BUPIVACAINE VERSUS LIDOCAINE LOCAL ANESTHESIA FOR OPEN CARPAL TUNNEL RELEASE: A RANDOMIZED COMPARATIVE STUDY

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ABSTRACT

Background

Carpal tunnel syndrome is symptomatic compression of the median nerve at the wrist; surgery can be performed under general and local anesthesia. Local anesthesia is associated with shorter operative time and fewer coast.

Objectives

To compare the use of Bupivacaine and Lidocaine when performing open carpal tunnel surgery.

Patients and Methods

We studied the visual analogue scale, intraoperative blood loss and postoperative intake of analgesics in 85 patients (100 wrists), whom divided randomly to two groups, each receiving one type of local anesthesia. Age range between 20-80 years, female 84 and one male, 61 patients having moderate and 24 having severe grades.

Results

The mean visual analogue score was significantly less in the first group in the first 10 hours, 7 days and 14 days postoperatively (p values 0.001, 0.001, 0.02), thereafter the mean difference was not significant (P value 0.06-0.11). Intra operative bleeding was significantly less in the bupivacaine group (66% ≤ 6 ml), when compared to the Lidocaine group, (92% ≥6ml and 59% having loss of 10 ml). The difference in consumption of acetaminophen in the first two weeks was statistically significant. In the first group, 39 patients (76.4%) taking <15 grams, while in the second group, 36 patients (73.4%) taking >15 grams.

Conclusion

Bupivacaine provides longer postoperative pain relief, less chance of long standing pain and significantly less intraoperative bleeding. The need for postoperative analgesia is significantly less, making the procedure relatively safe and less costly when using bupivacaine.

Keywords: *Carpal tunnel syndrome, Open surgery, Local anesthesia, Bupivacaine, Lidocaine.*

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INTRODUCTION

Paget first described carpal tunnel syndrome (CTS) in 1854. The American Academy of Orthopedic Surgeons (AAOS) defines it as a symptomatic compression neuropathy of the median nerve at the level of the wrist [1]. Incidence rates of up to 276:100,000 per year have been reported, with a prevalence rate up to 9.2% in women and 6% in men [2].

Surgical release of the transverse carpal ligament is advised when conservative treatment fails [3]. The first carpal tunnel decompression was performed by Learmonth in 1933. It was not common until Phalen popularized carpal tunnel surgery in the 1950s; thereafter the use of local anesthetics since 1966 makes the procedure to become a day case procedure [4].

Lidocaine is the commonest type of local anaesthetic agent used for wide awake carpal tunnel release [5] .The most commonly used safe dose of Lidocaine is 10 ml of 2% or 20 ml of 1% to be infiltrated locally, maximum of 7 mg/kg in a 70 kg patient if used with epinephrine and 3mg/kg if no epinephrine added [6].

The addition of epinephrine to the local anesthesia (LA) allows for a higher dose of the drug to be used, increases the duration of the local anesthetic effect post operatively, provide less bloody field and so eliminating the need for tourniquet use and concomitant administration of intravenous sedation [Wide-Awake Local Anesthesia No Tourniquet (WALANT)] [7] .

Bupivacaine is a safe local anesthetic agent in performing minor wrist and hand surgeries [8]. The safe dose of bupivacaine when used as a local infiltration is 2 mg/kg if used without epinephrine and 2.5 mg if epinephrine added [9].

Patient satisfaction is usually high with CTS surgery. (10) Acute postoperative pain may be followed by persistent pain in 10–50% of individuals after surgical operations [11].

The estimated prevalence of chronic post surgical pain (CPSP) is 22% following carpal tunnel surgery. [12]. This is due to activations of A- and C-fibers that causes long-lasting changes in central neural functions. Proper postoperative analgesia will block the induction of central neural sensitization and thereby decreasing the chance of developing chronic post surgical pain [13].

PATIENTS AND METHODS

Patients

Carpal tunnel release was performed under local anaesthesia in 100 wrists of 85 patients over a period of 4 years (2014-2018) in Shar Teaching Hospital and Roonaky Private Hospital. Fifteen patients with bilateral involvement had decompression performed on the most symptomatic wrist first and then on the other wrist approximately 6 weeks later.

