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Early Versus Late Distal Tourniquet Deflation of Intravenous Regional Anesthesia for Hand and Forearm Surgery

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ABSTRACT

Background: The time of distal tourniquet inflation in intravenous regional anesthesia (IVRA) or Bier's block is still arbitrary and no safe period interval from the local anesthetic injection to distal tourniquet deflation has been established to avoid local anesthetic toxicity.

Objective: This study aimed to compare the risk of local anaesthetic toxicity in early versus late distal tourniquet deflation of IVRA for hand and forearm surgeries.

Patients and methods: This study was carried out on 40 patients, scheduled for hand or forearm surgery. They were divided into two equal groups: Early deflation group (ED) and late deflation group (LD). In the ED group the distal tourniquet deflated after 20 minutes of induction of IVRA and in the LD group the deflation performed at the end of surgery but not more than 60 minutes after induction of IVRA. Any systemic local anesthetic toxicity was recorded and compared between both groups during the procedure and every 2 hours postoperatively for 24 hours. Hemodynamic effects and sensory and motor block recovery times in both studied groups were reported and compared. Surgeon and patient satisfactions were recorded and statistically compared in both groups.

Results: No local anesthetic systemic toxicity (LAST) effects were recorded in both groups of early and late deflation of distal tourniquet in IVRA for hand and forearm surgery. Also, with comparable hemodynamic effects and sensory and motor block recovery times in both studied groups as p-values were > 0.05. Surgeon and patient satisfactions were more in early deflation group than in late deflation group but statistically insignificant (p-value > 0.05).

Conclusions: In this study; there is no difference as regard symptoms and signs of LAST between early and late deflation groups of distal tourniquet in IVRA for hand and forearm surgeries. Also with no significant differences in; hemodynamic effects, sensory and motor block recovery time and surgeon and patient satisfactions.

Keywords: IVRA, Tourniquet deflation, Hand and forearm surgery.

INTRODUCTION

Biers' block, also known as IVRA, is a method of administering anesthesia to the extremities of the body in which a local anesthetic is given intravenously and kept out of circulation using a tourniquet [1, 2].

However, the systemic toxicity of the local anesthetic employed was linked to the most dangerous IVRA adverse effects [3, 4]. The central nervous system (CNS) is the first system affected and then the cardiovascular system (CVS), the respiratory system (RS) and the gastrointestinal system (GIS) [5, 6].

Many factors share in the facilitation or limitation of LAST as the pharmacokinetics, the dose and the rate of injection of the local anesthetic, other drugs given for sedation, good function of the tourniquet, adequate patient monitoring and time limit of tourniquet deflation [7, 8]. But, the time for tourniquet deflation is still arbitrary and no safe period interval has been established [9, 10].

The primary outcome was to compare the risk of local anesthetic toxicity in early compared to late release of distal tourniquet in IVRA for hand and forearm surgeries. The secondary outcomes were to contrast motor and sensory recovery block time, hemodynamic effects and patient and surgeon satisfaction, in early compared to late release of distal tourniquet in IVRA for hand and forearm surgeries.

PATIENTS AND METHODS

This Prospective, randomized, comparative, double blinded study was conducted on 40 patients, between 20 to 70 years old, American Society of Anesthesiologists (ASA) I-II physical status, and scheduled for hand or forearm surgery, at Sohag University Hospital through the period from 1/1/2023 - 1/8/2023.

Exclusion criteria: Severe Raynaud's Disease, Sickle cell disease, crush injury to the limb, psychic patients, known hypersensitivity or contraindications to use lidocaine, uncooperative patients and patients' refusal. All patients were fasting, as the patient may need sedation to improve co-operation in a dose of 1-1.5 mg/kg propofol or patient may convert to general anesthesia.

A computerized system was used to randomly assign the patients into two equal groups (number=20 for each): Group I early deflation group (ED) and group II late deflation group (LD). After establishing non-invasive arterial blood pressure, ECG, peripheral oxygen saturation monitoring, two venous cannulae were inserted: One in a vein in the dorsum of the hand of the operative side for local anesthetic injection and the other in the other side for crystalloid infusion, sedation and emergency drugs. A double-pneumatic tourniquet was applied to the operative side upper arm then the limb raised for 2 minutes, and using an

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Esmarch bandage, the venous system of the arm was emptied, then the proximal tourniquet was inflated to a pressure of 250 mmHg and circulatory disappearance of the limb was confirmed by inspection, lack of radial pulse and failure of pulse oximetry tracing of ipsilateral index finger then Esmarch bandage was removed.

