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# Value of Combining Intercostal Block by the Operating Surgeon with Other Pain Control Modalities on Post-thoracotomy Pain Management

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## ABSTRACT

**Background:** In current medical practice conventional thoracic surgery is one of the most painful surgeries due to significant post-thoracotomy pain that can lead to post-operative diaphragmatic dysfunction and respiratory compromise.

**Aim:** This study aimed to evaluate the efficacy of intercostal block when combined with thoracic epidural analgesia and other modalities for control of post-thoracotomy pain in conventional thoracic surgery.

**Patients and methods:** This retrospective single-center study included 500 cases of conventional thoracic surgery done at the Cardiothoracic Surgery Department, Tanta University through the period from January 2018 to January 2023. Cases were divided into 5 groups each group included 100 patients. Group A **(**Patients received medications without intercostal block), group B **(**Intercostal block combined with medical treatment), group C (Intercostal block combined with thoracic epidural analgesia), group D **(**intercostal block combined with sacrospinalis block) and group E [intercostal block combined with postoperative patient-controlled analgesia pump (PCA)].

**Results:** There was a significant difference in favor of (group E) regarding the post-operative volume achieved on spirometer ($P$ = 0.044), post-operative pain severity score and length of hospital stay ($P$ < 0.001). But there was no significant difference as regards fentanyl requirement ($P$ = 0.499), length of ICU stay and morbidity and mortality ($P$ = 0.938, 0.113, 1.0) respectively.

**Conclusions:** Combining intercostal block with patient-controlled analgesia pump "PCA" achieved a superior level of post-thoracotomy pain control followed by combined intercostal block with sacrospinalis block and both were superior to the lone use of pain medications, intercostal block with medical treatment or with thoracic epidural analgesia.

**Keywords:** Intercostal block, Post-thoracotomy pain**,** Patient controlled analgesia pump.

## INTRODUCTION

Conventional thoracic surgeries done via the traditional thoracotomy incisions are considered very painful surgeries and are associated with significant post-thoracotomy pain that can lead to diaphragmatic dysfunction and post-operative respiratory compromise [(1)]. Thoracic epidural analgesia (TEA) dominated the last century as the most commonly used modality of post-operative pain management in thoracotomy patients and was considered to be the 'gold standard however it has several complications that may be dangerous including hypotension, urinary retention, partial or patchy block and, in rare cases, devastating neurological injuries [(2)]**.** Epidural analgesia may alleviate the surgical stress response and provide a favorable homeostatic milieu regarding the endocrine, coagulation, gastrointestinal and immune function [(3)]**.**

Intercostal nerve block (INB) since a long time had been used by several thoracic surgeons and anesthesiologists for post-operative analgesia in routine conventional thoracic surgery. Anatomically, the intercostal spaces are the continuation of the thoracic para-vertebral spaces to the thoracic cage [(4)]. The intercostal nerve, intercostal artery and vein run between the intercostal internal muscle and the intercostal innermost muscle along the lower edge of the ribs. Posterior to the angles of ribs, the intercostal nerves divide into the collateral branches and the lateral cutaneous branches that run into the intercostal muscles and divide into anterior and posterior branches [(5)].

This study aimed to evaluate the efficacy of intercostal nerve block when used as adjunct to thoracic epidural analgesia and with other methods used for the control of post-thoracotomy pain in the patients undergoing conventional thoracic surgery operations via thoracotomy incisions.

## PATIENTS AND METHODS

This retrospective single-center observational comparative study included 500 patients of conventional thoracic surgery done at the Cardiothoracic Surgery Department, Tanta University during the period from January 2018 to January 2023. The studied patients were divided into 5 groups. Group A included100 cases where intercostal block was not done and these patients received medical treatment only "pain medications" for control of their post-thoracotomy pain. Group B comprised 100 cases who had intercostal block combined with postoperative medical treatment. Group C contained 100 patients who had intercostal block combined with thoracic epidural analgesia. Group D included 100



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patients who had intercostal block combined with sacro-spinalis block. Group E comprised100 patients who had intercostal block combined with postoperative PCA pump.

