THE STUDY OF EFFECT OF DEXMEDETOMIDINE ON THE CHARACTERISTICS OF BIER'S BLOCK (INTRAVENOUS REGIONAL ANAESTHESIA) WHEN ADMINISTERED IN ADDITION TO LIDOCAINE FOR FOREARM AND HAND SURGERIES

Diptanu Bhaumik[1], Amol Singam[2], Nand Kishore Agrawal[3]

[1]Postgraduate Resident, Department of Anaesthesiology, Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical Sciences (DMIMS), Sawangi (Meghe), Wardha, Maharashtra.
[2]Associate Professor, Department of Anaesthesiology, Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical Sciences (DMIMS), Sawangi (Meghe), Wardha, Maharashtra.
[3]Professor, Department of Anaesthesiology, Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical Sciences (DMIMS), Sawangi (Meghe), Wardha, Maharashtra.

ABSTRACT

BACKGROUND

Bier's Block (IVRA) is being commonly used as anaesthetic technique for conducting forearm and hand surgeries. It is technically simple and reliable with success rate between 94-98%. However, its use is limited by tourniquet pain and inability to provide postoperative analgesia. To improve the quality of Bier's block, the addition of α-2 adrenergic receptor agonist, dexmedetomidine have been the focus of interest for their sedative, analgesic and perioperative sympatholytic and cardiovascular stabilising effects. The aim of the present study was to evaluate the efficacy of 0.5 mcg/kg dexmedetomidine when added to (0.5%) lidocaine (40 mL) with lidocaine alone in IVRA.

MATERIALS AND METHODS

After approval from Institutional Ethical Committee, 60 patients of ASA Grade I and II of either sex aged between 20-60 years scheduled for various forearm and hand surgeries were included in the study. Patients were randomly divided into two groups 30 in each. Patients in Group L received (0.5%) lidocaine 40 mL with 1 mL NS making it to a total volume of 41 mL and Group LD received (0.5%) lidocaine with the test drug, 0.5 mcg/kg dexmedetomidine diluted up to 1 mL NS to a total volume of 41 mL. Both sensory and motor block onset and regression times, incidences of tourniquet pain, haemodynamic changes, quality of block were noted. Sedation score using Ramsay sedation scale, duration of postoperative analgesia and associated complications were also recorded. Intraoperative and postoperative pain score was recorded by using VAS. Rescue analgesia was given when VAS $\geq$3.

RESULTS

Significant shorter onset times and prolonged regression times of sensory and motor block were recorded in Group LD as compared to Group L. Better haemodynamic stability, prolonged tourniquet tolerance and improved quality of anaesthesia were found in Group LD. Time to first analgesic requirements was significantly longer in Group LD in the postoperative period.

CONCLUSION

We concluded that addition of 0.5 mcg/kg dexmedetomidine to (0.5%) lidocaine for IVRA improves quality of anaesthesia, tourniquet pain and postoperative analgesia without causing side effects.

KEYWORDS

Dexmedetomidine, IVRA, Postoperative Analgesia.

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Corresponding Author:
Dr. Diptanu Bhaumik,
Postgraduate Resident, Department of Anaesthesiology,
Jawaharlal Nehru Medical College,
(DMIMS), Sawangi (Meghe), Wardha-442005,
Maharashtra.
E-mail: bdiptanu@gmail.com
DOI: 10.18410/jebmh/2016/1037

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BACKGROUND

IVRA was first described by August Bier in 1908.[1] It is being commonly used as anaesthetic technique for conducting forearm and hand surgeries. It is technically simple and reliable with success rate between 94-98%.[2] However, its use is limited by tourniquet pain and inability to provide postoperative analgesia.[3] Lidocaine is the most frequently used LA agent for IVRA.[4] Despite its benefits, it has a relatively brief duration of action, which may limit the postoperative analgesia that can be provided and also causes tourniquet pain.

