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Clinical comparison of bupivacaine and ropivacaine for neurostimulation-guided brachial plexus block by axillary approach

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SUMMARY

Objective: To evaluate the anesthetic quality, as well as the analgesic efficiency and length, between ropivacaine (0.75%) and bupivacaine (0.5%) using a dose of 3 mg/kg for the blockade of the axillary brachial plexus in hand surgery through a peripheral nerve localizer. **Material and methods:** It was performed a prospective study on 60 patients in a randomized way with the same probability of receiving either ropivacaine or bupivacaine. The patients were assigned to two different groups, and every patient was soothed by means of midazolam and fentanyl. The localization of the brachial plexus was effective for finding a response in the median (MN), radial (RN), and ulnar (UN) nerves through a peripheral nerve stimulator. It was evaluated the starting time, the efficacy of the anesthesia, the motor and sensible blockade; as well as of postoperative length of the anesthesia. **Results:** There were no significant demographic differences between both groups, even though the starting time of the sensible blockade was significantly lower for the ropivacaine group (22.77 minutes) than for the bupivacaine group (37.48 minutes). The length of the analgesic effect was higher for ropivacaine (18.62 hours) than for bupivacaine (13.11 hours). The scale of basal pain was not significant. **Conclusion:** Ropivacaine shortens the latency time with respect to bupivacaine in the blockade of the axillary brachial plexus.

Key words: Axillary blockade, ropivacaine, bupivacaine, peripheral nerve location.

RESUMEN

Objetivo: *Valorar la calidad anestésica así como la eficacia y duración analgésica entre ropivacaína al 0.75% y bupivacaína al 0.5% utilizando dosis de 3 mg/kg para bloqueo de plexo braquial axilar en cirugía de mano, mediante localizador de nervios periféricos.* ***Material y métodos:*** *Se realizó un estudio prospectivo de 60 pacientes de manera aleatoria con igual probabilidad de recibir ropivacaína como bupivacaína, asignados en 2 grupos, todos los pacientes fueron sedados con midazolam y fentanyl. La localización de plexo braquial fue efectiva al encontrar respuesta en el nervio mediano, radial y ulnar mediante neuroestimulador de nervios periféricos. Se evaluó el tiempo de inicio, la eficacia de la anestesia, el bloqueo motor y sensitivo; así como la duración de la analgesia postoperatoria.* ***Resultados:*** *No hubo diferencias demográficas significativas entre ambos grupos, aunque el tiempo de inicio de bloqueo sensitivo fue significativamente menor para el grupo de ropivacaína 22.77 min y para bupivacaína 37.48 minutos. La duración analgésica fue mayor para ropivacaí-*

na 18.62 h y bupivacaína 13.11 h. La escala de dolor basal no fue significativa. ***Conclusión:*** *Ropivacaína acorta el tiempo de latencia con mayor tiempo de duración analgésica con respecto a la bupivacaína en el bloqueo de plexo braquial vía axilar.*

Palabras clave: *Bloqueo axilar, ropivacaína, bupivacaína, neuroestimulación.*

INTRODUCTION

The axillary block has a long history, existing to date, providing surgical anesthesia and rehabilitating analgesia, as well as also it has demonstrated to be a useful and sure technique in postoperative analgesia[1]. At present there is an increased interest in performing peripheral block techniques because there is the technology ensuring a high rate of success as such the selective neurostimulation[2] and a large scientific evidence, these two factors support the benefits of these regional techniques in hand surgery.

The neurostimulation has come to revolutionize the certainty of success in regional anesthesia, although there are some inconsistencies with regard to specific territories that are not blocked either by the Biophase circumstances or stimulating sympathetic or sensory fibers only[3] or perhaps because of unknown in the volumes and concentrations of specific local anesthetics[4]. Success in axillary block begins with the selection of local anesthetic, use of appropriate concentrations, and anesthesia of the surgical setting, leading e.g. to specific neurolocalizations of skin muscle. The physicochemical properties of ropivacaine and bupivacaine suggest a similar start time and an equal analgesic potency, their pharmacological profiles are well described in the literature, as well as their use in the supraclavicular approach[5]. Theoretically, ropivacaine offers high level of sensory block and lesser motor block as compared to with bupivacaine[6].

