has the potential to reduce the requirement of volatile anaesthetic agents<sup>1</sup> and neuromuscular blocking agents (NMBA).<sup>2</sup>

Adequate analgesia with regional anesthesia could provide better hemodynamic stability in the perioperative period. However, epidural anesthesia is often contraindicated in patients with cardiovascular disease because of anticoagulants and/or antiplatelet agents. In addition, epidural anesthesia can easily induce

hypotension or heart rate abnormalities. Fascial plane blocks brought a new dimension in anaesthesia. It is mainly used for postoperative analgesia but the advent of new techniques can have a greater impact in the intraoperative period. These blocks have also been shown to reduce opioid use during surgery, indicating that they can reduce surgical stimulation. Not all approaches of TAP block are effective for complete dermatomal coverage of the abdomen. Subcostal TAP block medial to the linea semilunaris covers dermatome T7 to T9. Lateral TAP block covers dermatome T10 to T12. So we hypothesized that application of bilateral dual TAP block (BD - TAP) could be the answer to cover T<sub>7</sub> - T<sub>12</sub>.

Reduced requirement of NMBA and opioid is very important for fast tract surgery. T. Karaman et al. demonstrated that TAP block in total abdominal hysterectomy reduced requirement of volatile anaesthetic dose in Sevoflurane - Remifentanyl anaesthesia.<sup>3</sup> TAP block provides better postoperative pain management with reduced pain in coughing, early mobilisation and opioid consumption.<sup>4</sup> Støving et. al. showed that TAP block is associated with consistent and significant muscle relaxing effect of the abdominal wall.<sup>5</sup> Eappen et al. Proposed decreased afferent input to the brain could lessen excitatory descending modulation of the spinal cord motoneurons and suppress motor function.<sup>18</sup>

In this study we evaluated the effect of BD - TAP block in laparoscopic cholecystectomy surgery. We measured the intraoperative requirement of Sevoflurane in 60% N<sub>2</sub>O, total dose of NMBA, requirement of opioid and other supplemental drugs to balanced anaesthesia and hemodynamic stability, postoperative opioid consumption and duration of hospital stay.

### Materials and methods:

This is a double blind case control study performed in Apollo Hospitals Dhaka after getting approval from the hospital clinical research ethical board. Patients with significant cardiac and endocrinological, neurological diseases, or coagulation disorders, allergy to local anesthetics, technically difficult patients to perform blocks were excluded from the study. Operations that started as laparoscopy but transitioned to open surgery for a surgical reason were also excluded.

Total 40 patients ASA I - II, age 20 - 60 years, BMI < 35 kg/m<sup>2</sup> undergoing laparoscopic cholecystectomy surgery were randomly assigned into two equal groups of 20 patients each. Simple random sampling technique was used.

All patients received preemptive IV Paracetamol (15 mg/kg) and IV Diclofenac (1 mg/kg) as part of multimodal preemptive analgesia.

BIS sensor and TOF watch electrode was attached to every patient before induction of anaesthesia.

Anaesthesia workstation with Dräger Primus Infinity empowered, Depth of anaesthesia with BIS™ Complete 2-Channel Monitor, peripheral nerve stimulator TOF - watch SX were used in this study.

All patients were induced to anaesthesia with Propofol 1 mg/kg, Fentanyl 1 µg/kg, midazolam 2 mg. No inhalation anaesthetic was used during induction. After induction of anaesthesia, peripheral nerve stimulator was calibrated. Rocuronium was administered at 0.5 mg/kg.

Endotracheal intubation was done after TOFR became 0. Maintenance muscle relaxation was maintained with supplemental increment Rocuronium at 0.15 mg/kg after appearance of second TOF count.

After intubation maintenance of anaesthesia was achieved with initially FGF rate at 4 L/min, O<sub>2</sub> 40%, N<sub>2</sub>O 60% and dial of Sevoflurane vaporizer set at 2 v/v%. After achieving end tidal Sevoflurane concentration 1.0, FGF was reduced to 0.5 L/min and Sevoflurane vaporizer dial at 2.0 v/v% maintaining BIS index 45 - 55.

