A Randomised Controlled Trial to Study the Effects of Intercostal Nerve Block on MIDCAB Surgeries Posted for Single Vessel Disease Left Anterior Descending in Coronary Artery Disease Patients

Original Article

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ABSTRACT

Background: Minimally Invasive Direct Coronary Artery Bypass (MIDCAB) surgery requires a surgical incision like a thoracic surgery offering a less invasive alternative to traditional midline sternotomy for cadiac surgical procedures. Intercostal nerve blocks (ICNB) play a crucial role in enhancing postoperative outcomes by minimizing pain and improving lung function.

Material and Methods: This prospective, double-blinded, randomized controlled trial aimed to assess the role of ICNB in MIDCAB procedures regarding pain reduction, expedited extubation, and improved lung function. Forty patients were randomized into two groups: one receiving ICNB with bupivacaine and the other receiving ICNB with saline (control). ICNB was administered post-surgery, and patients were transferred to the intensive care unit (ICU). Pain scores, duration of analgesia, rescue analgesic use, duration of ventilation, and inspiratory flow rates were recorded post-extubation.

Results: All patients in both groups completed the study. Patients receiving ICNB demonstrated significantly longer duration of analgesia ($p<0.0001$), reduced duration of ventilation ($p<0.0001$), fewer breakthrough pain episodes, and lower consumption of rescue analgesics compared to the control group. Pain scores in sedentary and dynamic states were consistently lower in the ICNB group at various time points post-extubation ($p<0.05$). Inspiratory flow rates were higher in the ICNB group throughout the study period ($p<0.05$).

Conclusion: Intercostal nerve blocks significantly improve postoperative outcomes in MIDCAB procedures, including prolonged analgesia, reduced ventilation time, decreased breakthrough pain, and enhanced lung function. Incorporating ICNB into perioperative management protocols can optimize patient comfort and expedite recovery following MIDCAB surgery.

Key Words: Cardiothoracic surgery, intercostal nerve block, lung functions, pain management, thoracotomy.

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INTRODUCTION

Minimally invasive direct coronary artery bypass (MIDCAB) procedure represents a significant advancement in the field of cardiac surgery. It offers a less invasive alternative to traditional on-pump coronary artery bypass surgery, specifically tailored to specific coronary artery diseases. MIDCAB's innovative approach involves a smaller incision made on the left side of the chest, typically between the ribs, rather than the traditional sternotomy.

In MIDCAB, a small segment of a healthy blood vessel, typically taken from the left internal mammary artery, serves as a graft. This graft is then meticulously connected to the Left Anterior Descending (LAD) artery downstream from any blockage. The result is the restoration of blood flow to the heart muscle, effectively bypassing the obstructed coronary arteries. This technique differs markedly from other surgical procedures used for coronary revascularization, primarily due to its left thoracotomy incision approach. Consequently, MIDCAB offers a unique set of benefits and complications compared to other methods using a midline sternotomy which include shorter hospital stay and faster recovery times[1].

Patient selection becomes important in MIDCAB surgery as it can be done only on patients having a favourable coronary anatomy and a non anomalous chest. Recent trials have reported multi-vessel minimally invasive direct coronary artery bypass grafting[2]. Our study was done on patients having a diseased left anterior descending artery (single vessel disease in LAD).

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One of the primary challenges to be addressed in MIDCAB is the need for a faster and more aggressive extubation protocol. This adaptation considers the less invasive nature of the surgical approach. Additionally, a robust pain management strategy is essential to manage thoracotomy-related pain effectively.

Intercostal nerve blocks (ICNB) play a pivotal role in enhancing the MIDCAB procedure's overall success. By administering a local anesthetic agent into the intercostal spaces adjacent to the surgical site, intercostal nerve blocks effectively minimize nociceptive transmission originating from chest wall incisions. This precise blockade results in reduced pain perception and lessens the reliance on systemic opioids, thereby mitigating the associated adverse effects such as respiratory depression, nausea, and sedation. After CABG using sternotomy the peri operative intercostal nerve blocks used in the enhanced recovery after surgery (ERAS) multimodal pain management regimen reduced the amount of opioids used and effectively managed pain[3].