The Department of Hand and Microsurgery at the Instituto Nacional de Rehabilitación (National Institute of Rehabilitation) performs annually in average 700 surgeries using regional anesthetic techniques in 95% of cases, and like in reports from other orthopedic centers in which regional anesthesia is performed, these surgeries are carried out mostly using axillary approach in about 70% of cases. Racemic bupivacaine and (S)-ropivacaine are some of the local anesthetics available in Mexico, unfortunately it is not the case of the levobupivacaína, these two long life local anesthetics show differences in their toxicity profile and is therefore of great interest recognize what are the advantages and behavior of these local anesthetics in brachial plexus block via axillary in patients undergoing upper extremity surgery. Previous studies show no consistent results regarding the advantages of ropivacaine over bupivacaine, even there are reports where differences between them are mentioned[7].

For all these reasons, the aim of this study was to compare the two anesthetics using equianalgesic doses per kg weight of the patient in hand and forearm surgery using the neurostimulation-guided single injection technique at high volumes.

MATERIAL AND METHODS

A randomized, controlled clinical assay is elaborated in which 60 patients underwent hand surgery were included, they were classified according to their diagnosis and surgery such as traumatic hand, soft tissue, minimally invasive surgeries, and microsurgery. After obtaining approval of the hospital's Ethics Committee and under informed consent of the patient, adult patients with surgical risk (ASA I-III) and with equal probability of receiving both bupivacaine and ropivacaine for brachial plexus block via axillary were selected randomly by a computer program, they were allocated in Group B (bupivacaine) or Group R (ropivacaine).

After non-invasive monitoring using conscious sedation for regional anesthesia according to Wilson II[8], with 2 mg/kg midazolam and 1 mg/kg fentanyl. Brachial plexus block was performed using axillary approach, the patient was placed in dorsal decubitus position with the arm in abduction at 90 degrees to identify the pulse of the axillary artery, proximal to the underarm, asepsis and skin antisepsis were performed later and dermal soap was applied, the brachial plexus was identified using Stimuplex B Braun ® neurostimulator connected to a 22G gauge, 50 mm long, short bevel,, free-tip, insulated-needle. After obtaining a grade II motor response[9] of the ulnar, radial or median nerve depending on the surgical area with a output current of 0.8 to 0.4 mA using intermittent negative aspiration, a 3 mg/g dose of 7.5 mg/mL hydrochlorinated ropivacaine (Naropin, Astra Zeneca®) or a 3 mg/g dose of hydrochlorinated bupivacaine was applied. Additionally, the volume was completed with lidocaine and epinephrine, 5 mg/kg dose. Tourniquet inflation (250-300 mmHg) was used, approximately 100 mmHg systolic blood pressure in all patients, and start time records were initiated of sensory block by wet cotton on the skin, followed by the cutaneous innervation of the median, radial, ulnar, and musculocutaneous nerves. At 10, 20, 30 and after surgery. It was assessed as follows: 0 = No sensory block, 1 = Sensitivity loss to fine touch, 2 = Sensibility loss to the rough touch. The motor block was recorded accord-

ing to the scale of the 4P's[10] Push, Pull, Pinch, Pinch, 0 = no motor block, 1 = partial motor block, and 2 = complete motor block, according to the specific movements for each nerve.

Anesthetic quality was measured by the amount of opioids required as well as supplementary blocks. Additionally, the analgesic was measured for 24 h using the visual analogue scale.

The data were captured in the statistical program SPSS 11.0. The results were expressed by mean and standard deviation, considering the latter as the best prediction. The patient distribution by age, weight, sex, ASA status, with the Pearson's chi-square test. t-test was applied to compare the groups; on the other hand, the duration of surgery, type of surgery, and fentanyl requirements were assessed. Latency time, duration of analgesia, sensory and motor block with Mann-Whitney non-parametric test. Considering a significant $p < 0.05$.

RESULTS

The study group was comprised of 60 patients from the Instituto Nacional de Rehabilitación (National Institute of Rehabilitation), 30 patients allocated to the ropivacaine group (R) and 29 patients allocated to the bupivacaine group (B) of which one patient was eliminated due to neurotoxicity. With an average weight between groups of 69.9 and 67.7 kg respectively, a mean age of 44.6 years, 35 males and 24 females, which showed no significant differences (Table I).