The diagnosis of carpal tunnel syndrome was based on clinical history, physical signs, provocative tests (Tinel's sign, Phalen's test and Durkan carpal compression test) and electrophysiological studies.

Inclusion Criteria

Clinical and electrophysiological prove of carpal tunnel syndrome, failure to respond to conservative therapy, Moderate and severe grade by electrophysiological studies, Able to provide informed consent, Accept operation under local anesthesia and first time carpal tunnel surgery.

Exclusion Criteria

Known Lidocaine or Bupivacaine allergy, uncontrolled DM, pregnancy, more than one procedure is being performed at the same setting, Symptomatic cervical spondylosis, pronator syndrome, Peripheral neuropathy, Preoperative anxiety and catastrophising, Possible causes of bleeding tendency and Rheumatoid arthritis and gouty arthritis.

Methods

Patients were divided randomly to either type of anesthesia on the sequence of their appointment for operation.

Group A: Comprises 51 wrists of 43 patients in whom 8 were bilateral and received Bupivacaine type of local anesthesia.

Group B: Comprises 49 wrists of 42 patients in whom 7 were bilateral and received Lidocaine type of local anesthesia.

Anesthesia is induced in the operating room under aseptic technique before the start of the operation. A 27G needle is used, 4 ml of 0.5% bupivacaine (maximal dose 2mg/kg) or 10 ml of 2% Lidocaine (maximal dose 3mg/Kg), is infiltrated along the line of the proposed

incision using the modified Altissimi and Mancini technique 5mm proximal to the wrist crease and 5 mm medial to the median nerve [5].

Few technical tricks to decrease the pain of injection:

The local anesthesia should not be cold. Distract the patient's attention with stabilize the syringe by the other hand with thumb on the plunger before insertion. Inject 0.5ml under the derm, wait till the patient is not feeling the needle tip then give 2ml more before proceeding deeper with at least 1cm bulge in front of needle tip, and reinsert the needle within 1 cm of blanched skin.

The injection should extend over a width sufficient to allow placement of sutures to close the wound. When the patient reaches the operating theatre the surgical field is completely anesthetized.

Longitudinal incision placed along the axis of the radial border of the ring finger, approximately 2 mm ulnar to the thenar crease, it begins distally at Kaplan's cardinal line (which is a line drawn obliquely from the apex of the inter-digital fold between the thumb and index finger distally, toward the ulnar side of the palm parallel to the proximal palmar crease, and passing 4–5 mm distal to the pisiform) and is extended 2 to 4 cm proximally toward the wrist crease but not crossing it, using one small self-retaining retractor controls residual ooze.

Routine carpal tunnel decompression is performed using a McDonald dissector to protect the median nerve. The wound is closed using subcuticular sutures of 2/0 proline to the skin. The wrist is bandaged and not splinted; active ROM finger exercise started intraoperatively; the patient is then discharged home 10 hours after operation with the limb is elevated in an arm sling for the first 48 hours. Fig 1-4.

Postoperative treatment for all includes two doses of 1 gm IV cephalosporin, 1gm acetaminophen tablet on patients request, the first dose of this started when the patient start feeling pain.

Variables assessed includes {Intraoperative pain and bleeding, early postoperative pain, long standing pain and scar tenderness and average intake of acetaminophen in the first two weeks}.

Pain assessments starts intraoperatively, immediate postoperatively, 2, 4,6,10 hours, then 1,4,7 and 14 days at time of stitch removal and then monthly for the next 6 months.

The patients were evaluated using the visual analog scale (VAS) for subjective pain assessment, a 10-cm baseline is recommended for VAS scales and assessment done before receiving the analgesic doses.

No Worst

Pain 0----------10---------- cm Pain

Directions

Ask the patient to indicate on the line where the pain is in relation to the two extremes. Measure from the left hand side to the mark on the right end [14, 15] .