Furthermore, intercostal nerve blocks contribute significantly to preserving crucial respiratory dynamics post-MIDCAB surgery. Effective postoperative pain management is vital to ensure patients can perform deep breathing and coughing effectively. Intercostal nerve blocks alleviate the pain-related impediments to these respiratory maneuvers, reducing the risk of atelectasis, pneumonia, and other respiratory complications. This aspect holds particular significance in MIDCAB patients, as maintaining proper lung function aids in preventing complications and expedites recovery. In patients with chest wall pain,traumatic rib fractures, they (ICNB) have been shown to consistently improve respiratory function[4].

The current study aimed to comprehensively evaluate the role of intercostal nerve blocks in MIDCAB procedures in relation to their proposed reduction in pain scores, expedited intubation and better lung functions. The primary outcome was a comparison of duration of analgesia in both groups. Secondary objectives included comparisons of time required for extubation, rescue analgesics used,post extubation inspiratory flow rates (incentive spirometry) and pain scores.

MATERIAL AND METHODS

The study design was a prospective double blinded randomised controlled trial. It was carried out over a period of two years after getting ethical clearance. Ethical approval was obtained from the ethics committee of Shri Mahant Indresh Hospital (Reference no SGRR/IEC/03/20 dated 23/05/2020) with ethical committee registration number ECR/710/Inst/UK/2015/RR-18. A total of forty patients scheduled for coronary artery bypass surgery for a diseased left anterior descending artery (LADA) were carefully selected based on inclusion and exclusion criteria. Reporting of the trial is as per the "Consolidated Standards of Reporting Trials (CONSORT) guidelines".

Inclusion criteria were medically stable patients aged 30-60 years willing to consent, NYHA class 1 and 2, left ventricle ejection fraction more than 50%, normal renal and hepatic function, and normal bedside pulmonary function tests. Exclusion criteria were patients having more than 50% stenosis in right coronary and left circumflex artery, patients in congestive heart failure, patients having arrhythmias, patients having moderate to severe lesions of any of the heart valves. Patients having prolonged post operative course, patients unable to understand NRS pain score in pre operative check up, having deranged coagulation parameters, any infections in the proposed sites of ICNB, having allergy to local anaesthetic bupivacaine were also excluded. Patients developing haemodynamics instability in the peri operative period were also to be excluded from the study. Peri-operative use of intra aortic balloon pump, re exploration cases, and patients requiring reintubation in post operative period were to be excluded.

The process of randomisation was performed by allocating a computer generated random number in a 1:1 ratio. Allocation concealment was done by use of opaque envelopes. Double blinding was done by blinding the anesthesiologist as well as the patients. The drug was prepared in identical syringes (two 10ml syringes each time both for intervention and control) by a technician not involved in any other part of the study. Block was given by cardiac surgeon who was completely unaware of the study groups of the patients. Persons involved in data collection, data analysis were blinded to the study groups of the patients.

In our study, the primary outcome variable was the duration of analgesia. Duration of analgesia was defined as the time since extubation to the point of first analgesic request by the patient. Sample size calculation was based on duration of analgesia. In order to detect a difference of thirty minutes in the duration of analgesia, each group required sixteen patients. To compensate for attrition the sample size was kept as 20.

The patients were divided into two groups at random: group A received 15mL of 0.5% bupivacaine for intercostal nerve block. group B received 15mL of normal saline 0.9% as control.

Before the operation, all patients underwent a general and systemic examination in the pre-anesthetic check-up, one day prior. The purpose and nature of the study were fully explained to all the patients and written informed consent was obtained. Patients were explained about the Numeric Rating Scale (NRS) of pain in the pre anaesthetic check up. Pain scores were measured in both sedentary (lying down) and dynamic (after coughing) positions.

All patients selected for the study were given tab. alprazolam 0.5mg on the night before surgery with a light dinner. On the day of surgery patients received pre-medication with intravenous midazolam (0.02mg/kg), ranitidine (50mg), and metoclopramide (10mg) one hour before surgery Oxygen was given by a face mask @ 6 L/min after premedications.