The surgery types are shown in Table II, when the classification of subtypes of performed surgeries is observed, no differences were found between groups in regard to the diagnosis of traumatic hand where there were 12 patients in group A and 8 patients in group B , this diagnosis was the most frequent one.

The duration of surgery was 1.5 h on average, also no significant difference was observed. Anesthetic quality measured indirectly through the supplementary fentanyl requirement was similar in both groups, 3 patients were required in group R and 6 patients in group B, these patients required more than 100 mg, no significant difference was observed between groups. Another indirect measurement of anesthetic quality was supplementary infiltration of local anesthetic, which took place the same number of times in both groups (two patients in each group) (Table III). It's notable that one patient in group A was managed with *general anesthesia* due to significant deficiency in the anesthetic quality.

The start time of block was significantly lower in group A with 21.2 minutes as compared to the group B with 28.6 minutes ($p < 0.001$), as shown in Table IV (Figure 1). The duration of analgesia was on average significantly higher in the ropivacaine group up to 18.6 h with a $p < 0.003$ (Figure 2).

The sensory block decreases inversely in regard to motor block level achieved at 15 minutes (Figure 3); after the 20 minutes there were no significant differences in the propor-

Table I. Demographic variables.

Variable	Group Ropivacaine (n = 30)	Bupivacaine (n = 29)	p
Age (years)	44.7 (22.3)	44.5 (20.7)	0.97
Weight (kg)	69.9 (15.8)	67.7 (14.4)	0.59
Sex (Male)	16 (53.3%)	19 (65.5%)	0.24
ASA 1	13 (43.3%)	15 (51.7%)	
2	9 (30.0%)	11 (37.9%)	0.27
3	8 (26.7%)	3 (10.4%)	

Table II. Surgery types.

	Group Ropivacaine (n = 30)	Bupivacaine (n = 29)	p
Soft tissue	8 (26.7 %)	6 (20.7 %)	
Hand traumatic	15 (50.0 %)	12 (41.3 %)	0.68
Surgery	3 (10.0 %)	5 (17.3 %)	
Minimal invasive			
Microsurgery	4 (13.3 %)	6 (20.7 %)	

Table III. Anesthetic quality valuation by group.

Variable	Ropivacaine (n = 30)	Bupivacaine (n = 29)	
Fenta request >100 µg (yes)	3…….(10.0%)	6……(20.7%)	0.21
Local infiltration (yes)	2…….(6.66%)	2……(6.68)	0.68
General anesthesia (yes)	1…….(3.33)	0……(0.00%)	0.50
Surgery time (hours)	1.4…….(0.62)	1.5……(0.79)	0.68

Table IV. Sensory and motor block percentages.

Variable	Gruop Ropivacaine (n = 30)			Bupivacaine (n = 29)			p
Motor block 15 min*	0	1	2	0	1	2	
	14	7	9	17	11	1	0.023
Sensory block**							
Radial	0	3	27	1	1	27	0.37
N medium		2	28		1	28	0.51
Axillary	1	3	26	1	2	26	0.91
Cubical	1	0	29	0	2	27	0.21
Musculocutaneous	1	2	27	0	2	27	0.61

*Motor block was registered acording to the scale of 4P's[10] Push, Pull, Pinch, Pinch; 0 = No motor block, 1 = partial motor block and 2 = complete motor block.
**Sensory block scale: 0 = without sensory block, 1 = Loss of sensitivity to light touch, 2 = Loss of sensitivity to thick touch.

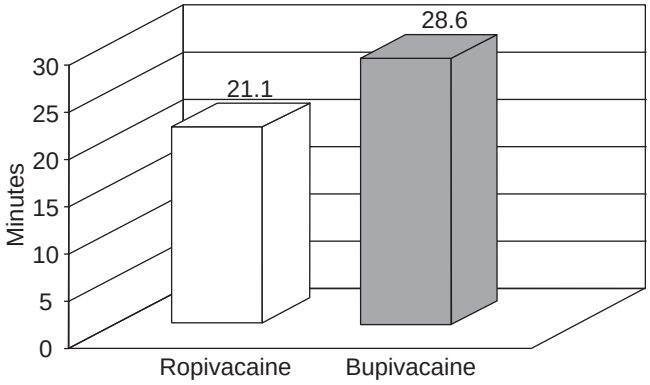

Figure 1. Latency time was minor with ropivacaine, p < 0.001.