Several adjuncts have been combined with local anaesthetics such as opioids (morphine, fentanyl),[5] muscle relaxants like atracurium.[5] Nonsteroidal Anti-Inflammatory Drugs (NSAIDS)[6] neostigmine,[7] but their use was limited because of their side effects or limited efficacy. To improve the quality of regional blocks, the addition of α-2 adrenergic receptor agonists (clonidine and dexmedetomidine) have been the focus of interest for their sedative, analgesic and perioperative sympatholytic and cardiovascular stabilising effects with reduced anaesthetic requirements.[8,9] Dexmedetomidine, a potent α-2 adrenoceptor agonist is approximately 8 times more selective towards the α-2 adrenoceptors than clonidine.[10] In addition to sympatholytic effects, dexmedetomidine has antihypertensive, anxiolytic, sedative/hypnotic and analgesic effects. It has been used clinically as an adjuvant to anaesthesia as an analgesic agent and also as a sedative in intensive care unit.[3] This prospective, randomised, double-blind study was designed to evaluate the efficacy of dexmedetomidine (0.5 mcg/kg) as an adjuvant to lidocaine (0.5%, 40 mL) in IVRA for forearm and hand surgeries.

MATERIALS AND METHODS

The study was conducted at Acharya Vinoba Bhave Rural Hospital affiliated to Jawaharlal Nehru Medical College, Sawangi (Meghe), Wardha, Maharashtra, from July 2014 to April 2016. After obtaining approval from Ethical Committee, a comparative, randomised and double-blinded study involving 60 patients of either sex aged between 20-60 years of ASA Grade I and II posted for orthopaedic forearm and hand surgeries under IVRA were included in the study. Patients with history of Raynaud's disease, crush injuries, sickle cell anaemia, compartment syndrome, skin diseases on the operating hand, cardiovascular disease, CNS disorders and allergy to any drug were excluded from the study.

Patients were divided into two groups according to the drug, which they received.

- Group L (control group): (n=30) will receive lidocaine (0.5%) 40 mL with 1 mL NS making it to a total volume of 41 mL.
- Group LD (dexmedetomidine group): (n=30) will receive lidocaine (0.5%) 40 mL with the test drug, dexmedetomidine of 0.5 mcg/kg diluted up to 1 mL NS making it to a total volume of 41 mL.

None of the patients in two groups were premedicated. Premedication with sedatives and narcotics was deliberately avoided so as to avoid any interference in the assessment of sensory and motor blockade. On arrival at the operation theatre (OT) before establishing the anaesthetic block, 2 intravenous cannula was placed. One 22G cannula in a vein on the dorsum of the operative hand and the other 20G cannula in the opposite hand for crystalloid infusion. All the patients underwent standard monitoring including an ECG, noninvasive blood pressure and pulse oximetry (SpO_2). Baseline vital parameters were recorded and continuous monitoring was done during the procedure. Before starting the procedure, it was ensured to keep resuscitation equipments and emergency drugs to deal with any untoward effect.

Two cuffed pneumatic tourniquets was tested and positioned around the upper arm. The operative arm is elevated to 90 degrees for 3 mins., then exsanguination with an Esmarch bandage was done followed by inflation of the proximal cuff to 100 mmHg higher than patients SBP. This criteria was fixed for all cases of the study. Before injecting the local anaesthetic solution, circulatory isolation of the arm was verified by inspection, absence of radial pulse and loss of pulse oximetry tracing of the ipsilateral index finger. Then, a dose of 40 mL 0.5% lidocaine injected slowly either with NS or dexmedetomidine (in 1 mL) depending upon the group as mentioned earlier and then IV cannula on operative side was removed. The drug solution was prepared by the anaesthesiologist not involved in the study. Both the patient and the anaesthesiologist monitoring the case were blinded to the drug injected. After injecting the study drug, the sensory blockade is assessed by pinprick method using fine hypodermic needle. Sites used for sensory assessment included the thenar eminence (median nerve), hypothenar eminence (ulnar nerve) and first web space (radial nerve). Loss of pinprick sensation in all three skin areas was considered as complete sensory block. The onset of sensory block was defined as time taken from the completion of injection of study drug till the subject does not feel the pinprick in any of the dermatomes.