**Inclusion criteria:** Adult (≥18-year-old) patients, ASA physical status I, II and III and patients who were scheduled to undergo elective postero-lateral thoracotomy incision (fifth intercostal space) for lobectomy, bi-lobectomy, pneumonectomy and open decortication or wedge resection of the lung.

**Exclusion criteria:** Patients with contraindication to thoracic epidural, a contraindication to any of the study drugs, additional surgical incisions during the same sitting, previous thoracotomy/thoracoscopy, previous radiotherapy to the thorax, chronic pre-operative pain (defined as the use of pain medications continuously for more than 1 week in the 4 weeks preceding surgery) and declined informed consent.

**Methods:** Each group of the studied patients were subjected to their respective modality of post-thoracotomy pain management, so group A patients didn't receive intercostal nerve block, group B patients received intercostal nerve block, group C patients received intercostal nerve block combined with thoracic epidural analgesia, group D patients received intercostal nerve block combined with sacrospinalis block and group E patients received intercostal nerve block combined with postoperative patient-controlled analgesia pump.

Basic patients' demographic data including gender, age, weight, height, body mass index, and the type of surgery. Prior to induction of general anaesthesia, the 100 patients of group C had a thoracic epidural catheter placed at the the mid-thoracic level. A test dose consisting of 3 ml of 1.5% lignocaine and 15 micrograms of adrenaline was injected through the catheter to rule out intra-vascular or intra-thecal placement. Once a negative response to test dose was established, the patients received general anaesthesia with intravenous (IV) fentanyl 2 µg/kg, IV propofol titrated to loss of verbal response and IV vecuronium 0.1 mg per kg. Prior to surgical incision, 6 to 8 ml of 0.1% bupivacaine with 2 µg per ml of fentanyl was injected through the thoracic epidural catheter. If there is hemodynamic instability or hypotension, then the following treatment was given in the form of intravenous fluids (boluses of 5 ml/kg) and mephentermine (6 mg bolus) and the initial epidural dose was delayed until the patient was haemodynamically stable. Subsequent to the bolus, the patients received an epidural infusion of 0.1% bupivacaine with 2 µg per ml of fentanyl at 6 to 8 ml per hour.

Paravertebral (sacrospinalis) block utilized the local regional anaesthetic (bupivacaine) to the ipsilateral sacrospinalis muscle at the level corresponding to the thoracotomy incision level.

The patient-controlled analgesia pump components used in this study were a mixture of nalbuphine, paracetamol, ketorolac, dexamethasone, hydrocortisone and metoclopromide mixed together to fill the PCA pump and connected to the intravenous line either peripheral venous cannula or central venous line. The PCA pump was connected to the patients of group E and started immediately after recovery from general anesthesia bedside in the intensive care unit or patient room.

**Procedure:** The scheduled conventional thoracic surgical procedure was performed as per standard protocol. The operating room anaesthesiologist gave additional boluses of fentanyl, (0.5 µg per kg) if the heart rate and blood pressure exceeded baseline by more than 30%. At the end of the surgery, before closure of the thoracotomy incision, the patients were randomized to one of the 5 study groups. Group A. The 100 patients didn't receive intercostal nerve block (ICB) and they received pain killer medications only for the control of their post-thoracotomy pain as NSAIDs for mild and moderate pain and narcotic analgesics for severe pain. Group B, the 100 patients received ICB with 0.25% bupivacaine at the level of the thoracotomy incision and at the two levels above and below the level of thoracotomy incision, with 2 ml of solution per level using a 22-gauge needle. The ICB was given by the operating surgeon under direct vision, between the dorsal end of the parietal pleura incision and the costo-vertebral junction in addition to the post-operative medical treatment when needed for control of their post-thoracotomy pain, group C where the 100 patients received ICB combined with the thoracic epidural analgesia, group D where the 100 patients received ICB combined with sacrospinalis block and group E where the 100 patients received ICB combined with postoperative patient-controlled analgesia pump "PCA" containing a mixture of paracetamol, nalbuphine, ketorolac, dexamethasone, hydrocortisone, metoclopromide and ketamine.