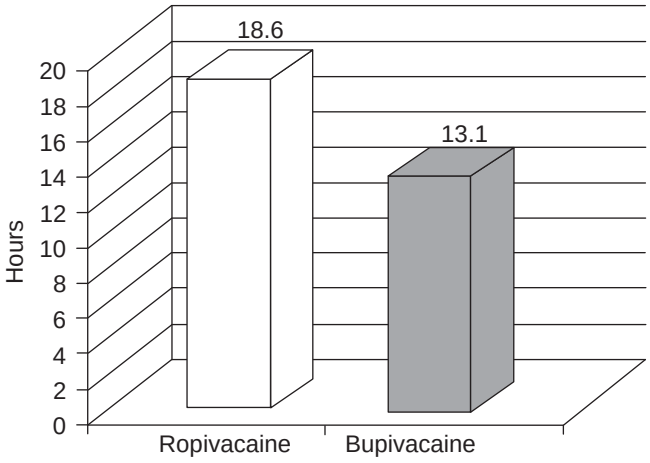

Figure 2. Analgesia time was higher with ropivacaine *vs* bupivacaine, p < 0.003.

tions of patients at various levels of motor block. The motor block was achieved more deeply in group B as the highest scores of immobility are in this group.

There were no significant differences in the two groups in sensory block of the nerves studied (Table IV) (Figures 4 and 5). The postoperative pain scale was similar in both groups. The two groups had an average VAS score of 3 at all measure times, except when the duration of the analgesia was reduced in the group B, so highest VAS scores were observed in these patients.

DISCUSSION

This study shows the clinical behavior data of ropivacaine and bupivacaine at the same volumes at a fixed dose of 3 mg/kg in thoracic extremity surgery. It is well known that the injection site has particular effects of local anesthetics varying their clinical profile according not only to the concentrations and type of surgery, but also according to the approach; on the other hand, there appears to be a particular physiology for each course of the brachial plexus. The results of this study showed similar VAS values, administered fixed volumes, rescue analgesics, and side effects. The success rate found in this study coincides with other authors in over to 90% of cases. Almost all patients in our study had complete sensory and motor block; a likely explanation is that even though our institution is a teaching hospital, the blocks were conducted by teachers for the preparation of this research. Additionally, the data are consistent with the

judgment expressed by the patients at the end of surgery, which indicated a high satisfaction at least during the surgery. Decrease in the latency time was found in the R group, which was statistically significant, similar to Bertini et al.[1]

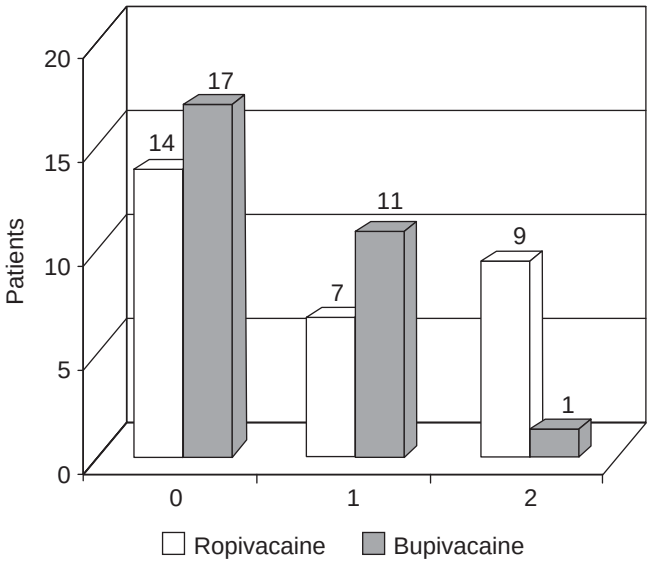

Figure 3. Statistical difference was found concerning motor block only to the 15 minutes, where 0 = No motor block, 1 = Partial motor block and 2 = Complete motor block, $p < 0.023$.

and in disagreement with other authors such as Hickey et al and Vainionpaa et al, both anesthetics have similar physicochemical characteristics, relating start time with PK (8.2), the power with the solubility, and the duration of the anesthetic effect with the protein binding (95%)[11]. Despite this, recent researches showed a significant most fast start time both in upper and lower extremity blocks as using ropivacaine [12].