If BIS index < 45 then Sevoflurane vaporizer dial was set to 1.5 v/v% and if BIS index > 55, dial was set in 2.5 v/v%. Age and weight adjusted MAC of Sevoflurane to maintain BIS index 45 - 55 was noted for every patient.

During maintenance of anaesthesia all patients were mechanically ventilated to maintain PaCO<sub>2</sub> 30 - 32 mmHg. All patients were monitored with electrocardiography (ECG), peripheral oxygen saturation (SpO<sub>2</sub>), heart rate (HR), and noninvasive blood pressure (NIBP).

Regional anaesthesia procedure was conducted after endotracheal intubation by another anaesthetist who was an expert on regional

anaesthesia and blinded on the drug preparation. Patients of group A received preemptive bilateral dual transversus abdominis plane block (BD - TAP) as part of multimodal analgesic approach and group B also received BD - TAP injection but with normal saline.

BD - TAP was performed with bilateral Subcostal (medial to linea semilunaris) and lateral TAP block. Total 70 ml of drug volume was injected. Group A received drug solution containing plain Bupivacaine 15 ml (0.1%), Lidocaine 35ml (1%), Dexamethasone 10 mg.

On pneumoperitoneum if HR or mean arterial pressure (MAP) increased > 25%, supplemental Fentanyl was administered 20 µg bolus. In other occasions, if MAP raised > 25% then IV Labetalol 20 mg bolus was administered.

15 minutes before completion of surgery vaporizer setting was reduced to 0 v/v% maintaining 0.5 L/min FGF. Following completion of suturing, the ventilator was switched to spontaneous ventilation and the system was purged with 100% oxygen at 6L/ min. Reversal drugs (Neostigmine and Glycopyrrolate) were administered after attaining at least TOF count three or more. Extubation was done after attaining TOFR > 90% and BIS index > 70.

After completion of surgery, anaesthetic machine was checked to collect the machine derived total Sevoflurane usage data. Soda lime was changed following each surgery.

After patients were shifted to PACU, a trained nurse who was experienced in pain assessment and blinded about the study group, assessed the level of analgesia 30 mins interval in PACU with numerical pain rating scale (NPRC). IM Pethidine was administered if NPRC > 4. Patients were shifted to the postoperative ward after attaining modified Aldrete score > 9.

Postoperative analgesia was maintained with IM pethidine in p.r.n dose and oral Acetaminophen in regular doses. Patients were discharged from hospital following the "Postanaesthesia Discharge Scoring System (PADS) for Determining Home-Readiness" proposed by Marshall S, Chung F.

Total opioid requirement, muscle relaxant and volatile anaesthetic used and duration of postoperative hospital stay were recorded.

### Statistical analysis:

SPSS software version 20.0 (Statistical Package for the Social Sciences Inc, Chicago, IL, USA) was used for statistical analysis. Distribution of variables was evaluated with the Kolmogorov-Smirnov test. Variables are expressed as mean ( $\pm$ ) standard deviation (SD). The t-test was used to compare variables between groups if variables were normally distributed. Statistical significance level was set at  $P < 0.05$ .

### Results:

Sixty patients were enrolled in this study. There was no significant difference between the groups in terms of age, sex, BMI and duration of anaesthesia of the patients. In all patients, the layers of the abdominal wall were easily visualized and the TAP block was performed after one attempt without complications.