After confirming the patient's identity and ensuring their informed consent, they were transferred to the operating room on a tilting table. The pre anesthetic records were reviewed, and standard anesthesia monitors, including an electrocardiogram (ECG), and pulse oximeter.Radial artery cannulation was done for invasive blood pressure monitoring.

Patients received induction with intravenous fentanyl 3 micrograms/kg and titrated dose of etomidate 0.3mg/kg. Endotracheal intubation was done after muscle relaxation with intravenous vecuronium 0.1mg/kg using a cuffed oral endotracheal tube. Post intubation central venous catheter was placed in right internal jugular vein. Also a femoral artery cannulation was done to record the central aortic pressures. Anesthesia was maintained by oxygen - air mixture with isoflurane and intermittent intravenous vecuronium half hourly. Intraoperative analgesia was maintained by additional fentanyl boluses of 1mcg/kg repeated every hourly. Intraoperative haemodynamics were maintained within 30% of the baseline values (recorded in pre operative check ups) by use of deepening the anaesthesia plane, additional beta blockers, nitroglycerin infusion and noradrenaline and doubtamine infusions.

At the end of surgery 3ml of 0.5% bupivacaine was also introduced around the drain site.

ICNB was given after the completion of surgery by the surgeon. The block was performed after ascertaining haemodynamic stability, stable haematocrit,satisfactory blood gases and electrolytes in arterial blood gas (ABG). Block was given at the level of surgical incision and two intercostal spaces above and below the incision. The block was given in left lateral position in line of the posterior axillary fold. A standardised approach of giving ICNB was followed with the chief operating surgeon completing the block. The procedure followed for block included a 20 degree cephalad approach in the intercostal groove walking down the rib. A total of 15ml volume of study drugs was injected, 3ml in each intercostal space. Group A received ICNB with bupivacaine 0.5% whereas group B received ICNB with volume matched normal saline 0.9% which served as control.

After placement of ICNB to patients, all anesthetics were stopped and patients were shifted to intensive care unit (ICU) and kept on ventilation and weaned gradually. Patients were weaned from ventilator after reversal of neuromuscular blockade and extubated after they fulfilled the extubation criteria. Extubation was allowed if they were adequately following commands and maintaining adequate oxygenation (PaO_2>100 on 40% inhaled oxygen) and ventilation ($PCO_2$30 to 40mm Hg) in an arterial blood gas sample on continuous positive airway pressure (CPAP). Duration of ventilation required in both the groups was recorded.

Post operative pain management was managed as per fixed protocols of study. On arrival in the post surgical ICU all the patients were given intravenous paracetamol 8 hourly. Patients were interrogated for pain using NRS score as taught to them in pre operative check. NRS scoring was done by intensivists in sedentary lying down position as well as after coughing. It was done at intervals of 4 hour starting from extubation time (the zeroth hour) till 24 hours after extubation. Pain was graded into no pain (NRS= 0), mild (NRS 1 to 3), moderate (NRS 4to 6), severe (NRS 7 to 10). Total episodes of breakthrough pain -(defined as sedentary NRS ≥4) were noted across both the groups. Rescue analgesia was planned to be given if sedentary NRS was equal or more than 4 (or on patients request) by intravenous fentanyl 1mcg/kg. Second rescue analgesic planned was intravenous diclofenac 75mg if NRS was persistently above 4 after 30mins of the first rescue analgesic. The above observations were made from the 0 hours (extubation) to the first 24 hours post extubation. The total number of rescue analgesia (both primary and secondary) administered were recorded across both the groups.

Incentive spirometery was performed at similar time intervals as NRS to assess the number of balls as an indicator of inspiratory flow rate. (1 ball -600ml, 2 balls -900ml, and 3 balls -1200ml).

Post operative haemodynamics were maintained within 30% of the pre operative levels by use of beta blockers, noradrenaline and dobutamine infusions. The total dose of above drugs was not recorded and they were used as per need to provide an acceptable range of haemodynamic parameters of invasive blood pressure and heart rates.