**Post-operative care:** All the studied patients received intravenous Ketorolac (0.5 to 1 mg per kg) (to a maximum of 60 mg) 8 hourly. If the pain scores remained above 4, 30 minutes after receiving Ketorolac, the patients received intravenous paracetamol (20 mg per kg) (to a maximum of 1 gram) every 8 hours.

**Ethics of the study: Tanta Ethical Committee Approval Code: (36264PR103/2/23). In accordance with The Declaration of Helsinki developed by the World Medical Association as a statement of ethical principles for medical research involving human subjects, including research on identifiable human material and data. Informed written consents were**

**taken from all the studied patients after explanation of the benefits and the risks, any unexpected risk appeared during the course of the study was cleared to the patients and the ethical committee on time. The proper measures were taken to maintain privacy of participants' confidentiality of data through putting a code number for each participant from the beginning to the end of the study. The results of this research were used only for scientific purposes. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.**

***Statistical analysis***

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Significance of the obtained results was judged at the 5% level. Chi-square test was used for categorical variables to compare between different groups. F-test (ANOVA) was used for normally distributed quantitative variables to compare between more than two group.

**RESULTS**

Table (1) showed that there was no statistically significant difference between the studied groups as regards baseline patients demographic data ($p > 0.05$).

**Table (1):** Comparison between the studied groups as regards the baseline demographic data

| | Group A (n=100) | | Group B (n=100) | | Group C (n=100) | | Group D (n=100) | | Group E (n=100) | | Test | *P-value* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Age** | | | | | | | | | | | | |
| Range | 21 – 73 | | 23 – 73 | | 21 – 74 | | 22 – 72 | | 21 – 73 | | F= 0.818 | 0.514 |
| Mean ± SD | 46.18 ± 14.5 | | 48.11 ± 14.79 | | 48.32 ± 15.96 | | 45 ± 15.27 | | 46.82 ± 15.73 | | | |
| **Sex** | No. | % | No. | % | No. | % | No. | % | No. | % | $\chi^2$= 3.015 | 0.555 |
| Female | 20 | 20.0 | 27 | 27.0 | 25 | 25.0 | 28 | 28.0 | 30 | 30.0 | | |
| Male | 80 | 80.0 | 73 | 73.0 | 75 | 75.0 | 72 | 72.0 | 70 | 70.0 | | |
| **BMI** | | | | | | | | | | | | |
| Range | 14.2 – 33.1 | | 13.1 – 34.7 | | 13.4 – 35.7 | | 13.9 – 36 | | 13.4 – 35.8 | | F= 1.537 | 0.190 |
| Mean ± SD | 22.17 ± 4.76 | | 22.89 ± 5.05 | | 23.62 ± 5.31 | | 22.97 ± 4.89 | | 22.15 ± 4.79 | | | |
| **Volume achieved on spirometry** | | | | | | | | | | | | |
| Range | 1300 – 2650 | | 1300 – 2650 | | 1300 – 2650 | | 1300 – 2650 | | 1300 – 2650 | | F= 1.135 | 0.339 |
| Mean ± SD | 1938 ± 419.9 | | 1913 ± 400.48 | | 1980 ± 383.1 | | 2025.5 ± 389.93 | | 1960 ± 414.08 | | | |

SD: Standard deviation $\chi 2$: Chi square test F: one-way ANOVA t-test p: p value for comparing between different categories *: Statistically significant at $p \leq 0.05$.

Table (2) showed that there was no statistically significant difference between the studied groups as regards type of surgery (p=0.573).

**Table (2):** Comparison between the studied groups as regards thoracic operation

| | Group A (n=100) | | Group B (n=100) | | Group C (n=100) | | Group D (n=100) | | Group E (n=100) | | Test | *P-value* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Type of surgery** | No. | % | No. | % | No. | % | No. | % | No. | % | $\chi^2$= 6.663 | 0.573 |
| Lobectomy | 38 | 38.0 | 31 | 31.0 | 34 | 34.0 | 38 | 38.0 | 38 | 38.0 | | |
| Pneumonectomy | 18 | 18.0 | 21 | 21.0 | 18 | 18.0 | 25 | 25.0 | 14 | 14.0 | | |
| Others | 44 | 44.0 | 48 | 48.0 | 48 | 48.0 | 37 | 37.0 | 48 | 48.0 | | |

SD: Standard deviation $\chi 2$: Chi square test F: one-way ANOVA t-test p: p value for comparing between different categories *: Statistically significant at $p \leq 0.05$

Table (3) showed that there was a statistically significant difference between the studied groups as regards the ribs broken (p= 0.026), but there was no statistically significant difference as regards fentanyl requirement (p=0.566).