Motor function was assessed by asking the patient to move the fingers and flex the elbow. Onset of motor block was defined as the time taken from injection of study drug to inability of the patient to move the fingers and flex the elbow in supine position. After achieving surgical anaesthesia, the distal tourniquet, which overlies part of the anaesthetised arm was inflated and proximal one was deflated after that surgeons were allowed to proceed. Before switch over of tourniquet, 5 mins. after initiation of surgery and throughout the procedure at the interval of 10 mins. Pulse Rate (PR), Blood Pressure (BP), Respiratory Rate (RR), ECG and oxygen saturation (SpO_2) were monitored regularly. Any signs and symptoms of LA toxicity like perioral numbness, tinnitus, nausea, vomiting, pain, skin rashes, hypotension, bradycardia, convulsions were vigilantly looked for and the patients were strictly monitored in this view. Hypotension (25% decrease from baseline) was treated with mephentermine (3-6 mg bolus), bradycardia (25% decrease from baseline value) was treated with IV atropine 0.6 mg and arterial oxygen saturation less than 91% was treated with oxygen supplementation.

Tourniquet pain was assessed by using visual analogue scale (VAS) of 0-10.[11] A score of 0 was given for no pain and 10 for intolerable pain and the degree of sedation by Ramsay sedation score (scale 1-6)[12] at regular interval of 5 mins. till the end of surgery. Intraoperatively, boluses of 1 mcg/kg fentanyl was provided for tourniquet pain treatment when required (VAS $\geq$3). The cuff was not deflated until 40 mins. after local anaesthesia injection even if surgery was completed before 40 mins. and not inflated more than 60

mins. The cuff deflation was performed in cyclic deflation technique. For this, the cuff is deflated for 10 secs. and then reinflated for 1 min.

This sequence is repeated 3 times. After tourniquet deflation, all the vital parameters such as PR, MBP, RR and SpO_2 were monitored at the end of 5, 10, 15 and 30 mins. Total duration of surgery was defined as the duration between first skin incision and complete closure.

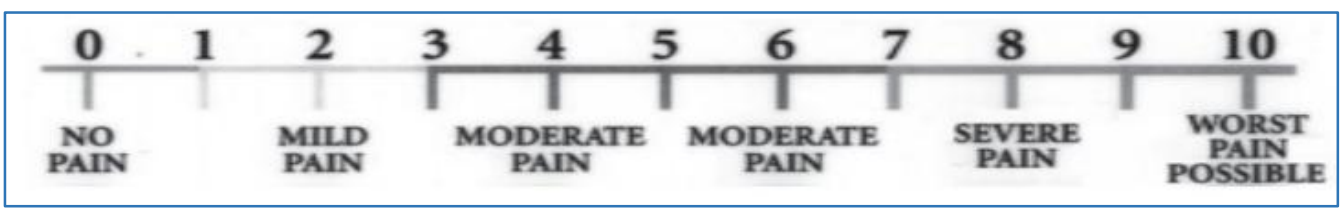
Tourniquet time was defined as time from the inflation of distal cuff to deflation of cuff and it was recorded in every case. All the patients were observed for at least 30 mins. postoperatively in recovery for signs of any untoward reaction.

Assessment of Quality of Block

The quality of overall block was assessed by according to the grading described by Ware R.J. (1979)[13] as follows-

1. Excellent- Complete anaesthesia (lack of any sensation to pinprick and no movements of wrist and fingers).
2. Good- Complete anaesthesia (touch sensation maybe preserved, but no pain to pinprick and minor movements of fingers).
3. Fair- Adequate anaesthesia (slight discomfort, but tolerable without any supplementation).
4. Poor- Inadequate anaesthesia (requiring supplementation with either sedative systemic analgesics or general anaesthesia).