Intraoperative and postoperative bleeding assessed by measuring the number and percentage of saturation of 4X4 inch gauze sponges on the basis if 25% saturated (6.1ml), 50%(9.7ml) and if 100%(13.5ml) [16,17] Fig 5.

The Research Ethical Committee of the University of Sulaimani properly approved this study and all the participants signed a free and informed consent statement.

Statistical analysis

After data collection and prior to data entry and analysis, the questions of study were coded. Data entry performed via using an excel spreadsheet then the statistical analysis was performed by SPSS program, version 21 (IBM SPSS Statistical Package for the Social Sciences).

The data presented in tabular forms showing the frequency and relative frequency distribution of different variables among the both groups of patients (bupivacaine group and Lidocaine group). Chi-square tests were used to compare the categorical data between these two groups of patients in respect to different variables as amount of blood loss, Scar pain after one month, Scar pain after two – six months and average intake of acetaminophen.

Independent t test were used to compare the mean score of pain between these two groups in different timing starting few hours then days and then by months. Different types of Bar charts and Pie charts as well as arithmetic scale line graphs were used to describe the some variables of the study diagrammatically. P values of 0.05 were used as a cut off point for significance of statistical tests.

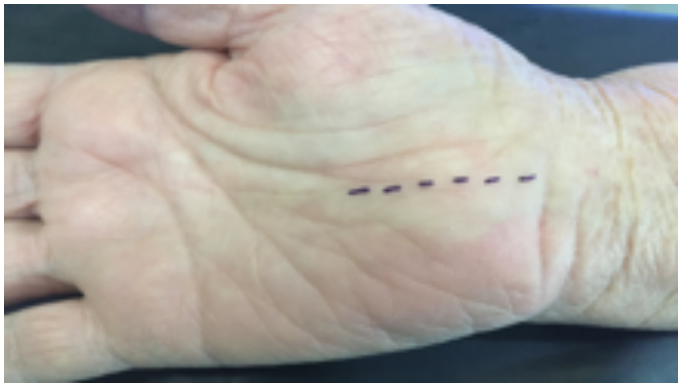
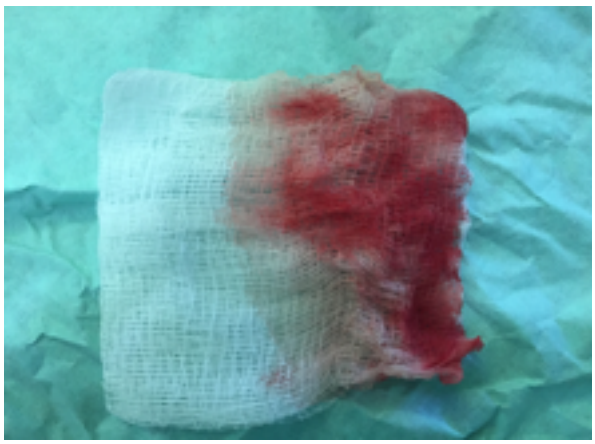


Figure 1. Skin incision marked preoperatively.

Figure 2. Local injection of anesthetic agent.

Figure 3. Self-retaining retractor helps in hemostasis

Figure 4. Skin closure.



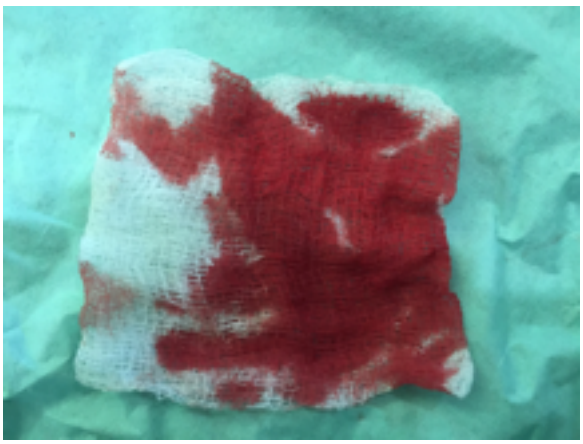


Figure 5. Gauze sponge 25% and 50% saturated.