High volumes were handled in this study for several reasons, one of them is to ensure the spread to the four peripheral nerves by a single injection to ensure the success rate, there are studies that have backed up volumes of up to 40 mL of 7.5mg/mL ropivacaine, i.e., 300 mg or approximately 4 mg/kg at total, which translates as high efficiency and without side effects in adult patients[13]. Moreover, 0.25% ropivacaine was used in this study decreasing further possible effects of neurotoxicity.

In regard to side effects, a case with disorientation, bradylalia which coincided with a blood puncture in a venous vessel was presented, this side effect is described in the literature as the most frequent[14]. The treatment was essentially respiratory support and use of benzodiazepines to continue the surgical procedure. No nausea, vomiting or technical problems were reported.

The quality of anesthesia was demonstrated by the need for a transoperative narcotic, unlike Bertini, both groups required similar supplementation.

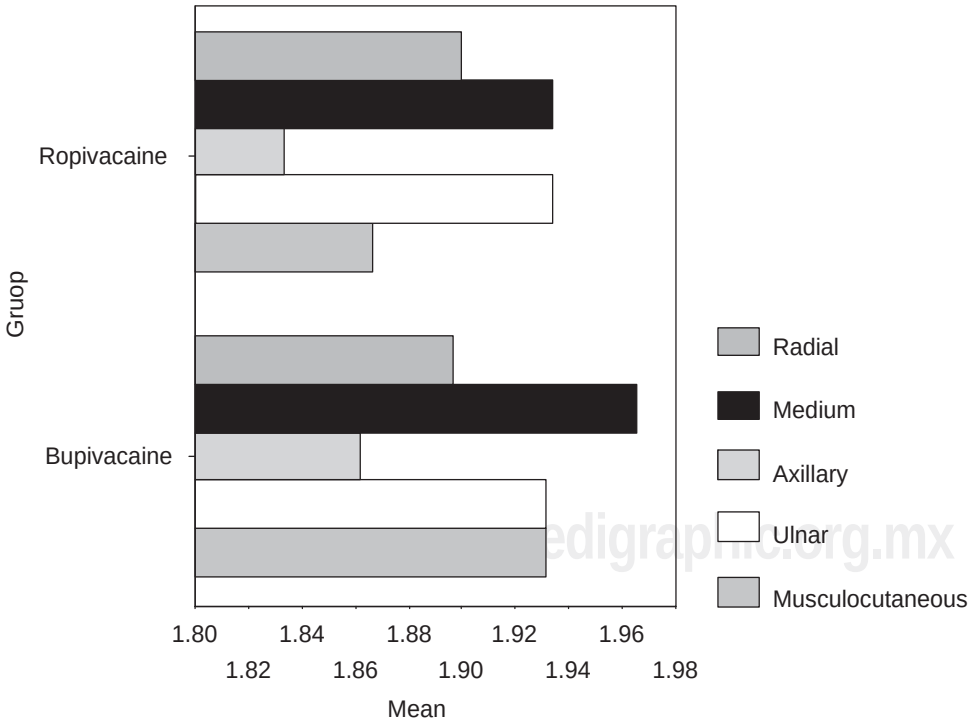

Figure 4. Analgesic quality mean for peripheral nerve. No statistically significant difference was found between groups $p > 0.05$.