Regression of sensory block was considered time elapsed after tourniquet deflation up to recovery of sensation in all dermatomes determined by pinprick test. Regression of motor block was considered the time from distal tourniquet deflation until return of voluntary movements of fingers. All the patients were shifted to recovery room till complete recovery of block and haemodynamics were monitored at the interval of 5, 10, 15 and 30 mins., thereafter, at the interval of 15 mins. till patient complaint of pain (VAS $\geq$3). Assessment of postoperative pain was done by VAS score between 0-10.[11]



Duration of postoperative analgesia was noted from deflation of tourniquet to VAS score $\geq$3 and Inj. Diclofenac sodium 75 mg IM was given as rescue analgesic. Assessment of sedation postoperatively was done by Ramsay sedation scale.

Ramsay Sedation Scale[12]

Score	Response
1	Anxious or restless or both
2	Cooperative, oriented and tranquil
3	Responding to commands
4	Brisk response to stimulus
5	Sluggish response to stimulus
6	No response to stimulus

STATISTICAL ANALYSIS

Statistical analysis was done by using descriptive inferential statistics using chi-square test and student's unpaired t-test and software used in the analysis were SPSS 17.0 version, GraphPad Prism 6.0 version and EPI-INFO 6.0. All the data was recorded and expressed as Mean±SD and $p<0.05$ is considered as level of significance.

RESULTS

The groups were comparable with respect to age, weight, gender, duration of surgery and tourniquet time.

Variable	Group L (n=30)	Group LD (n=30)	p value
Age (years)	34.36±11.12	41.05±11.77	0.076
Weight (kg)	56.83±10.87	54.33±10.06	0.544
Gender (M:F ratio)	22/8 (3:1)	21/9 (2:1)	0.40
Duration of surgery (mins.)	40.50±6.30	40.73±6.73	0.21
Tourniquet Time (mins.)	47.63±2.87	46.90±4.02	0.66

Table 1. Patient Characteristics in the Two Groups

Data was described as mean±SD and number; $p>0.05$ was statistically not significant.

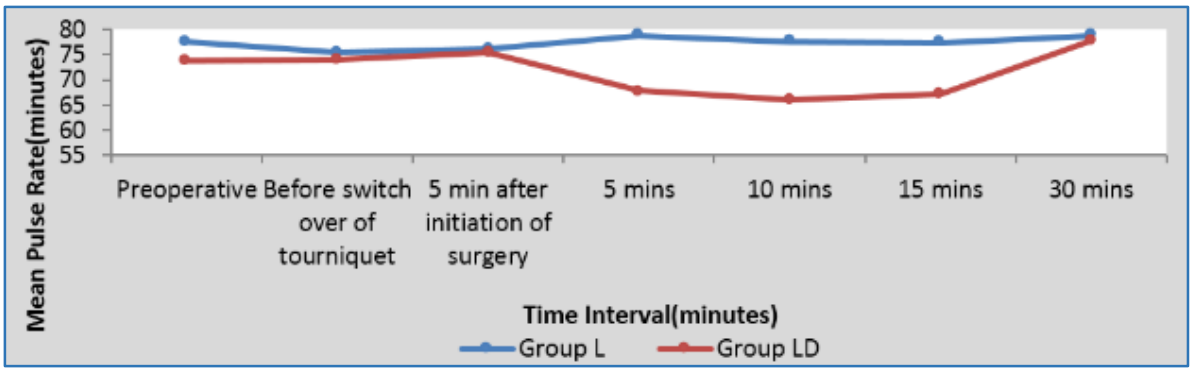
Variables	Group L	Group LD	p value
Onset of sensory block	4.30±0.98	3.30±1.02	0.0096
Regression of sensory block	4.06±1.11	6.60±1.03	0.0001
Onset of motor block	8.10±1.05	4.43±0.89	0.0001
Regression of motor block	6.40±0.93	8.70±0.95	0.0001