**Table (3):** Comparison between the studied groups as regards the intra-operative data

| | Group A (n=100) | | Group B (n=100) | | Group C (n=100) | | Group D (n=100) | | Group E (n=100) | | Test | *P-value* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ribs broken** | No. | % | No. | % | No. | % | No. | % | No. | % | | |
| No | 61 | 61.0 | 58 | 58.0 | 72 | 72.0 | 65 | 65.0 | 77 | 77.0 | $\chi^2$= 11.023 | 0.026* |
| Yes | 39 | 39.0 | 42 | 42.0 | 28 | 28.0 | 35 | 35.0 | 23 | 23.0 | | |
| **Fentanyl requirement (µg/kg)** | | | | | | | | | | | | |
| Range | 1.8 – 5.7 | | 1.5 – 5.4 | | 1.7 – 5.4 | | 1.6 – 5.4 | | 1.5 – 5.4 | | F= 0.739 | 0.566 |
| Mean ± SD | 3.63 ± 1.13 | | 3.48 ± 1.16 | | 3.57 ± 1.15 | | 3.38 ± 1.09 | | 3.57 ± 1.13 | | | |

Table (4) showed that there was a statistically significant difference between the studied groups as regards the severity of post-thoracotomy pain (p<0.05).

**Table (4):** Comparison between the studied groups as regards pain

| | | Group A (n=100) | Group B (n=100) | Group C (n=100) | Group D (n=100) | Group E (n=100) | Test | *P-value* |
|---|---|---|---|---|---|---|---|---|
| **Pain at rest** | **2 to 4 hours** | | | | | | | |
| | Range | 0 – 6 | 0 – 6 | 0 – 6 | 0 – 6 | 0 – 6 | F= 3.703 | 0.006* |
| | Mean ± SD | 3.29 ± 1.78 | 3 ± 1.79 | 3.23 ± 1.84 | 3 ± 1.58 | 2.44 ± 1.71 | | |
| | **18 to 24 hours** | | | | | | | |
| | Range | 0 – 6 | 0 – 6 | 0 – 6 | 0 – 5 | 0 – 6 | F= 4.064 | 0.003* |
| | Mean ± SD | 2.47 ± 1.83 | 2.21 ± 1.74 | 2.31 ± 1.78 | 2.15 ± 1.55 | 1.57 ± 1.56 | | |
| **Pain at cough** | **2 to 4 hours** | | | | | | | |
| | Range | 1 – 9 | 1 – 9 | 1 – 9 | 1 – 9 | 1 – 9 | F= 2.972 | 0.019* |
| | Mean ± SD | 5.14 ± 1.88 | 4.9 ± 1.98 | 5.27 ± 1.97 | 5.04 ± 1.85 | 4.41 ± 1.94 | | |
| | **18 to 24 hours** | | | | | | | |
| | Range | 0 – 9 | 0 – 9 | 1 – 9 | 0 – 8 | 1 – 9 | F= 2.416 | 0.048* |
| | Mean ± SD | 4.59 ± 2.02 | 4.4 ± 2.03 | 4.75 ± 1.94 | 4.51 ± 1.93 | 3.94 ± 1.94 | | |

Table (5) showed that there was a statistically significant difference between the studied groups as regards the post-operative volume achieved on spirometer (p=0.044), but there was no significant difference as regards the fentanyl requirement (p=0.499).

