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Neurostimulation and peripheral nerve block in regional anesthesia

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SUMMARY

Recently regional anesthesia has been developed with the technology available. The improvement of the nervous location through an electrical current has allowed to know the different responses motor from peripheral nerves, and with it to offer to anesthetic procedures and analgesic insurances, reliable and effective. The neurostimulation has been a technique of nervous location based on the anatomy, in the knowledge of the described classic approach for more than 8 decades. This issue articulate reviews the bases, the ideal technique, ideal responses and eliciting for responses well as recommended doses and volumes; multiple and selective or unique indications of each approach and stimulations as much from the point of view anglosajon like european. Due to the previous thing with the only objective of the diffusion of the neurostimulation within the regional anesthesia since in Mexico a text does not exist, so that the anesthesiology accedes of practical form to the knowledge of this one technique.

Key words: Neurostimulation, block, peripheral nerve, approach, plexus brachial, plexus lumbar.

RESUMEN

Recientemente la anestesia regional se ha desarrollado a la par de la tecnología disponible. El perfeccionamiento de la localización nerviosa a través de una corriente eléctrica, ha permitido conocer las diferentes respuestas motoras de nervios periféricos, y con ello brindar procedimientos anestésicos y analgésicos seguros, confiables y eficaces. La neuroestimulación es una técnica de localización nerviosa basada en la anatomía, en el conocimiento de los abordajes clásicos descritos hace más de 8 décadas. Este artículo revisa las bases, la técnica, respuestas ideales y respuestas esperadas, así como dosis y volúmenes recomendados; indicaciones de cada abordaje y estimulaciones múltiples y selectivas o únicas tanto desde el punto de vista anglosajón como el europeo. Todo lo anterior con el único objetivo de la difusión de la neuroestimulación dentro de la anestesia regional ya que en México no existe un texto, para que el anestesiólogo acceda de forma práctica al conocimiento de esta técnica.

Palabras clave: *Neuroestimulación, bloqueo, nervio periférico, abordaje, plexo braquial, plexo lumbar.*

INTRODUCTION

The first percutaneous block of a peripheral nerve was performed by Hirschel[1] 100 years ago. In the following 60 years, regional anesthesia was a true form of “art”. It was necessary to have a full knowledge of anatomy and pharmacology of local anesthetics. While these two basic sciences remain essential to ensure the role of the block and patient safety, the art of conducting a block has gradually been reconceptualized by science. The key to success was depending on the acuity of the placement of the needle, the location of the nerve and the injection of local anesthetic. The pioneers of regional anesthesia described the popular mystique thereof 30 years ago, until the peripheral nerve neurostimulator to aid the location and identification of peripheral nerves was introduced by Ballard Wright[2]. In 1952 Stanley and Charlotte Sarnoff in Boston developed the first transcutaneous neurostimulator to locate the phrenic nerve, thereby stimulating ventilation in patients with poliomyelitis[3]. It was Von Perthes -German doctor- who took the first step in designing a prototype neurostimulator, subsequently Grenblatt in 1962 worked on the design of needles, and Montgomery and Raj in 1973 managed the first self-powered and isolated needles. A major publication in this story is that of Hadzic et al[4] who tells us about the characteristics and lack of refinement of the current neurostimulators. There was no needles of atraumatic design and high levels of current was requiring to produce a stimulation of motor response (3 to 5 mA) when this technology appeared. Stimulation of motor activity was not very specific and the needle tip to the proximity of the nerve could be quite distant and the unsuccessful block was common. But this has changed and developed, with the advent of more refined, focused and sophisticated technology.

Regional anesthesia, in developing countries like ours, has been conducted under the real economy framework that these techniques provide and a need, with no alternative in the absence of other resources. Now, however, regional anesthesia has taken other paths. Just 2 years ago the first reports on neurostimulation[5.6] were made in Mexico; however they are not yet available to all anesthesiologists. We stand at the door of a new era; *neurostimulation* or selective location of peripheral nerves and there is no return. Current techniques for real nervous location on marked surfaces estimate the location of the nervous target structures, so that we can’t leave to assist to this moment in the history of regional anesthesia, the easily accessible massive broadcasting to all anaesthesiologists is of immediate concern, reason and purpose of this review.