Table 2. Comparison of Sensory and Motor Block in Two Groups

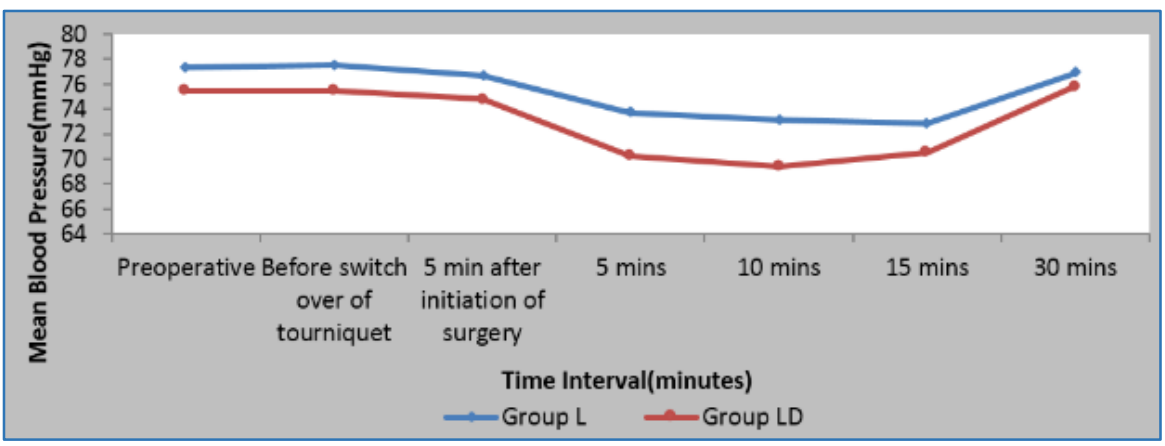
Data was described as mean±SD and number; $p<0.05$ was statistically significant.

As seen from table 2, the onset of sensory and motor block was significantly faster in Group LD as compared to Group L.

Similarly, regression of sensory as well as motor block was significantly prolonged in Group LD after deflation of tourniquet.



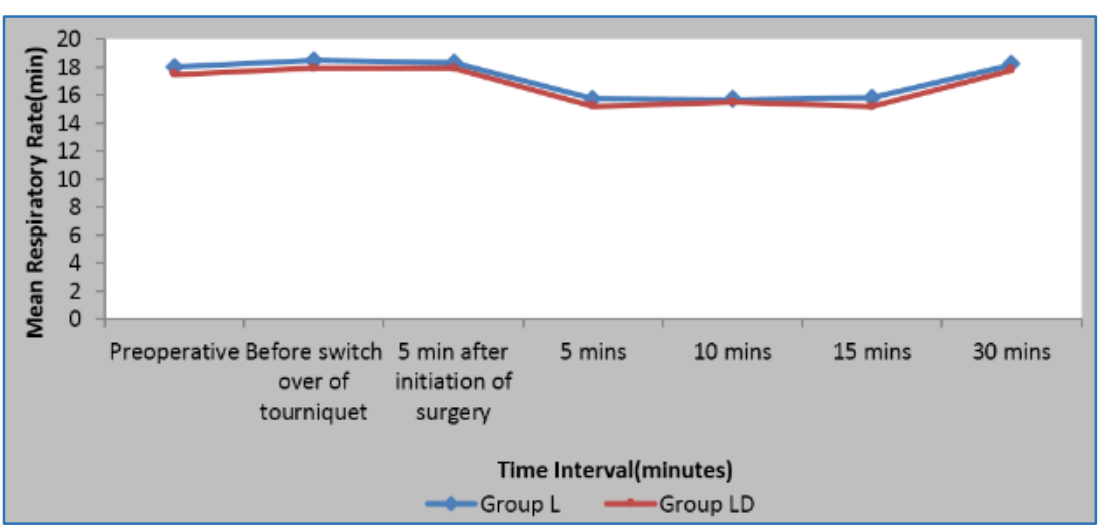
Graph 1. Comparison of Pulse Rate per min. in Patients of Both the Groups (Total No. of Patients = 60, n=30)



Graph 2. Comparison of Mean Blood Pressure (mmHg) in Patients of both the Groups (Total No. of Patients = 60, n=30)

Haemodynamic Changes (Graph 1 and 2)

There was no significant changes in the pulse rate as well as mean blood pressure in both the groups during preoperative period before switch over of tourniquet and 5 mins after initiation of surgery ($p>0.05$). However, there was significant changes in pulse rate as well as mean blood pressure in patients belonging to Group LD after tourniquet deflation during the first 5, 10 and 15 mins ($p<0.05$), but it was reverted back to baseline values at the end of 30 mins.