**Table (5):** Comparison between the studied groups as regards the post-operative volume achieved on spirometer and Fentanyl requirement

| | Group A (n=100) | Group B (n=100) | Group C (n=100) | Group D (n=100) | Group E (n=100) | Test | *P*-value |
|---|---|---|---|---|---|---|---|
| **volume achieved on spirometer** | | | | | | | |
| Range | 500 – 165 | 550 – 1700 | 550 – 1700 | 600 – 1750 | 650 – 1750 | F= 2.468 | 0.044 |
| Mean ± SD | 1064 ± 333.94 | 1120.5 ± 337.11 | 1105.5 ± 353.76 | 1186.5 ± 351.03 | 1189 ± 343.08 | | |
| **Fentanyl requirement (µg/kg)** | | | | | | | |
| Range | 1.7 – 8.4 | 0.5 – 8.5 | 0.4 – 8.4 | 0.3 – 8.2 | 0 – 9.4 | F= 0.842 | 0.499 |
| Mean ± SD | 4.79 ± 1.93 | 4.33 ± 2.24 | 4.53 ± 2.43 | 4.23 ± 2.35 | 4.53 ± 2.85 | | |

Table (6) showed that there was a high statistically significant difference between the studied groups as regards the post-thoracotomy pain severity score and the length of hospital stay (p<0.001), but there was no significant difference as regards the length of ICU stay, postoperative morbidity and mortality (p= 0.938, 0.113, 1.0) respectively.

**Table (6):** Comparison between the studied groups as regards postoperative pain severity score and length of ICU and hospital stays, morbidity and mortality

| | Group A (n=100) | | Group B (n=100) | | Group C (n=100) | | Group D (n=100) | | Group E (n=100) | | Test | p |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **pain severity score** | | | | | | | | | | | | |
| Range | 6 – 8 | | 5 – 6 | | 4 – 5 | | 0 – 2 | | 1 – 3 | | F= 1306.089 | <0.001* |
| Mean ± SD | 7 ± 0.8 | | 5.47 ± 0.5 | | 4.54 ± 0.5 | | 0.88 ± 0.81 | | 1.87 ± 0.81 | | | |
| **Length of ICU stay** | | | | | | | | | | | | |
| Range | 1 – 3 | | 1 – 3 | | 1 – 3 | | 1 – 3 | | 1 – 3 | | F= 0.200 | 0.938 |
| Mean ± SD | 2.01 ± 0.82 | | 1.92 ± 0.79 | | 1.98 ± 0.88 | | 1.96 ± 0.8 | | 1.93 ± 0.82 | | | |
| **Length of hospital stay** | | | | | | | | | | | | |
| Range | 12 – 15 | | 8 – 12 | | 6 – 8 | | 2 – 4 | | 3 – 6 | | F= 1476.392 | <0.001* |
| Mean ± SD | 13.4 ± 1.07 | | 9.78 ± 1.34 | | 7.11 ± 0.87 | | 2.99 ± 0.87 | | 4.49 ± 1.19 | | | |
| | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** | **$\chi^2$** | **p** |
| **Postoperative morbidity** | 10 | 10.0 | 8 | 8.0 | 5 | 5.0 | 2 | 2.0 | 4 | 4.0 | 7.468 | 0.113 |
| **Mortality** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0.0 | 1.0 |

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## DISCUSSION

**1.** Our study results revealed that there was no statistically significant difference between the studied groups as regards the baseline patients' demographic data including patients' age, gender, body mass index, pre-operative volume achieved on spirometer.

**2.** There was no statistically significant difference between the studied groups as regards the type of surgery with the lobectomy operation being the most common and frequently performed procedure more than the pneumonectomy operation and other thoracic operations

**3.** There was a statistically significant difference between the studied groups as regards the ribs broken as group (A) and group (B) were the most affected by broken ribs, and there was no significant difference between all the groups regarding the need of intra-operative fentanyl administration.

**4.** There was a statistically significant difference between the studied groups as regards the degree or severity of the post-thoracotomy pain, as after 2-4 hours group E (intercostal block combined with post-operative "PCA") achieved the least pain score at rest (Numerical Rating Scale mean was 2.44 ± 1.71) as well as after 18-24 hours with mean NRS of 1.57 ± 1.56. Also, as regards the NRS during cough after 2-4 hours and 18-24 hours we found that group E had significantly lower pain score with mean of 4.41 ± 1.94 and 3.94 ± 1.94 respectively.