BASIS OF NEUROSTIMULATION

Stimulation of peripheral nerves is accomplished by establishing an electrical circuit. Between the two poles of this circuit is positioned the peripheral nerve to be stimulated. The minimum effective current for nerve stimulation is called threshold (Figure 1). The electric field created by the pulsations will have a maximum depolarizer effect when cathode (negative pole) in contact with the nerve. The magnitude of this current depends on the speed in reaching the peak and the total time of its use. An important factor in determining the magnitude of the current is the resistance (impedance) of the body where the nerve is located and the internal resistance of the stimulator. This phenomenon follows Ohm’s law where the current is directly proportional to the potential difference or voltage and inversely proportional to the resistance[7]. The current flowing during each pulse follows the path of least resis-

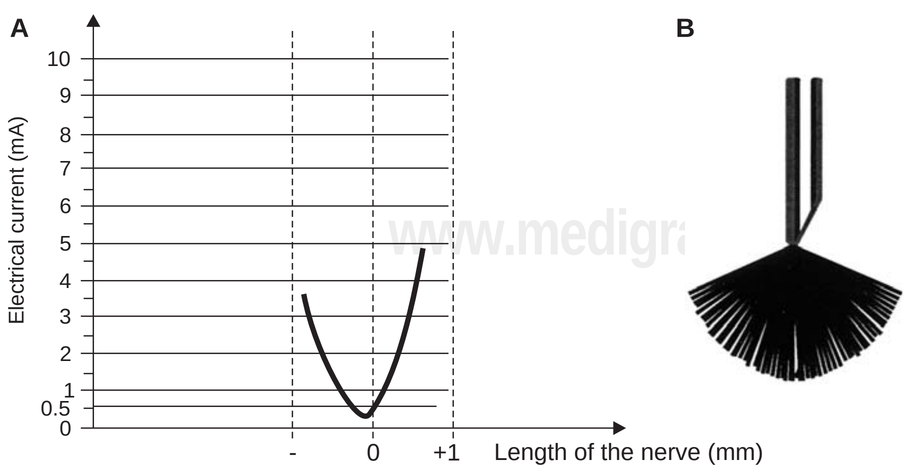

Figure 1A. Electrical field and current density of needle of neurostimulation. **B** Electrical field, needle covered with teflon until the tip, short bevel.

tance. Between the electrodes, the current is directed from the anode, formed by an electrode placed on the skin, to the cathode formed by the needle. This situation is electrically isolated bodies of needles to prevent false locations to make contact with it[8]. By this situation, the bodies of the needles are electrically isolated to avoid false locations when in contact with it[8]. The current is the most important variable in neurostimulation, as the current threshold is the same for all the peripheral nerves and has no interindividual variation. Motor fibers have a lower threshold than sensory fibers, the low-frequency stimulation causes muscular responses whereas high frequency stimulation produce pain. The energy required to initiate an action potential is expressed in Coulomb's law, where there is an inverse relationship between energy and the square of the distance running from electrode to nerve when both are within a conductor body. Which translates to a less distance less energy to trigger an action potential and therefore a muscle contraction[9]. The electrical resistance of the human body ranges from 1-10 KW (kiloOhms) and by penetrating the dermis have only 0.5 KW, so the future neurostimulator shall use nanocoulomb (nC). To exceed the threshold requires a minimum amount of current needed to trigger a nerve impulse, this minimum current amplitude (stimulus) is called *rheobase*. Another important term in nerve stimulation is that of c*hronaxy*, defined as the duration of an effective electrical stimulus to trigger a response, is the point where the breadth thereof is twice the value of the *rheobase*[10]. The *biophase* or interphase refers to the phenomenon where an electrical current can pass and not disperse, due to a aqueous substance between the nerve and the needle tip such as blood, water or local anesthetic[11]. Variations in the output current in relation to age or normal patient pathology 120 nC, 60 nC in children, over 1000 nC in diabetic have been studied.