RESULTS

The study sample includes 85 patients; with surgery performed on 100 wrists as 15 of the patients had bilateral disease; their age ranged between 20-80 years, mean of 47.2 year, female 84 and male only one. The majority were from Sulaimani center and surrounding districts, 59 patients (69.4%) had activities that were predominantly home-based, 25 of them (29.4%) were employee, while one (1.2%) has involved in labor work. Table 1.

The duration of symptoms ranged from 3 to 48 months with mean of (9.6); Forty-nine patients (57.6%) the right hand affected, 21 patients (24.7%) the left one and 15 patients (17.6%) the condition was bilateral.

Electrophysiological studies revealed moderate disease in 61 patients (71.8%) and severe grade in 24 patients (28.2%). The dominant hand affected in 64 patients (74.3%) while the non-dominant side in 21 patients (24.7%). Table 2.

The difference in mean postoperative pain score was statistically significant between the two groups in the first ten hours especially at the 6^{th} and 8^{th} hours postoperatively (P value < 0.001). The Bupivacaine group being experiencing less pain and discomfort. This difference continued in the 1^{st}, 4^{th} and 7^{th} day postoperatively, although it's less profound but still statistically significant (P value < 0.001). Two weeks after operation still the pain score difference between Bupivacaine and Lidocaine groups are significant (1.9 and 2.6 respectively) with (P value 0.02). Table 3, Figure 6.

The mean pain score difference one month and till the end of the follow up at six month was statistically non significant (P value 0.06-0.11), although the pain values are generally higher in the Lidocaine group when compared to the Bupivacaine group. Table 3, Figure 7.

Intra operative bleeding was significantly less in the Bupivacaine group when compared to the Lidocaine group, 34 patients (66%) have blood loss ≤ 6 ml in the first group while 45 patients (92%) have bleeding of ≥6ml with 29 (59%) having loss of 10 ml in the second group (P value 0.004). Figure 8, 9 and Table 4.

Regarding persistent postoperative scar tenderness; in the first group the scar tenderness was significantly less than the second group during the first two months after the operation (p value 0.05 and 0,001 respectively), thereafter in the third and sixth months post operatively no significant difference observed between the two groups (p value 0.13 and 0.13 respectively), Table 4.

The difference in the consumption of acetaminophen postoperatively in the first two weeks was statistically significant between the two groups.

The mean intake in the first group in grams was (12.88 ± 5.63), while in the second group was (21.74 ± 4.40) with (P values of < 0.001), Table 5.

In the first group 39 patients (76.4%) were taking less than 15 grams of acetaminophen, while in the second group 36 patients (73.4%) were taking more than 15 grams of the same medication.

Table 1. Socio demographic characteristics.

Characteristics of study sample		Frequency	%
Age (Years)	20 - 35 years	24	28.2%
	36 - 50 years	24	28.2%
	51 - 65 years	24	28.2%
	66 - 80 years	13	15.3%
	Mean ± SD	47.2 ± 15.6	
Gender	Female	84	98.8%
	Male	1	1.2%
Residence	Sulaimani	53	62.4%
	Surrounding Districts	25	29.4%
	Other Iraq governorates	7	8.2%
Occupation	Housewife	59	69.4%
	Employee	25	29.4%
	Labor worker	1	1.2%

Table 2 Condition characteristics of study sample.

Characteristics of study sample		Frequency	%
Duration (months)	3 - 6 months	21	24.7%
	7 - 12 Months	54	63.5%
	13 - 48 Months	10	11.8%
	Mean ± SD	9.6 ± 6.1	
Sites	Right	49	57.6%
	Left	21	24.7%
	Bilateral	15	17.6%
Grade	Moderate	61	71.8%
	Severe	24	28.2%
Dominance	Yes	64	75.3%
	No	21	24.7%