Graph 3. Comparison of Respiratory Rate per min. in Patients of Both the Groups (Total No. of Patients = 60, n=30)

Grading of Quality of Block	Group L	Group LD
	No. (%)	No. (%)
Excellent	2 (6.67)	24 (80.00)
Good	20 (66.67)	4 (13.33)
Fair	8 (26.67)	2 (6.67)
Poor	0 (0.00)	0 (0.00)
Total	30 (100.00)	30 (100.00)
x^2 Value	32.88	
p-value	0.0001, S, p<0.05	

Table 3. Quality of Block

Table shows the grading of quality of blockade among both groups. We can see that it was excellent in 80% of patients belonging to Group LD.

Group	Number of Patients (Sedation Score)		
	30 mins.	60 mins.	90 mins.
L	0	0	0
LD	2 (1)	1 (1)	1 (1)

Table 4. Sedation Score After Tourniquet Deflation

Variables	Group L	Group LD	P value
Rescue analgesia Yes/no	20/10 (66.67%)	0/30 (0%)	0.0001
Total duration of analgesia (min.)	40.73±15.09	232.66±18.21 mins.	0.0001

Table 5. Tourniquet Pain (Rescue Analgesia Requirement) and Total Duration of Analgesia in Two Groups

p <0.05, statistically significant

Complications	Number of Patients	
	Group L	Group LD
Dry Mouth	0	1
Bradycardia	0	2
Tinnitus	0	0
Perioral numbness	0	0
Hypotension	0	0

Table 6. Complications

DISCUSSION

In IVRA, we occlude the circulation by application of tourniquet and give intravenous injection of local anaesthetics, which provides analgesia to the distal part of a limb. It has been postulated that the site of action in IVRA is probably by blockade of small nerves or possibly nerve endings and not the major nerve trunks.[14] It is ideal for short operative procedures on the extremities performed on an ambulatory basis.[2,15] The drawback with this technique include inability to provide postoperative analgesia.

The pharmacological properties of α-2 agonists are sedation, analgesia, anxiolysis, perioperative sympatholysis, cardiovascular stabilising effects.[16] It reduced anaesthetic requirements and preservation of respiratory function, which have been extensively studied and clinically employed in regional anaesthesia. Dexmedetomidine is 8-10 times more selective towards α-2 adrenergic receptors and is 3.5 times more lipophilic than clonidine. It thus prolongs the duration of sensory and motor blockade induced by local anaesthetics irrespective of the route of administration.[10] Mainly, two doses of dexmedetomidine have been used as an adjuvant in IVRA by many researchers in various studies, i.e. 0.5 mcg/kg and 1 mcg/kg,[17] but high doses of dexmedetomidine is associated with significant sedation postoperatively.[9,18] So, we chose dose of 0.5 mcg/kg.

This study was carried out with the aim of assessment of effectiveness of dexmedetomidine 0.5 mcg/kg in addition to 0.5% (40 mL) lidocaine for IVRA. Table 1 shows distribution of patients in both the groups according to age, weight, gender, duration of surgery and tourniquet time. Patients were comparable in both the groups (p>0.05). Table 2 shows onset and regression times for both the sensory and motor blockade of Bier's block using either dexmedetomidine-lidocaine or lidocaine alone. Dexmedetomidine-lidocaine mixture have earlier onset and prolong regression times for both sensory and motor block. The results were comparable with the study done by Memis et al,[19] Shilpashri et al[20] and Balamurugan et al.[21]

Graph 1 and Graph 2 shows haemodynamic changes. It was observed that mean pulse rate and mean blood pressure in preoperative period before switching over of tourniquet and 5 mins. after initiation of surgery were almost comparable in both Group L and LD, but there was statistically significant fall in mean pulse rate and mean blood pressure. After tourniquet deflation in the first 5, 10 and 15 mins. in Group LD (p<0.05), no intervention was required. At the end of 30 mins., pulse rate came back to near baseline and were comparable with Group L. Respiratory rate (Graph 3) was similar and comparable in both the groups preoperatively, intraoperatively and postoperatively.