Basic Description of the Technique

I. Turn the neurostimulator
II. Screen is illuminated and sound is started
III. Select the frequency of 1 Hz or 2 Hz
IV. Connect the alligator clip to electrode of the skin
V. Connect the needle to the cable connector
VI. Choose the output current around 1.0 mA
VII. Insert the needle into the puncture site
VIII. The yellow light flashes again, indicating that the circuit has been closed
IX. Advance the needle to the plexus until seeing muscle contractions (Table I)
X. Reduce the current and optimize the position of the needle until the contractions reappear
XI. The optimum position of the needle is achieved when the muscle contractions are less than 0.5 mA and higher than 0.2 mA in a scale of grade II motor response[6]
XII. After injecting the dose, a test of local anesthetic is the absence of muscle contractions in 5 seconds

Neurostimulation Technique as Sala-Blanch[12]

Phase of Location
Phase of approach
Phase of injection
Phase of establishing

An abstract of expected ideal motor responses according to the searched brachial plexus nerve, as well as the volume of recommended local anesthetic, and finally the needles on the market today and its clinical application is shown in the following Tables I, II and III.

BRACHIAL PLEXUS INTERSCALENIC ROUTE

Anterior and Posterior Approach

In 1846 Ansbro first described the technique of continuous brachial plexus block, by using the supraclavicular route to relieve pain and improve circulation after vascular accidents in the upper limb. The events that contributed to the scientific development of current techniques are described below: subsequently in 1884 Halstedt observed under direct vision (open pit at level of plexus neck); Crile uses a similar technique; the use of percutaneous techniques began in 1911; single injection Kulenkampff technique by supraclavicular route; Kappis in 1912, by posterior paravertebral route; Bazy in 1914, anesthesia line between Chassaignac's tubercle and coracoid process; Mulley in 1919, lateral paravertebral approach; Labat in 1922, multiple supraclavicular injections; Etienne in July 1925, omotrapezoidal triangle; Patrick in 1940, anesthetic wall into the aponeurotic envelope by supraclavicular route; Winnie in 1964, subclavian perivascular technique. Burnham in 1958, De Jong in 1961 and Winnie in 1964[14] described a "neurovascular space", what allowed to perfect the various techniques, Dekrey in 1969[15] and Winnie again in 1970[16] described new techniques for continuous blockage in 1990; posterior access was reintroduced by Pippa[17].

The brachial plexus is formed by the interlacement of the anterior branches of the nerve roots C5 to C8 and T1. It is not uncommon to also receive C4 anastomosis (2/3 of patients) and T2 (1/3 of patients). By abandoning these nerves, conjunction holes converge together to form three trunks located behind the anterior and middle scalene muscles, ie, the upper (C4-C6), middle (C7), and lower trunk (C8-T1). At the exter-

Table I. Neurostimulation in the branchial plexus*.

Peripheral nerves	Root	Trunk	Division	Cord	Muscles innervated	Motor response
Radial	C7, C8, C6	Medial/lateral	Later	Later	Triceps	Wrist extension
		Superior	Later	Later	Braquio radialis	Abduction of thumb
		Superior/medial	Later	Later	Extensor carpi radialis	Extension metacarpophalangeal
		Medial/lateral	Later	Later	Anconeus	
		Medial/lateral	Later	Later	Extensor digitorum	
		Medial/lateral	Later	Later	Extensor indicis	
Ulnar	C7, C8, T1	Medial/lateral	Previous	Lateral/medial	Flexor carpi ulnaris	Ulnar deviation of the wrist
		Medial/lateral	Previous	Lateral/medial	Flexor digitorum profundus (III-IV)	Metacarpophalangeal flexion
		Medial/lateral	Previous	Lateral/medial	Flexor digitorum profundus (III-IV)	Adduction of thumb
Medium	C6, C7, C8, T1	Medial/lateral	Previous	Lateral/medial	Pronador teres	Wrist flexion
		Superior/medial/lat	Previous	Lateral/medial	Flexor carpi radialis	Finger flexion
		Lateral	Previous	Medial	Pronator quadratus	Opposition of thumb
		Lateral	Previous	Medial	Opponens pollicis	
		Medial/lateral	Previous	Lateral/medial	Flexor digitorum profundus	
Musculocutaneous	T1, C5, C6	Superior	Previous	Lateral	Biceps brachii Anterior braquialis	Elbow flexion and supination