Table 3. Mean pain score difference of the two groups assessed by VAS

Post operative pain score	Mean Pain score ± SD		P value
	Bupivacaine	Lidocaine	
2 hours	0.8 ± 0.4	1.2 ± 1.5	< 0.001
4 hours	0.5 ± 1.2	2.0 ± 1.9	< 0.001
6 hours	0.8 ± 1.4	3.8 ± 1.8	< 0.001
8 hours	1.5 ± 1.6	5.3 ± 0.9	< 0.001
10 hours	3.2 ± 1.3	5.7 ± 0.7	< 0.001
1st day	4.9 ± 1.3	5.8 ± 0.8	< 0.001
4th day	3.8 ± 1.2	4.6 ± 0.6	< 0.001
7th day	3.2 ± 1.2	4.0 ± 0.7	< 0.001
14th day	1.9 ± 1.4	2.6 ± 1.5	0.02
1 month	1.0 ± 1.2	1.5 ± 1.7	0.06
2 months	0.5 ± 1.0	1.0 ± 1.5	0.11
3 months	0.4 ± 0.9	0.8 ± 1.3	0.07
6 months	0.4 ± 0.9	0.7 ± 1.2	0.11

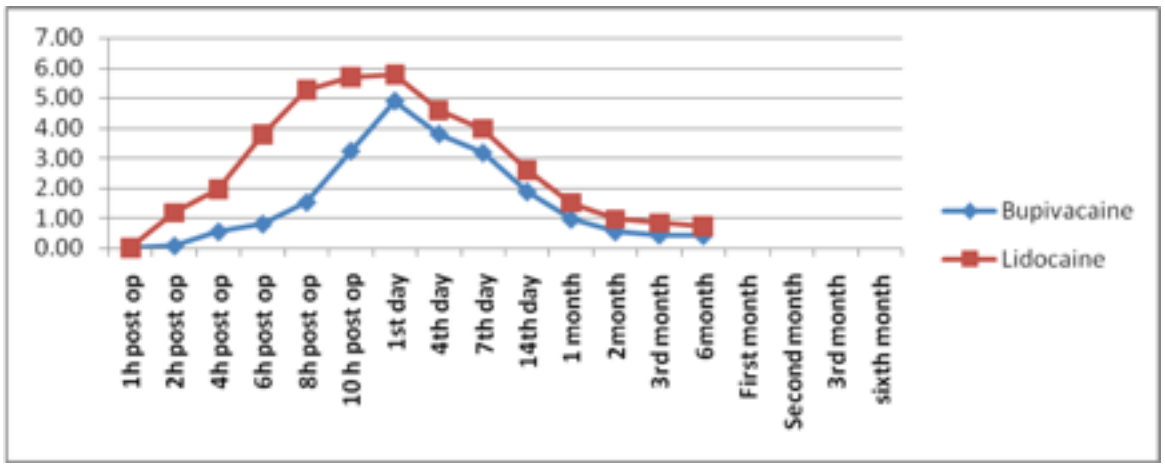


Figure 6. VAS pain score difference at different time interval.