Statistical analysis

Data were recorded in a Microsoft excel spread sheet and Statistical Analysis was done by Statistical Package for Social Sciences (SPSS version 16.0) statistical analysis software. Student's *t* test was used to examine whether there was a difference between the means of the two groups for continuous variables. Categorical datas were reported as frequency and percentage and were analysed using Chi square test.'*p'* value <0.05 was significant and '*p'* value >0.05 was taken as non significant.

RESULTS

All the patients in both the groups completed the study (Figure 1).

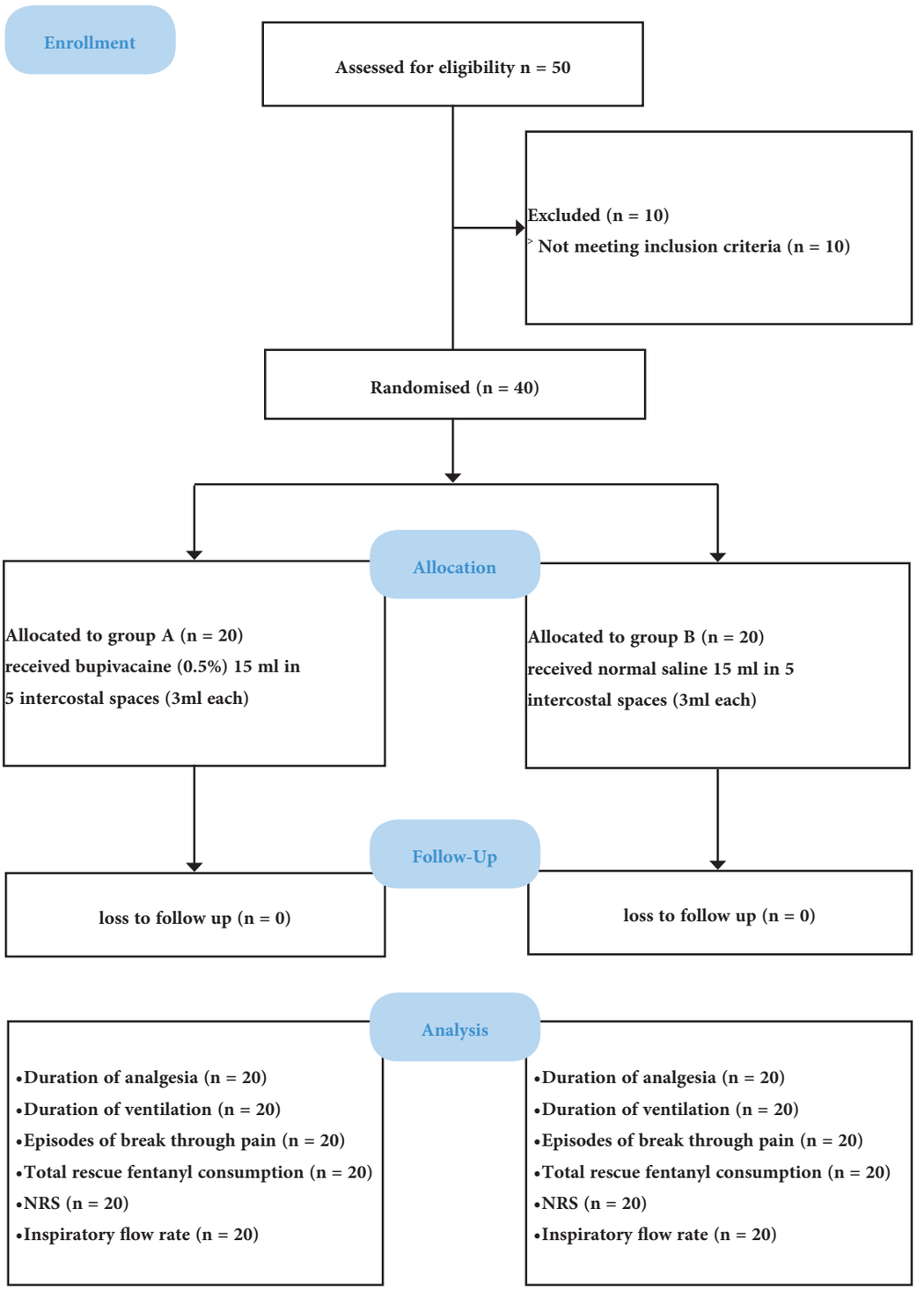

Fig. 1: CONSORT flow diagram CONSORT, Consolidated Standards of Reporting Trials.

The two groups were comparable with relation to age group, sex, height, weight, comorbidities of hypertension and diabetes, NYHA class, baseline arterial oxygen and carbon dioxide levels and the duration of surgery (Table 1).

Table 1: Demographic characteristics of the patients:

	Group A (ICNB)	Group B (CONTROL)	*p* value
Age(years)	43.85±15.90	48.05±17.25	0.428
Male	13(65%)	11(55%)	0.52
Female	7(35%)	9(45%)	
Weight (kg)	6485±13.87	60.70±10.95	0.300
Height (cm)	165.45±8.77	159.95±11.03	0.891
Hypertension	14(70%)	13(65%)	0.85
Diabetes	10(50%)	11(55%)	0.83
NYHA class 1	13(65%)	14(70%)	0.85
NYHA class 2	7(35%)	6(30%)	0.79
Duration of surgery (hours)	2.5±0.96	2.7±1.1	0.272

Group A: 0.5% bupivacaine 15ml (ICNB); Group B: Given normal saline (CONTROL); All values were expressed as mean±SD or number of subjects (%).

NYHA: The New York Heart Association.

In (Table 2) we see that duration of analgesia was much higher in group A (17.20±5.64) as compared to group B (2.85±0.99) and was statistically highly significant (P<0.0001). Also the duration of ventilation in patients receiving ICNB in group A (108.5±24.33) was significantly less as compared to control group B (206.3±47.04) with a statistical value of p<0.0001. The number of episodes of breakthrough pain were only 8 in group A (ICNB) as compared to control group B wherein 34 episodes were recorded. The total amount of rescue analgesic fentanyl consumed in first 24 hours in group A (ICNB) was 24.86±35.77 as compared to control group B (146.90± 33.68). Both the groups did not require any second rescue analgesic in the form of intravenous diclofenac.

Table 2: Duration of analgesia, duration of ventilation and analgesic requirement across the two groups:

	Group A (ICNB)	Group B (CONTROL)	*p* value
Duration of analgesia (hours)	17.20±5.64	2.85±0.99	<0.0001
Duration of ventilation (mean extubation time) in mins	108.5±24.33	206.3±47.04	<0.0001
Total episodes of break through pain	8	34	<0.0001
Total Fentanyl consumption (rescue analgesia)	24.86±35.77	146.90±33.68	<0.0001
Total diclofenac consumption	0	0	

Group A: 0.5% bupivacaine 15ml (ICNB); Group B: Given normal saline (CONTROL); All values were expressed as mean±SD or number of subjects (%).

The (Tables 3, 4) show the pain scores in sedentary state and after coughing. Pain scores of both types, resting and dynamic, were found to be significantly lower in patients who received ICNB (group A) at 0, 4, 8, 12, 16 hours from extubation. At 20 hour and 24 hour it was found that NRS were comparable between the two groups and no statistical difference was detected between them. Pain scores on cough were also found to be of comparable values at same times of 20 and 24 hours with p values being more than 0.05.

Table 3: Sedentary NRS scores at different time points:

Time in hrs (post extubation)	Group A (ICNB)	Group B (CONTROL)	*p* value
0	1.46±1.3113	4.41±0.6763	<0.0001
4	1.01±0.9721	3.81±0.7478	<0.0001
8	1.14±1.0391	4.39±1.0311	<0.0001
12	1.57±1.2234	3.71±1.2212	<0.0001
16	1.67±1.1231	3.55±1.2109	<0.0001
20	2.84±1.1136	3.28±1.0310	=0.2026
24	3.00±1.4863	2.87±0.6707	=0.7234

Sedentary NRS scores at different time points; Group A: 0.5% bupivacaine 15ml (ICNB); Group B: Given normal saline (CONTROL); Values are mean±SD; NRS: Numeric rating scale; SD: Standard deviation.