**5.** There was a statistically significant difference between the studied groups of patients as regards pain severity score and the length of ICU stay as group (D) and group (E) had the least pain score in comparison with the other 3 groups, also group (D) and group (E) had shorter hospital stay than the other 3 groups. There was no significant difference between all groups regarding total length of hospital stay (LOS) and also regarding the occurrence of post operative morbidity or mortality.

**6.** there was a statistically significant difference between the studied 5 groups as regards the post-operative volume achieved on spirometer. As group D (intercostal nerve block combined with sacrospinalis block) and E achieved higher volumes than other 3 groups with mean of 1186.5 ± 351.03) and (1189 ± 343.08) ml in group D and in group E respectively.

The results of our study are in agreement with the results of the study of **Wurnig *et al.*** [6] who compared between 2 groups (intercostal nerve block group and thoracic epidural catheter analgesia group) there was no significant difference regarding demographic data and the type of surgery. But not in agreement with their results regarding on the day of surgery, there was no statistically significant difference between the two groups. However, on the first, second and third post-operative days, the intercostal nerve block (ICB) group (group II) showed a higher pain score in relaxed position than those in the thoracic epidural analgesia (EPC) group (group II) (t-test for independent samples, P, 0.05). There were no differences between pain scores during activity and relaxed position in both groups (P = 0.05).

The results of our study are not in agreement with the results of the study done by **Meierhenrich *et al.*** [7] who found that the patients in the intercostal nerve block group needed larger doses of fentanyl than the patients in the group with epidural analgesia. But the results of our study are in agreement with their findings that at rest, the post-operative pain control was good for both the thoracic epidural analgesia group and the intercostal nerve block group and the combined intercostal nerve block with intravenous patient-controlled analgesia (PCA) groups and found that in comparisons with the NRS values on

coughing demonstrated significantly higher values in the intercostal nerve block group during the first and second postoperative days.

The results of our study are in agreement with the results of the systematic review done by **Loop *et al.*** [8] who found that the use of either TEA or TPVB (thoracic paravertebral block) provides comparable and effective analgesia for thoracic surgery. TPVB reduces the incidence of post-operative pulmonary complications and post-operative hypotension. TEA perse is superior to lone intra-thecal and intercostal techniques. The results of our study are in agreement with the results of the study done by **Khalil *et al.*** [9] who conducted a comparative study to evaluate the post-thoracotomy pain control on 2 groups of patients comparing operative intercostal nerve blocks with long-acting bupivacaine liposome versus the continuous thoracic epidural analgesia and reported that there was a statistically significant lower mean pain score for the intercostal nerve block (IB) group on day 1 ($p<0.04$) and day 3 ($p<0.04$). The results of our study are in agreement with the results of the review article done by **(Chin & Valchanov)** [10] who found that combining conventional pain management strategies that involve regional local anaesthetic agents with systemic opioids remain the mainstay of effective treatment for acute post-thoracotomy pain.

The results of our study are in agreement with the results of the study done by **Goto** [11] who found that ICNB blocks the intercostal nerves, and the para-vertebral block (PVB) and the thoracic epidural analgesia (EPI) lead to blockage of both the intercostal nerves and the sympathetic nerves. The vagus and phrenic nerves cannot be blocked by regional anaesthesia. Thus, unless opioids or non-steroidal anti-inflammatory drugs (NSAIDs) are concomitantly systemically given to the patients, no satisfactory level of analgesia can be achieved. So, the multi-modal analgesic strategies, which utilize and combine different techniques together, such as combined application of regional anesthetics with different action mechanisms, local infiltration anesthesia for the thoracotomy wounds, and opioid intravenous patient-controlled analgesia, appear to be more useful and more effective than each single method per se.

The results of our study are in agreement with the results of the review done by **Kelsheimer *et al.*** [12] who reported that a multi-modal medical approach combined with regional anesthesia techniques provide the patients with acceptable level of pain control, allowing the patients to facilitate the coughing, ambulation and deep breathing exercises that are necessary and needed for optimal post-operative pulmonary hygiene and function.