Both groups received 2% lidocaine 3 mg/kg (maximum 200 mg), diluted in 0.9% normal saline to a total volume of 40 mL and administrated over 60s by the anesthesiologist in the cannula of the operative side and the surgeon started sterilization of the operative site. After 5 minutes from giving lidocaine, the distal tourniquet was inflated to 250 mmHg and then the proximal one deflated and the surgeon started to work after sensory testing. In the ED group the distal tourniquet deflation performed after 20 minutes of induction of IVRA and in the LD group the deflation occurs at the end of surgery but not more than 60 minutes of induction of IVRA. All patients were given paracetamol 1gm every 6 hours intravenously postoperatively.

Measurements: Patients' demographic data, duration of surgery, type of surgery and tourniquet time for both groups, were recorded. Any systemic complications as CNS effects including perioral paraesthesia, tinnitus, light-headedness, dizziness, nystagmus and convulsions, CVS effects as hypotension, bradycardia, irregular pulse, or cardiac arrest, also, respiratory effects as hypoxemia, bradypnea or tachypnea and gastrointestinal (GIT) symptoms as nausea and vomiting, all were recorded and managed if observed during the procedure and every 2 hours postoperatively for 24 hours.

Also, any tourniquet related complication as neurological injury or compartment syndrome was reported. Onset and recovery of motor and sensory block for both groups were recorded and compared.
Hemodynamics in the form of MAP, HR and SpO_2 were recorded at onset, 5 minute, 10 minutes and every 10 minutes after injection of local anesthetic to the end of the surgery. Patient and surgeon, who weren't aware of the study group, were inquired to qualify their satisfaction according to tourniquet discomfort and field congestion respectively, as; 1= unsuccessful, 2= poor, 3= acceptable, 4= perfect [11].

Sample size calculation: G*Power 3.1.9.2 was used to calculate the sample size (Universitat Kiel, Germany). The following factors were taken into account while determining the sample size: Three instances were added to each group to overcome dropout, and the study's power was 90%, with an effect size of 0.477 and a 95% confidence limit. We thus enlisted 20 patients in each group.

Ethical approval: Following permission from the Ethical Committee of Sohag Faculty of Medicine, Sohag University, under registration number (IRB) Soh-Med-21-11-01, under Clinical Trials.gov.ID (NCT05234619). Each patient provided an informed written permission. The Helsinki Declaration was followed throughout the course of the investigation.

Statistical analysis

SPSS version 27.0 was used for the statistical analysis. Histograms and the Shapiro-Wilks test were employed to assess the data distribution's normality. The ANOVA (F) test and post hoc test (Tukey) were used to analyze quantitative parametric data, which were shown as mean ± SD.

The IQR and median of quantitative non-parametric data were displayed, and each group was compared using the Kruskall-Wallis test and the Mann Whitney test. The X^2-test was used to analyze the qualitative variables, which were shown as frequency and percentage (%). Statistical significance was defined as a two-tailed P value ≤ 0.05.

RESULTS

After sixty-seven patients had their eligibility evaluated, nine patients declined to take part in the study, and eighteen patients did not fit the requirements. Two groups of 20 patients each were randomly selected from the remaining 40 patients. Every patient (40) was monitored and statistically examined (Figure 1).