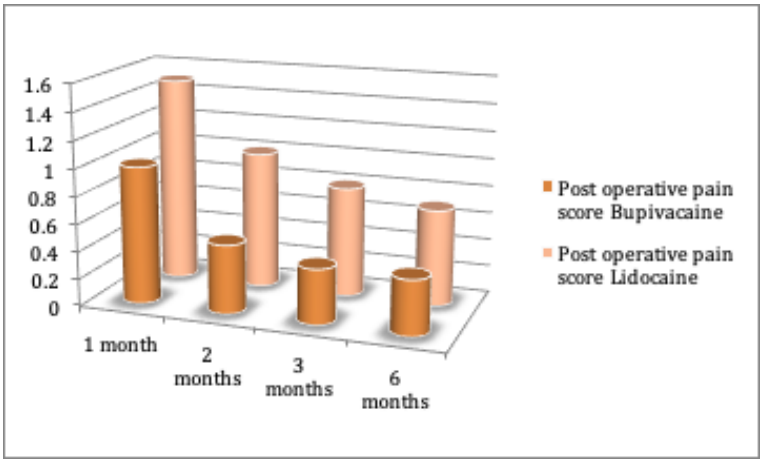


Figure 7. VAS pain score difference 1-3 months post operative

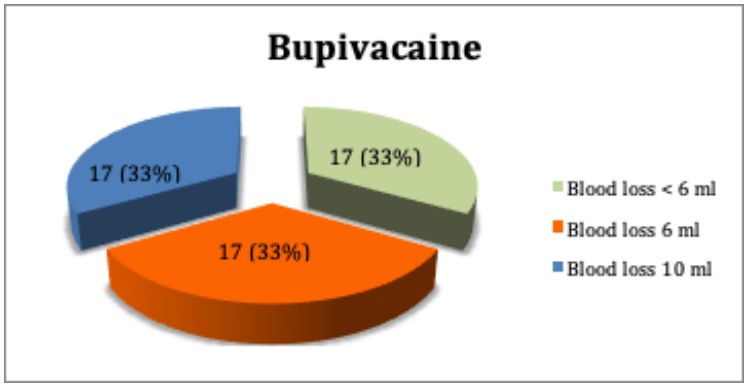


Figure 8. Approximate blood losses in the first group.

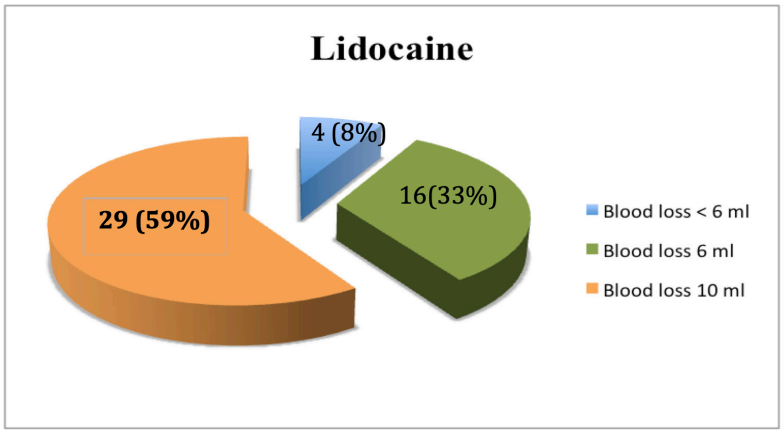


Figure 9. Approximate blood losses in the second group.

Table 4. Operation characteristic differences of the two groups.

Operation characteristics		Bupivacaine	Lidocaine	P value
Blood loss	< 6 ml	17	4	0.004
	6 ml	17	16	
	10 ml	17	29	
Scar pain after one month	Yes	31	49	< 0.05
	No	20	0	
Scar pain after two months	Yes	25	44	< 0.001
	No	26	5	
Scar pain after three months	Yes	9	15	0.13
	No	42	34	
Scar pain after six months	Yes	9	15	0.13
	No	42	34	

Table 5. The Average intake of acetaminophen in the first two weeks/gm.

Average intake of acetaminophen in the first two weeks/ grams	Bupivacaine	Lidocaine	P value
5 - 10	29	0	< 0.001
11 - 15	10	9	
16 - 20	9	18	
21 - 25	3	18	
26 - 30	0	4	
Mean ± SD	12.88 ± 5.63	21.74 ± 4.40	< 0.001

DISCUSSION

Pain during and after surgical procedures is one of the important concerns, both for the patient and the surgeon; it has a great economic impact on the health services.

A recent US study analyzed the efficacy of postoperative pain management in surgical inpatients from different surgical departments (Orthopedic, General surgery, Neurosurgery and Gynecology). It was reported that 12% of patients had severe to extreme pain, while 54% reported moderate to extreme pain on discharge. During the first 14 days after surgery, there were 13% of patients with severe to extreme pain, and 46% suffering moderate to extreme pain. Although these data is less than that before 10 years but still there is a significant postoperative pain [18].