Table 4: Dynamic NRS scores with cough at different time points:

Time in hours (post extubation)	Group A (ICNB)	Group B (CONTROL)	*p* value
0	2.03±1.6243	5.11±0.8751	<0.0001
4	1.71±1.2607	4.35±0.8770	<0.0001
8	1.89±1.1821	4.71±0.7681	<0.0001
12	2.14±1.3878	4.32±0.9242	<0.0001
16	2.41±1.3520	4.12±0.9871	=0.0001
20	3.21±1.2231	3.91±1.1091	=0656
24	3.61±0.9821	3.52±0.9876	=0.7742

Dynamic NRS scores with cough at different time points; Values are mean±SD; NRS: Numerical rating scale; SD: Standard deviation; Group A: 0.5% bupivacaine 15ml (ICNB); Group B: Given normal saline (CONTROL).

In (Table 5) it is seen that inspiratory flow rates as assessed by incentive spirometry were significantly higher in ICNB group (Group A) as compared to control group (Group B) at all study points of 0, 4, 8, 16, 20, 24 hours from extubation (P<0.05).

Table 5: Post operative Incentive spirometry (Inspiratory flow rate):

Time in hours (post extubation)	Group A (ICNB)	Group B (CONTROL)	*p* value
0	662.4±126.2306	543.3±94.0325	0.0017
4	691.5±126.0821	601.2±136.8081	0.0363
8	801.2±132.3425	700.4±120.9165	0.0163
12	835.2±124.0932	722.3±150.0953	0.0134
16	838.4±92.3243	760.43±120.9834	0.0276
20	851.3±96.7634	754.7±154.8021	0.0232
24	925.7±70.6541	844.3±127.7654	0.0350

Post operative Incentive spirometry (Inspiratory flow rate); Values are mean±SD; SD: Standard deviation; Group A: 0.5% bupivacaine 15ml (ICNB); Group B: Given normal saline (CONTROL).

Post operative complications (Table 6) related to the study were less. Group B had a higher incidence of post operative nausea and vomiting and it was statistically significant. There were no complications related to block.

Table 6: Post operative complications:

	Group A (ICNB)	Group B (CONTROL)	*p* value
Post operative nausea vomiting	3(15%)	11(55 %)	0.019
Pruritus	0	0	
Intravascular injection	0	0	
Pneumothorax	0	0	

Post operative complications.

DISCUSSION

Surgical procedures requiring a thoracotomy are associated with severe pain[5]. Prolonged pain during the perioperative phase can lead to serious complications such as arrhythmia, hypoxia, tachycardia, hypertension, myocardial infarction, and reduced pulmonary function. This pain may persist for years after surgery. A large percentage of patients have post-thoracotomy syndrome (PTPS), with up to 65% of patients reporting some pain and 10% reporting severe, incapacitating pain. Adequate treatment for acute thoracotomy pain typically results in its resolution.

A number of regional analgesic methods have also been tested for use in conjunction with systemic analgesia to relieve pain in thoracotomy patients. These comprise thoracic paravertebral block, ICNB, epidural analgesia, intrathecal opioids, extrapleural infusion of local anesthetics, and intrapleural administration of local anesthetics. Out of all of these methods, postoperative analgesia has improved consistently with the first three procedures[6,7]. Nevertheless, there is a chance that thoracic paravertebral and epidural analgesia can result in major procedure-related problems such as dural puncture, intrathecal local anesthetic dissemination, hypotension, vascular puncture, and hematoma[8].