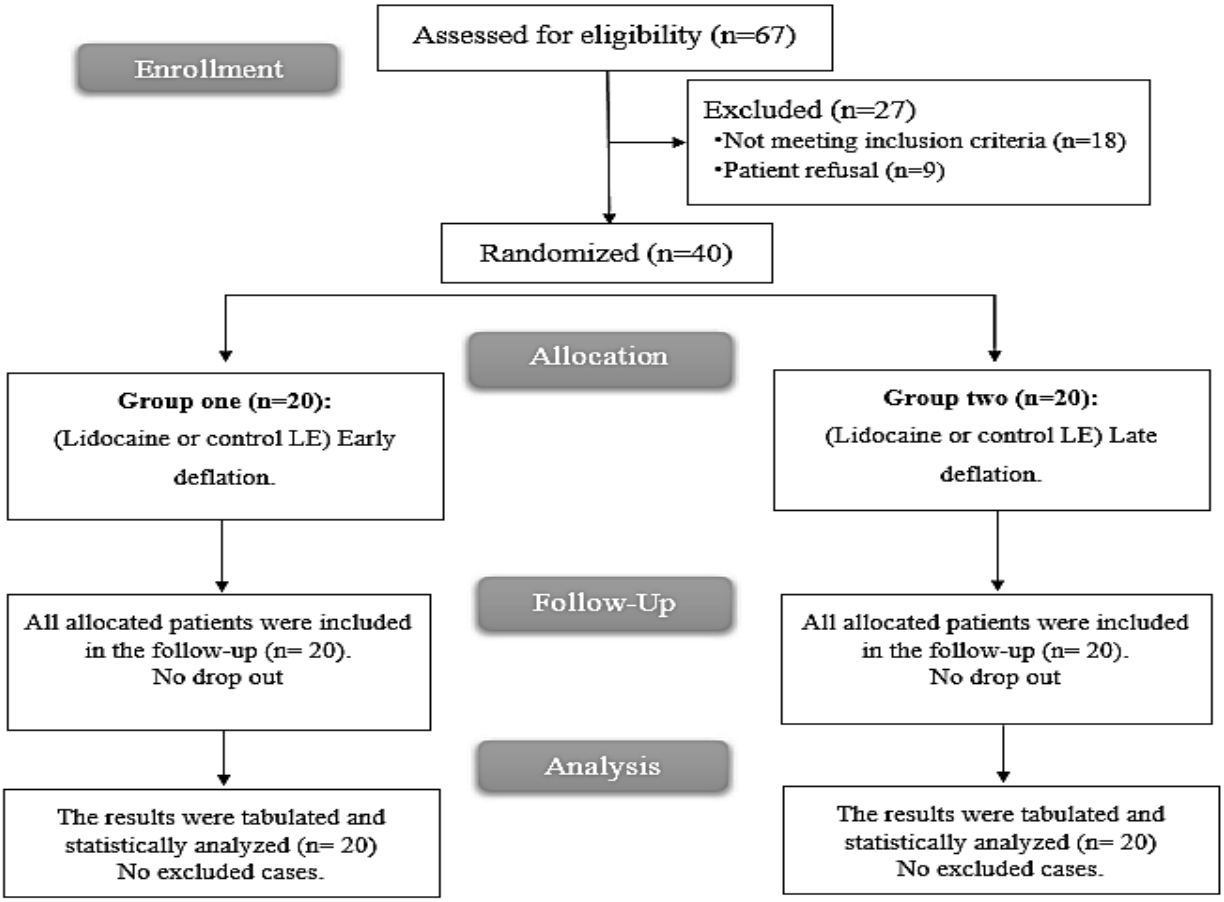


Figure (1): CONSORT flowchart of the studied groups.

Patients' characteristics (age and gender) and duration of surgery were insignificantly different among the studied groups (p-value > 0.05). Time of inflation were significantly lower in ED group than in LD group (P <0.001), as the mean time of ED group was 20 ± 0.00 (fixed variable) and for LD group was 40.9 ± 3.14 (Table 1).

Table (1): Patients' characteristics of both groups

Variables		ED (n=20)	LD (n=20)	P
Age (years)		31 ± 11.19	29.2 ± 9.17	0.656
Sex	**Male**	13 (65%)	12 (60%)	0.937
	Female	7 (35%)	8 (40%)	
Duration of surgery (min)		39.5 ± 5.24	40.5 ± 4.26	0.546
Inflation time (min)		20 ± 0.00	40.9 ± 3.14	**<0.001***

Data are presented as mean ± SD or frequency (%), *: significant as P value ≤ 0.05.

As regards type of surgeries between both groups there was no statistical clinical difference as surgeries were similar in type and number in both groups (p-value > 0.05). No systemic complications as CNS effects including perioral paraesthesia, tinnitus, light-headedness, dizziness, nystagmus and convulsions, CVS effects as hypotension, bradycardia, irregular pulse, and cardiac arrest. Also, respiratory effects as hypoxemia, bradypnea, tachypnea and gastrointestinal (GIT) symptoms as nausea and vomiting during the procedure or every 2 hours postoperative for 24 hours in both studied groups. Also, no tourniquet related complication as neurological injury or compartment syndrome was reported in both groups (Table 2).

Table (2): Type of surgeries between the studied groups

Variables	ED (n=20)	LD (n=20)	P
Carpal tunnel syndrome	3	4	0.677
Mass excision	3	3	1
Fixation of old fracture	9	7	0.747
Repair of old cut tendons	5	6	1

Data are presented as number (n), ED: early deflation group. LD: late deflation group.