### Demographic variables:

variables	Group A (BD - TAP)	Group B (control)	P value
Age (yrs)	43.7 ( $\pm 4.16$ )	46.0 ( $\pm 9.68$ )	0.25
Sex (M/F)	12/8	9/11	0.34
BMI	30.23 ( $\pm 2.18$ )	29.09 ( $\pm 2.15$ )	0.13
Duration of anaesthesia (min)	130.5 ( $\pm 55.77$ )	129 ( $\pm 27.97$ )	0.47

In group A patients, age and weight adjusted Sevoflurane MAC 0.6 ( $\pm 0.05$ ) was adequate to maintain BIS index 45 - 55 compared to 0.8 ( $\pm 0.2$ ) in the group B. So mathematically the truncal block reduced the MAC of Sevoflurane 25%.

In group A patients hourly Sevoflurane consumption was 5.5 ( $\pm 0.05$ ) ml/hr, compared to 6.8 ( $\pm 0.9$ ) ml/hr in the group B. Here 19.11% less Sevoflurane consumption in group A patients is statistically significant ( $p < 0.05$ ).

In term requirement of muscle relaxant, group A required 49.5 ( $\pm 2.85$ ) mg Rocuronium for anaesthetic duration of 130.5 ( $\pm 55.77$ ) min where the group B required 58 ( $\pm 4.21$ ) mg of Rocuronium for anaesthetic duration of 129 ( $\pm 27.97$ ) min. Group A used 14.66% less Rocuronium for intraoperative neuromuscular blockade.

**Intraoperative anaesthetic requirement:**

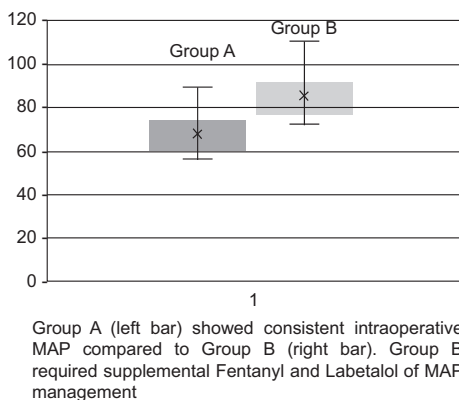
	Group A (BD - TAP)	Group B (control)	P value
Sevoflurane MAC	0.6 ( $\pm$ 0.05)	0.8 ( $\pm$ 0.2)	0.001
Sevoflurane (ml/hr)	5.5 ( $\pm$ 0.9)	6.8 ( $\pm$ 0.9)	0.006
Rocuronium (mg)	49.5 ( $\pm$ 2.85)	58 ( $\pm$ 4.21)	0.0008
Supplemental Fentanyl ( $\mu$ g)	2.9 ( $\pm$ 0.2)	12.6 ( $\pm$ 1.8)	0.00003
Labetalol (mg)	1.9 ( $\pm$ 0.6)	19.3 ( $\pm$ 2.6)	0.00002

In intraoperative period the mean arterial blood pressure (MAP) of Group A was 67.9 ( $\pm$  8.9) and group B was 85.25 ( $\pm$  10.27).

In group B, total 12 patients out of 20 required supplemental 20  $\mu$ g IV Fentanyl during Trocher insertion and pneumoperitoneum compared to 3 patients in group A required additional Fentanyl.

In the group B, 4 patients required IV Labetalol 40 mg and 13 patients required 20 mg. In group A, 2 patients required 20 mg IV Labetalol.

Intraoperative MAP difference between group A and Group B

**Postoperative management:**

Group A patients required 64% less prn IM Pethidine.

Most of the Group A patients were able to be discharged from the hospital on the first postoperative day. The main issue for the control group was pain on movement and during coughing.

	Group A (BD - TAP)	Group B (control)	P value
Pethidine (mg)	135 ( $\pm$ 22.9)	375 ( $\pm$ 46)	0.00
Hospital stay (days)	1.16 ( $\pm$ 0.5)	2.03 ( $\pm$ 0.5)	0.00

Total cost was measured by calculating the amount of Sevoflurane used per hour, postoperative opioid consumption, duration of hospital stay.

$$\text{Cost} = S + O + D$$

Sevoflurane (per ml) = 64 tk

Pethidine (per ample) = 100 tk

Bed rent (per day) = 4000 tk

Group A required 4450 tk and Group B required 8835 tk.