Multimodal analgesic techniques include the use of preoperative and postoperative nonsteroidal anti-inflammatory drugs, potent local anesthetics, α2- δ ligands and opioids; they prevent central neuroplastic changes from occurring so effectively reducing the chance of persistent postoperative pain following minor and major operations [13, 19]

Pressman et al conducted a survey to investigate the use of local anesthetics in carpal tunnel surgery. With a response rate of 65%, they found that 76% of 51 orthopedic surgeons routinely used local anesthesia, and 22% used other anesthetic approaches [4].

Karaca et al in their study compared the use of local anesthesia versus general anesthesia in carpal tunnel release and concluded that a high percentage of patients reported high levels of satisfaction, excellent results and improvements in their quality of life in both groups, and the type of anaesthesia has no effect on the results of surgical treatment of CTS [20]. Their study also concluded that general anesthesia could have more comorbidities especially respiratory problems; it has also a significantly longer discharge

time after surgery. In addition, cost is higher further because preoperative screening tests (blood tests, chest X-rays and electrocardiographs) are required. Also local anesthesia regulations do not require an anesthesia nurse or doctor for its use. Economically local anesthesia (LA) is probably more cost effective than general anesthesia (GA) [20]. Both lidocaine and bupivacaine are used as local anesthetics since their inventions (lidocaine in 1943, bupivacaine in 1957) [21].

In this study, we compared two randomly selected groups of patients undergoing open carpal tunnel release using two different local anesthesia drugs, bupivacaine and Lidocaine. In the first ten hours post operatively the bupivacaine group experienced less pain than the Lidocaine group of patients, when assessed by visual analogue scale.

Youha et al in their review on the updates on local anesthesia for carpal tunnel release found that there is level III evidence for those patients who had carpal tunnel release with bupivacaine or ropivacaine had longer pain relief than those who received Lidocaine alone[22]. This is consistent with the findings in this study. This fact is due to the longer anesthetic and analgesic effect of bupivacaine when compared to Lidocaine. Mansour et al also proved this, in their comparative study they found when comparing the duration of analgesia after bupivacaine and ropivacaine use, the former having analgesic effect that lasts for 10.3 hours [23].

This difference in pain perception lasts for the first two weeks after surgery, the explanation is that the longer period of postoperative analgesia provided by the bupivacaine blocks the effect of local tissue damage that causes acute early post operative pain from inducing both (primary hyperalgesia) which is increased sensitivity to further stimuli and (secondary hyperalgesia) which is central nervous system changes and sensitization causing pain transmission to takes place after previously non-noxious stimulation in the area surrounding the injury.

Both these, especially the secondary hyperalgesia are the main contributors to long standing postoperative pain and chronic postsurgical pain (CPSP) which may lasts for months after the surgical procedure [24, 25, 13].

Persistent pain and scar tenderness for the first two months observed in a significant number of patients received lidocaine when compared to bupivacaine. In these patients we excluded all the possible causes of persistent pain by clinical assessment (pillar pain, incomplete decompression, referred pain). The explanation of that is the fact that majority of patients in the first group experienced less acute post operative pain in the first 10-14 days and this has a profound effect on long standing pain and scar discomfort in that time, and this is in agreement with Katz et al, Lamacraft G, Crombie IK, Reuben et al [24, 25, 26, 13].

This study couldn't prove significant difference in pain perception between the two groups after two months from the operation, although generally the lidocaine group experienced more pain, the explanation is that our sample of patients for comparison may be small to prove that and probably if we prolonged the follow up period we may catch more patients with persistent pain when using Lidocaine.

In this study we used the concept of modified Wide-Awake Local Anesthesia No Tourniquet (WALANT), which includes the use of bupivacaine or Lidocaine without adrenalin, without tourniquet and without sedation. Lalonde et al, Antonio et al analyzed the safety of adding epinephrine to the local anesthesia in hand operations including the fingers, and reporting no single accidental ischemia or necrosis if used at a concentration of 1:100,000 or less [27, 28].

Still there are a lot of other reports of skin necrosis and finger ischemia after local infiltration of epinephrine or accidental subcutaneous extravasations. Kim et al and Majda et al both reported cases of skin necrosis and bullous lesions after subcutaneous extravasation of epinephrine [29, 30]. This with the potential risk of systemic toxicity and our desire to compare the two anesthetic agents regarding intra operative bleeding make us to omit the use of epinephrine.