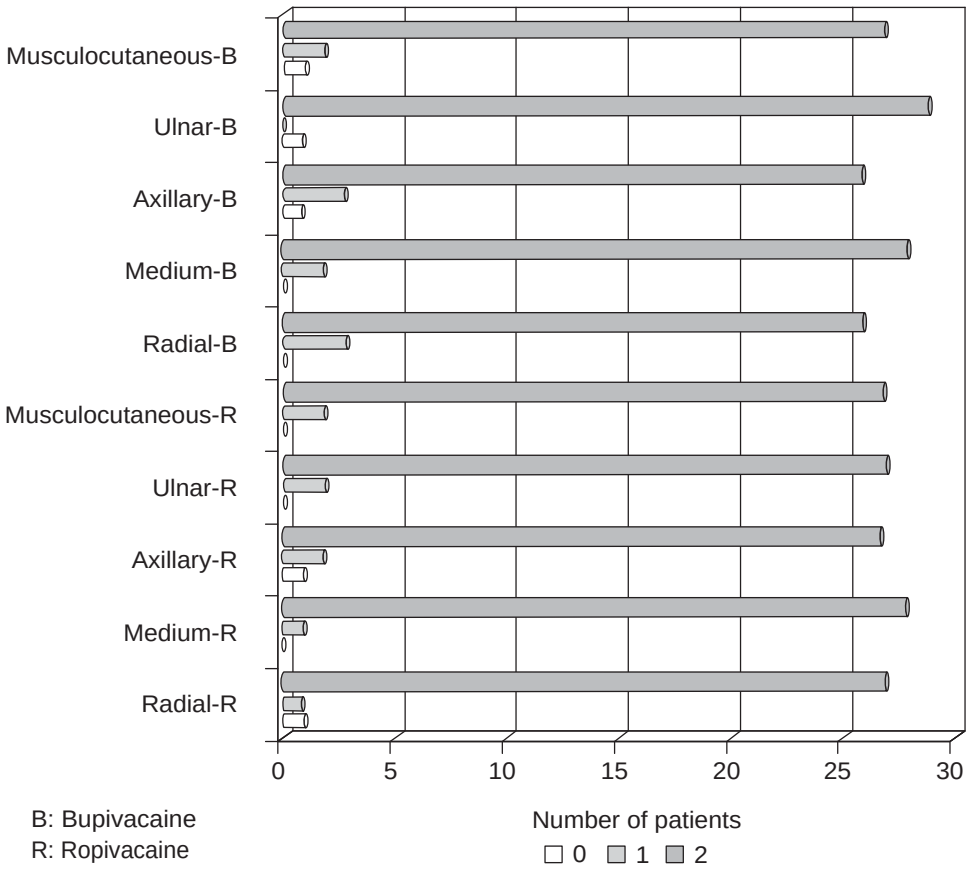

Figure 5. Measurement of analgesic quality by peripheral nerve between groups, where 0 = Without sensory block, 1 = Loss of sensitivity to light touch, 2 = Loss of sensitivity to thick touch. No statistically significant difference was found between groups p > 0.05.

In this study the traumatic hand was the most frequent diagnosis, this event guide us on the knowledge accuracy of the regional techniques of brachial plexus, since generally these patients are admitted on an emergency basis without fasting, and therefore the selective managements of peripheral anesthesia are techniques of choice, and therefore it is necessary to know exactly the onset and duration of local anesthetics. It should be noted that these surgical procedures are performed predominantly in the palm of the hands.

Our results show that both bupivacaine and ropivacaine provides effective postoperative analgesia, since there was no significant difference among the VAS scores; however, the duration of ropivacaine's analgesic effect exceeded to that of the bupivacaine by over 5 hours. We have speculated that some patients prefer to tolerate some pain so as not to feel dysesthesia or numbness of the operated limb, these results are probably due to the differential lock between ropivacaine and bupivacaine. The issue of the difference in power between these long-lasting anesthetics is controversial. Some studies have shown that ropivacaine administered epidurally is 40% less potent than bupivacaine (Capogna et al)[20]. However, both drugs appear to be equipotent at high concentrations by axillary route for brachial plexus surgery.

In brief, we conclude that ropivacaine shows advantages over bupivacaine for brachial plexus anesthesia with axillary approach due to its short latency, same motor block, long analgesic duration, and its low toxicity profile. Unfortunately we could not make measurements of plasma concentrations. But we believe that both local anesthetics are an effective and reliable choice for anesthesia of the brachial plexus.

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