Group B required supplemental Labetalol and Fentanyl in the perioperative period.

There was no incidence of postoperative nausea, vomiting or local anaesthetic toxicity in either group.

**Discussion:**

During the last decade, there has been increasing interest in using the transversus abdominis plane (TAP) block as a regional anesthetic technique for postoperative pain control after abdominal surgical procedures. In 2001, Rafi<sup>6</sup> described the "abdominal field block." This blind and landmark-based technique used the triangle of Petit to access the TAP. In 2007, Hebbard et al.<sup>7</sup> followed with a description of an ultrasound (US)-guided approach with the transducer placed in the midaxillary line to access the TAP. Several clinical trials have investigated the postoperative analgesic effects of the TAP block described by Hebbard et al, but the results are equivocal. In comparison to single injection technique, the Dual TAP block, which technically combines subcostal with lateral/posterior TAP block, provides a wider coverage for both the upper and lower abdominal walls. By anesthetizing both the upper TAP plexus (the intercostal plexus, which consists of large branch communications anterolaterally) and the lower TAP plexus (the deep circumflex iliac artery plexus), a lateral-to-medial long-needle approach can cover T<sub>7</sub> to T<sub>12</sub>.<sup>8,9</sup> The bilateral dual TAP block was introduced by Borglum et al.<sup>10</sup>

Recent findings emphasised the two wound model after abdominal surgery. The somatic wound corresponds to the abdominal wall and parietal layer of peritoneum, the autonomic wound corresponds to the visceral layer of peritoneum and visceral component. Bilateral dual TAP (BD - TAP) blocks provide somatic analgesia of the abdominal wall (skin, muscles, and parietal

peritoneum) which is innervated by the anterior rami of T<sub>7</sub> - T<sub>12</sub>.

Previously in many studies a variety of methods (post side injection, single site TAP block, Gallbladder bed local installation) were used to reduce the perioperative morbidity of laparoscopic cholecystectomy patients but there is no conclusive opinion on the superiority of a particular technique than others. Many studies used moderate volume (40 ml) of Bupivacaine (0.25% - 0.5%) solution in TAP block. As this fascial plane block is volume dependent, we opted high volume (70 ml) low concentration local anaesthetic solution.

Similar to previous study by T Karaman et al.<sup>3</sup> we found the effect of TAP block induced reduced requirement of volatile anaesthetic to maintain an adequate level of anaesthesia.

This finding supports 'Deafferentation theory'. Afferentation theory proposed that tonic sensory and muscle spindle activity maintains a state of wakefulness.<sup>11,12</sup>

Afferent signal from muscle has a stimulatory effect on cerebral activity. Activation of EEG in animals after increasing muscle afferent activity has shown an increase in cerebral blood flow that exceeds metabolic demand.<sup>13</sup> On the other hand, temporary peripheral denervation decreases the excitability of cuneate nucleus in the brainstem<sup>14</sup>, while acute block of tonic retinal discharges produced synchronization of the cortical EEG, which was otherwise desynchronized.<sup>15</sup> Forbes et al. demonstrated that neuromuscular blockade with pancuronium decreased the MAC of Halothane by 25% via abolition of muscle spindle activity and reduction of tonic afferent signaling to the brain.<sup>17</sup> More recent findings suggest that a spinal depressant action of isoflurane [16] or lidocaine<sup>16</sup> on ascending somatosensory transmission can modulate reticulo-thalamo-cortical arousal mechanisms.

Eappen et al. Proposed decreased afferent input to the brain could lessen excitatory descending modulation of the spinal cord motoneurons and suppress motor function [18]. This theory supports our finding of reduced NMBA requirements with BD - TAP block. According to previous studies (25, 26) immediate changes in central somatotopic representations occur after regional anesthesia.