The findings in this study proves that bupivacaine causes significantly less bleeding when compared with lidocaine without using local vasoconstrictors. This finding is due to the fact that the lower doses of bupivacaine used (20 mg) usually induce vasoconstriction when compared to the higher doses of lidocaine (200 mg) which induces vasodilatation and this is related to their difference in potency. It is well known that the aminoamide local anesthetics induce vasoconstriction when used in low doses and vasodilatation when we increase their dose.

Lim et al in his vitro study proved that the aminoamide local anesthetics (Levobupivacaine, ropivacaine, lidocaine and mepivacaine) produces vasoconstriction

both in vivo and in vitro and this effect is dose related, the less the dose the more vasoconstrictor effect. The potency with the vasoconstrictor effect is primarily related to their lipid solubility. Levobupivacaine being the most potent, having highest lipid solubility, requiring lower doses and having more vasoconstrictor effects than lidocaine [31].

Pucci et al in his in vivo study observed the same vasoconstrictor effect of bupivacaine on the spinal blood flow when used for spinal anesthesia in concentrations of 0.5% and 20mg doses [32]. Kapral et al, Casati et al proved in their study that when comparing Levobupivacaine with bupivacaine they have the same anesthetic properties, they induce the same hemodynamic changes when used and the only difference of Levobupivacaine is its less cardiotoxicity, neurotoxicity and a little more duration of action[33, 34].

Newton et al, in their experimental study on the local circulatory changes of lidocaine 2% when injected intradermaly in the forearm end in the conclusion that it induces a profound increase of microvascular blood flow when assessed by Laser Doppler imaging; Sinnott et al and Johns et al also have the same conclusions on the use of both 1% and 2% lidocaine which is the usual concentration used for most of the operations [35-37].

All these evidences and findings in this study support that bupivacaine 0.5% when used as local anesthesia induces less bleeding when compared to lidocaine 1% and 2% and this may eliminate the use of tourniquet and local epinephrine as vasoconstrictor agents, so avoiding the discomfort of tourniquet and need to use sedation during the procedure together with the risks of local epinephrine use.

Guinard et al in their study have a different conclusion that in therapeutic doses both anesthetic drugs induce vasodilatation and increased blood flow, the explanation of that he found the hyperemia when using 0.75% bupivacaine and 2% lidocaine, but we used the 0.5% bupivacaine and 2% lidocaine so the lower therapeutic dose of the former definitely cause less hyperemia than the latter [38].

The total consumption of acetaminophen is less when using bupivacaine in comparison to lidocaine in the first two weeks, the explanation is that the use of more potent local anesthetic agent bupivacaine promotes less pain perception and central sensitization in the first group during the first two weeks significantly reduced the postoperative analgesic and opioid consumption.

In this study no any side effects of either drugs were observed in the doses that used for the open carpal tunnel release, although literatures label bupivacaine to be more neurotoxic and cardiotoxic than lidocaine.

We have few limitations in this study, first is the number of patients which should be more, second the follow up should extend up to two years at least to catch more cases of persistent pain in either group, thirdly it is the finding in only two center but if it includes multiple centers probably gives the chance for a larger sample and more randomizations.

In conclusion, the above facts and these results suggest that the use of the more potent local anesthetic agent bupivacaine in lower doses when performing open carpal tunnel release provides better intraoperative analgesia, longer postoperative pain relief, less chance of long standing pain and scar discomfort when compared to the less potent agent lidocaine. Significantly less intraoperative bleeding observed when using the former agent, which encourage omitting the use of epinephrine locally and tourniquet, avoiding the local and systemic complications of that agent with the discomfort of tourniquet. The need for postoperative analgesia is also significantly less making the procedure relatively safe and less costly when using bupivacaine. It is strongly recommended to perform other studies including the more recent local anesthetic agent ropivacaine, which has more potent local vasoconstrictive effect than both the anesthetic agents we used, but probably its higher cost make us to choose the cheaper agents for comparison.

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