The results of our study are in agreement with the results of the study done by **Wojtyś *et al.*** [13] who found that there was no statistically significant difference regarding age and sex ($p = 0.74$) and ($p = 0.58$) respectively and found that most of the operations done were lobectomies followed by pneumonectomy.

The results of our study are not in agreement with the results of the study of **Kawagoe *et al.*** [14] regarding that the doses of fentanyl and remifentanil required during anesthesia were significantly less in the group of thoracic epidural analgesia (TEA) than in the group of patients-controlled analgesia (PCA) and intercostal nerve block (ICC) and PCA. However, the results of our study are in agreement with their results regarding that the length of hospital stay after surgery was not significantly different between the studied groups (group of intercostal nerve block combined with PCA and group of thoracic epidural analgesia).The results of our study are in agreement with the results of the study done by **Hainong *et al.*** [15] who found that the patients in the intercostal nerve block group had a similar pain score on post-operative day 0 ($p = 0.747$), 1 ($p = 0.438$), 2 ($p = 0.575$), and 3 ($p = 0.755$) and on the discharge day ($p = 0.353$) when compared to the patients in the paravertebral nerve block (PVC) group, and in comparison between the group with nerve block (CNB) to controls (PCA with post-operative Ketorolac injection) found that patients in the nerve block group had a lower pain score on post-operative day 0 ($p < 0.001$), 1 ($p < 0.001$), 2 ($p < 0.001$), and 3 ($p < 0.001$), and on the discharge day ($p < 0.001$). They also found that there was no significant difference in the length of post-operative hospital stay ($p = 0.878$) between ICC and PVC groups but when compared to the control group and patients in the intercostal nerve block group, there was a shorter post-operative length of hospital stay in the INB group ($p < 0.001$).

The results of our study are in agreement with the results of the systematic review done by **Badawy *et al.*** [16] who found that a multi-modal approach should be considered in the management of the post-thoracotomy pain starting even before the surgical trauma such as pre-emptive analgesia and the cognitive behavioral modalities.

The results of our study are in agreement with the results of the study done by **Poniatovska & Dubrov** [17] who found that in the patients undergoing conventional thoracic surgery, a multi-modal analgesic approach, which includes the use of (NSAIDs) in combination with thoracic epidural analgesia, resulted in better analgesia effect compared to the thoracic epidural aanalgesia alone.

The results of our study are in agreement with the results of the recent meta-analysis study done by **Zhou, K. *et al.*** [18] on different randomized controlled studies on comparison between intercostal nerve block and epidural thoracic analgesia in controlling post-thoracotomy pain and concluded that there was no statistically significant difference in post-operative pain scores between the ICB and EPI groups at 24-25 hours with or without adjuvant drugs [18]. The results of our study are in agreement with

the results of the study done by **O'Connor *et al.* [19]** who found that the same non-significant trend was seen with total hospital length of stay (LOS). Cryo-nerve block patients were discharged approximately 2 days sooner (9 (7–10) versus 11 (9–15.5), (p = 0.09).

**LIMITATIONS:** The limitations of this study are that it was a single-center study with a retrospective design, and a relatively modest number of cases. Prospective and randomized studies are needed to be compared with the retrospective studies and need to enroll larger number of patients. Second, the patients' follow-up duration was relatively short, and the long term follow-up data are needed to evaluate long-term chronic post-thoracotomy neuralgia and thoracic epidural catheter-related complications, which would be the focus of a future prospective study.

## CONCLUSION

Our study concluded that:

1. The results of combining intercostal nerve block with post-operative patient-controlled analgesia pump "PCA" achieved a superior level of post-thoracotomy pain control followed by combining of intercostal nerve block with sacro-spinalis block and both were superior to the other management methods including the use of lone usual pain killers' medications, intercostal nerve block with medical treatment and intercostal nerve block combined with thoracic epidural analgesia.
2- the multi-modal analgesic strategies, which utilize and combine different techniques together, such as combined application of regional anesthetics, local infiltration anesthesia, and opioid intravenous patient-controlled analgesia were more useful and more effective in post-thoracotomy pain management than each single method per se.

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