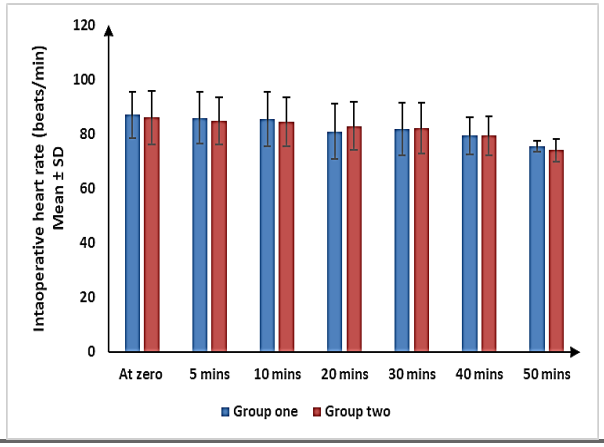
Onset of sensory and motor block was insignificantly different among the studied groups (p-value was 0.380 and 0.487 respectively). Onset of sensory and motor recovery was with no significant difference between groups I and II (p-value was 0.233 and 0.911 respectively) (Table 3).

Table (1): Sensory and motor block of the studied groups and sensory and motor recovery of the studied groups

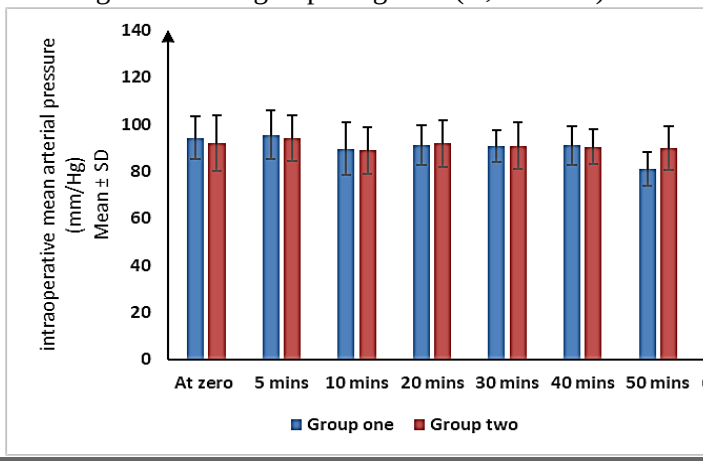
	Group I (n=20)	Group II (n=20)	P
Onset of sensory block (min)	5.3 ± 0.91	5.8 ± 0.99	0.587
Onset of motor block (min)	10.2 ± 0.95	10.1 ± 0.94	0.680
Onset of sensory Recovery (min)	69.6 ±8.5	72.3 ± 8.3	0.911
Onset of motor Recovery (min)	53.5 ± 7.3	52.5 ± 7.2	0.233

Data are presented as mean ± SD, n= number, P= p value.

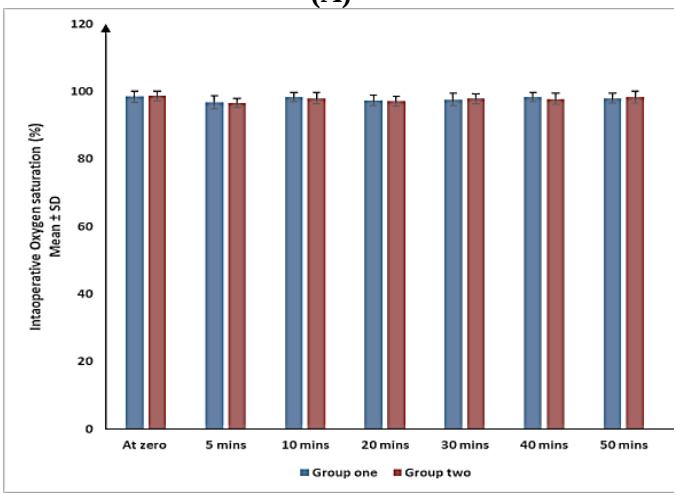
Intraoperative HR, MAP, SpO_2 were insignificantly different among the studied groups. Figure 2 (A, B and C)



(A)



(B)



(C)

Figure (3): Intraoperative (A) Heart rate, (B) mean arterial pressure, (C) SpO_2.

Surgeon and patient satisfaction were insignificantly higher in ED group than in LD group (p-value was 0.705 and 0.725 respectively) among both groups. Although no perfect surgeon satisfaction in both groups in relation to surgical field congestion but there was 80% accepted surgeon satisfaction in ED group versus 75% in LD group. There were 75% of patients showed perfect satisfaction in ED group versus 65% in LD group in relation to tourniquet discomfort, 15% accepted patient satisfaction in ED group versus 20% in LD group and 10% of patients showed poor satisfaction in both groups, (these patients of poor satisfaction belonged their opinion to their consciousness during the operation and they only said that postoperatively) (Table 4).