Acute plastic changes within primary somatosensory and motor cortices after reversible deafferentation by regional anaesthesia indicates that higher-order regions of cortex are affected.

Thus, the combination of decreased input from sensory and motor afferents seen with regional anesthesia would be a reasonable mechanism for a regional anesthetic effect and for a decreased MAC of volatile agents and reduced requirement of neuromuscular blocking agents.

In our study we used nitrous oxide. There are inconsistent opinions regarding using Nitrous oxide in laparoscopic cholecystectomy but it is effective to attenuate the visceral component of afferent stimulation. Nitrous oxide releases proenkephalin in the CNS. While single agent 66–70% nitrous oxide provides an analgesic effect similar to a whole blood concentration of remifentanyl of 2 ng/ ml.<sup>19</sup> Nitrous oxide acts as an *N*-methyl-D-aspartate (NMDA) receptor antagonist and potentiates the activity of gamma-amino butyric acid-A (GABA<sub>A</sub>) receptors and inhibits neuronal potassium channels. Thus Nitrous oxide is often referred to as a "volatile sparing agent". From a health economy perspective, it's reasonable to use Nitrous oxide in Laparoscopic cholecystectomy surgery.

As part of the "Preemptive preventive multimodal analgesia" approach we used Acetaminophen and Diclofenac sodium by infusion according to PROSPECT recommendation.<sup>20</sup>

Paracetamol has a central analgesic effect that is mediated through activation of descending serotonergic pathways. Debate exists about its primary site of action, which may be inhibition of prostaglandin (PG) synthesis or through an active metabolite influencing cannabinoid receptors. When administered before induction of anaesthesia, 1 g i.v. paracetamol was found to be equally successful to ketamine (0.5 mg/ kg bolus before induction, followed by 5 µg/ kg/ min).

We administered IV Diclofenac sodium (75 mg) preoperatively. It inhibits peripheral prostaglandin synthesis and more reasonable to administer it before the nociceptive stimulation.

The two main causative factors in eliciting the stress response to surgery can be summarised as follows: afferent neuronal stimulation and

circulating cytokines released in response to surgical trauma. There is evidence to show that autonomic as well as somatic afferent fibre activity is Important in triggering hormonal secretion.<sup>21</sup> Therefore, regional anaesthesia that fails to block completely autonomic innervation has little effect on the usual increased hypothalamo-pituitary secretion found during surgery.<sup>22</sup> In this regard TAP block is not effective for complete abolishment of surgical stress response.

The ratio of anesthesia cost to total treatment cost in hospitalized patients is around 5–6%, but there is still an expectation to decrease this ratio. Johnstone et al.<sup>23</sup> showed that by using an inexpensive medication instead of expensive ones, a 23% savings could be achieved in anesthesia expenses, but in the yearly budget of the hospital, a 23% savings in 5–6% of anesthesia is a very small amount. However, investigation of factors that result in any decrease in anesthesia costs always remains relevant in healthcare economics. In a study of the cost-effectiveness of total intravenous anesthesia versus the balanced anesthesia method, a higher cost was seen in total intravenous anesthesia.<sup>24</sup> In the present study, we preferred the general anesthesia method, standardized the anesthesia depth with BIS, and calculated the cost of the inhalation agents used.

Limitations of our study are that we could not evaluate the sensory block level due to the application of the block just after general anesthesia and we did not measure the blood levels of local anesthetics.

#### Key messages:

- Combining TAP block with general anesthesia promotes intraoperative hemodynamic stability.
- Tap block reduces intraoperative consumption of volatile agents, neuromuscular blocking agents and postoperative opioid consumption.
- TAP block could be effective in every patient undergoing abdominal surgery, not only high-risk patients.
- TAP block could be an important tool for successful day case surgery.
- Hospitals should have an organised protocol for rapid patient turn over to minimize the barriers of health economics.

- Anesthesiologists are encouraged to perform TAP block to improve the safety and quality of anesthesia in patients undergoing abdominal surgery.

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