This might be due to after deflation of tourniquet, dexmedetomidine coming to central circulation produces abrupt hypertension and bradycardia until the central sympatholytic effect dominates resulting in moderate decrease in both MAP and heart rate from baseline.[19] Nirvana and Salah[3] and Memis et al[19] also found similar trends in haemodynamic parameters. Table 3 shows quality of block, which was excellent in 80% cases in Group LD and as compared to 6.67% cases in patients of Group L. It was good in 66.67% cases of Group L and 13.33% of cases in Group LD. Quality of block was not found to be poor in any cases in either group. Mizrak et al[22] and Shah and Shabir[23] also found quality of blockade statistically better in dexmedetomidine group. As dexmedetomidine is known for

its sedative property, we compared both the groups with respect to sedation. We found that no patients was having sedation intraoperatively in both the groups.

Postoperatively, none of the patients had sedation in Group L. Four patients of Group LD had sedation and Ramsay sedation score was 1. At the end of 30 mins., two patients had sedation while one patient each at the end of 60 and 90 mins. after tourniquet deflation. Results showed low level of sedation with intergroup insignificant. Memis et al[19] in their study also found no statistical difference between groups for sedation values at any intraoperative and postoperative period when lidocaine and lidocaine-dexmedetomidine was compared.

Tourniquet pain and lack of postoperative analgesia are major drawbacks of IVRA. Table 5 shows 20 patients belonging to Group L required rescue analgesia (fentanyl 1 mcg/kg) for tourniquet pain while none of the patient in dexmedetomidine group required rescue analgesic. The mechanism of tourniquet pain remains unclear despite the role of fibres and myelinated C fibres. Dexmedetomidine depresses nerve action potentials especially in C fibres by a mechanism independent of stimulation of α-2 adrenergic receptors leads to strengthening of local anaesthetic block achieved by perineural administration of drug.[21]

Shilpashri et al[20] and Balamurugan et al[21] also found that the incidence of tourniquet pain was less in dexmedetomidine group than lidocaine group. Duration of postoperative analgesia, which was assessed by time to first analgesic requirement after deflation of distal tourniquet. In Group L, it was 40.73±15.09 mins. and in group LD it was 232.66±18.21 min., p-value was 0.0001, which was highly significant. Thus, our study shows that the duration of analgesia was prolonged in dexmedetomidine Group. α-2 adrenergic receptor located at nerve endings may have a role in the analgesic effect of dexmedetomidine by preventing norepinephrine release.[10] The results were comparable with the study done by Pachore et al,[18] Shilpashri et al[20] and Balamurugan et al.[21]

In our study, the deflation of tourniquet was done in cyclic manner, which prevented sudden release of drug in systemic circulation and associated with lesser side effects. No patients in Group L had any side effects. In Group LD, only one patient had dry mouth and two patients had bradycardia postoperatively, which required no intervention. Nirvana and Salah[3] and Esmaoglu et al[24] and did not observe any side effect such as hypotension or bradycardia, which required treatment. The limitation of study is small sample size.

CONCLUSION

Dexmedetomidine 0.5 mcg/kg when added to lidocaine for IVRA significantly shortens sensory and motor block onset time and prolongs the recovery of sensory and motor block. Dexmedetomidine decreases the pain associated with inflation of pneumatic tourniquet with better haemodynamic stability with lesser side effects. Dexmedetomidine also improves quality of block and postoperative analgesia.

RECOMMENDATIONS

According to the results obtained in the current study, we recommend dexmedetomidine can be used as an adjuvant in IVRA taking into considerations the possibility of relevant complications.

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