The use of intrathecal opioid or intercostal nerve block is advised in situations where these procedures are not feasible or appropriate, even though the insufficient length of analgesia necessitates the use of further systemic analgesia. In a meta-analysis, single-injection ICNB was determined to be clinically noninferior to thoracic epidural analgesia (TEA) or para vertebral block (PVB) over the first 24 hours following thoracic surgery. ICNB showed opioid-sparing effects; however, TEA and PVB were associated with higher reductions in postoperative opioid requirement, suggesting that ICNB may be most useful in circumstances where TEA and PVB are not feasible[9]. MIDCAB surgery necessitates the use of heparin which complicates the use of thoracic epidural analgesia in these patients. ICNB is associated with very low frequency of side effects considering the need of heparinization in these group of patients before placement of the graft (on the left anterior descending artery). Its also worthy to mention ICNB is far cheaper and cost effective than other forms of regional analgesia.

Our research showed that individuals who underwent an intercostal nerve block experienced analgesia for a significantly longer period of time (mean length: 17.2 hours). Analgesia following surgery is frequently limited to the first 24 hours following surgery when ICNB is administered as a single shot. The amount, quantity, and kind of local anesthetic administered all affect the duration of analgesia achieved[10]. Our study's results are consistent with the study conducted by Wurnig PN and colleagues, which showed that a single intercostals nerve block usually produces analgesic effects that last up to 24 hours. Analgesic benefits extending for 3 to 5 days postoperatively have also been reported by some authors[11,12].

Accordingly, intraoperative fentanyl and postoperative rescue analgesic consumption was significantly lower in the patients receiving ICNB with bupivacaine. Our findings are also supported by the study done by Abadi A. *et al.*, wherein it was shown that. The ERAS multimodal pain management protocol utilizing intraoperative parasternal blocks appears to reduce pain and decrease opioid use after CABG[3]. Episodes of breakthrough were accordingly less in the group A because of the extended analgesia offered by the intercostals nerve block. These episodes of breakthrough pain were mostly reported to be in the initial 12 hours following extubation.

Up to sixteen hours after surgery, we discovered that postoperative pain in patients receiving ICNB was significantly less than that of individuals in the control group. Following this, the pain scores were lesser in the ICNB group but not statistically significant. Patients who received ICNB had a noticeably longer time until they requested their first analgesic request. Since these patients had superior analgesia they could breathe more easily and as such could be extubated earlier than the control group. Application of intercostal nerve block actually expedited and fast tracked our weaning protocol.

In contrast to the pain scores which showed no statistical significance after 16 hours the inspiratory flow rates assessed through incentive spirometer showed statistically significant improvement at all study points till 24 hours. This highlights the added advantage of ICNB that the improvement in respiratory functions achieved extend well beyond the analgesia provided by the block. This can be more ascertained if a study is done well beyond 24 hours.

The pathogenesis of chronic pain is primarily focused on tissue degradation and trauma-induced nerve injury. Painful stimuli cause the central sensitization of sensitive dorsal horn cells[13]. One of the best strategies to prevent peripheral and central sensitization is to block the neural transmission of pain. Although they do not entirely stop it, systemic analgesics lessen its transmission. Since ICNB blocks this communication far more successfully, it was able to reduce postoperative pain to a higher degree.

There were no complications related to the intercostal nerve block in either group. Higher incidence of post operative nausea and vomiting was seen in control group. It might be because of higher fentanyl use in that group.

The study's primary weakness is that it only covers the first 24 hours following extubation. A more thorough investigation that takes into account the length of stay in the intensive care unit as well as the hospital's discharge schedule would paint a clearer picture. Another drawback was that no records of the administration of vasoactive medications to maintain appropriate hemodynamics were made. An accurate documentation of their use can provide more insight on the study's hemodynamic components and any effects of intercostals nerve block therein.

CONCLUSIONS

In MIDCAB surgeries, intercostal nerve blocks considerably improve postoperative outcomes, such as extended period of analgesia, increased lung function, less breakthrough pain, shorter ventilation times. Including ICNB in perioperative care guidelines can improve patient comfort and hasten recovery after MIDCAB surgery.

CONFLICT OF INTERESTS

There are no conflicts of interest.

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