Table (4): Surgeon and patient satisfaction

Variables		ED (n=20)	LD (n=20)	P
Surgeon satisfaction	**Unsuccessful**	0 (0%)	0 (0%)	0.705
	Poor	4 (20%)	5 (25%)	
	Acceptable	16 (80%)	15 (75%)	
	Perfect	0 (0%)	0 (0%)	
Patient satisfaction	**Unsuccessful**	0 (0%)	0 (0%)	0.725
	Poor	2 (10%)	2 (10%)	
	Acceptable	3 (15%)	5 (20%)	
	Perfect	15 (75%)	13 (65%)	

Data are presented as n: numbers and frequency (%), ED; early deflation group, LD; late deflation group.

DISCUSSION

In the present study as regard evaluation of LAST in early compared to late release of distal tourniquet of IVRA in forearm and hand surgeries, there was no difference in LAST as no patient showed any symptoms or signs of local anesthetic toxicity as regards CNS, CVS, respiratory system or GIS in both groups. Also, no patient showed any tourniquet related complication as neurological injury or compartment syndrome. This was because we were respecting the factors that precipitate or limit the occurrence of systemic toxicity that mentioned by **Guay** [7] as regards the pharmacokinetics of the drug. We used lidocaine, which is rapidly dissociates from sodium channels present in CNS and CVS that prevent its serum level to reach toxic values, the dose of the local anesthetic as we used lidocaine not more than 3 mg/kg with maximum 200 mg and as **Guay** [7] explained in his work; about one third of the dose get into circulation in one minute after deflation of the tourniquet and the net amount gradually follows over the next 45 minutes. We injected the local anesthetic slowly in 60 seconds as the rapid rate of injection may rise the venous tension and mitigate the action of the tourniquet, other drugs given for sedation may mask or increase the toxic effects and so we did not give any sedative drugs with good selecting and good psychological reassurance of the patients. We used a good functioning tourniquet and with adequate patient monitoring and also we limited the time of tourniquet inflation to be not less than 20 minutes before deflation, which is theoretically a suitable time for lidocaine to bind to tissues and so after release small dose of lidocaine entered the general circulation.

As this study is a **unique prospective** study and only one retrospective cohort study was done by **Richard *et al.*** [12] so we compared our results with their values. **Richard *et al.*** [12] retrospective study, which had been done for 430 patients that underwent IVRA in upper extremity and with tourniquet time of less than 20 minutes. About LAST, they concluded that no CNS or respiratory system symptoms or signs of toxicity were reported but in relation to CVS, only one of 430 patients showed transient postoperative decreased blood pressure that improved immediately after intravenous fluid bolus of small amount and the patient was known to be hypertensive and on b-blocker therapy and this was indifferent statistically and about the GIS toxicity symptoms they reported only one of 430 patients complained of vomiting during the operation and one complained of mild nausea postoperatively. One patient also complained of mild vomiting after the operation finished and one complained of severe nausea and vomiting postoperatively and these two patients took > 3 mg/kg lidocaine. All these 5 patients of LAST received sedation and in all of them the inflation time was from 15 to 17 minutes and all these 5 patients discharged free and this also was indifferent statistically. In relation to patients' demographic data, duration of surgery and type of surgery, there were no clinical significant difference with both groups, which is in agreement with **Richard *et al.*** [12]. In our study as regards hemodynamic effects and sensory and motor block recovery times, there were no clinical significant difference between both groups and this is in agreement with **Richard *et al.*** [12] who reported that no intraoperative hemodynamic effects or sensory or motor recovery time in their retrospective cohort trial of early tourniquet deflation. In the current work, surgeon and patient satisfaction were more in early deflation group than in late deflation group but statistically insignificant. **Richard *et al.*** [12] did not mention any about surgeon and patient satisfaction as only our study reported this satisfaction.

CONCLUSION

There was no difference as regards symptoms and signs of LAST between early and late deflation groups of distal tourniquet in IVRA for hand and forearm surgeries. Also, there were no significant differences in hemodynamic effects, sensory and motor block recovery time and surgeon and patient satisfactions.

LIMITATION

One of the study's limitations was its limited sample size and it was a single center research.

No funding.

No conflict of interest.

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