* Modified of Dumitru D[13].

Table II. Motor response and ideal volume according to approach.

Approach	Best motor response	Volume (mL) selective technique
Axillar	Intrinsic muscle of hand	30
Interscalenic	Deltoid or biceps	20
Lumbar	Quadriceps	40
Femoral	Quadriceps	30
Sciatic	Dorsiflexion and plantar flexion of foot	

Table III. Types of needles for neurostimulation short bevel, nonsharp angle 30°.

Length, mm	Caliber	Clinical application
25	24	Upper limb blocks in pediatrics
50	22	Upper limb blocks in adult
100	21	Femoral blockade in adult, sciatic lateral via and pediatric sciatic, popliteus
150	20	Sciatic previous via, later via, behavior of the psoas

nal edge of the first rib is originated a division and each trunk forms an anterior branch and another posterior branch, below the clavicle, they form the trunks of the brachial plexus, in turn, separating them in terminal branches:

- *Lateral cord (C5, C6, C7):* Lateral pectoral, lateral median and musculocutaneous nerves are originated from it.
- *Medial cord (C5-C8, T1)*: It gives rise to medial pectoral, cubital, median (middle), medial cutaneous brachial nerves.

- *Posterior cord*: Gives rise to the upper and lower subscapular, thoracodorsal, axillary, radial nerves.

Concerning the sympathetic innervation, the nerve roots receive communicating branches, inferior cervical sympathetic ganglia, most frequently of stellate ganglion and sympathetic plexus associated with the vertebral artery. Sympathetic vasoconstrictor fibers reach the peripheral vessels via somatic nerves of plexus, thus distributing in this manner in the distal arterial system[18].

The technique described by Winnie in 1970, it is made in the neck at the level of the interscalene channel between the anterior and middle (lateral anterior) scalene with the patient in supine position with the head turned to the opposite side and arms along the body. The patient is asked to lift his head to emphasize the clavicular insertion of the sternocleidomastoid muscle. The index and middle fingers are placed just below the lateral edge of muscle at the cricoid cartilage and then the head is again supported. By relaxing the sternocleidomastoid muscle, the fingers will be in the belly of the anterior scalene muscle. The fingers are moved outward until finding the interscalene groove at the C5 transverse apophyses. With an adequate connection, the patient electrode must be near the upper limb to be stimulated[19]. On the other hand, the needle must be in the direction perpendicular to the skin, slightly down, backwards and inwards until obtaining a motor response of deltoid, biceps and pectoralis major[20-22]. If they are not found, the needle is further introduced until contacting the transverse apophyses, looking them about the transverse apophyses. After carefully aspirating, the chosen anesthetic solution is injected. During the injection of suitable volume, it is recommended to press with fingers on injection point in order to avoid the cranial spread of the anesthetic and make progress in the distal direction of the most volume. Another approach is the posterior route, in which the patient is asked to be in lateral decubitus position of the side opposite to the one that will carry out the procedure, the spinous process is marked at the C6 and C7, a midline to three centimeters above the base of the apophysis is marked between these two apophyses, this is the point to put the needle in posteroanterior direction and towards the cricoid, with preference at this point to be successful, a biceps and deltoid response is obtained, clinically there is no difference between the two techniques[23]. The best neurostimulation technique is the selective technique in multiple doses, ie looking for each of the cords, this will increase the success rate and decrease the volume[24].

The indications of interscalene block son surgical anesthesia, postoperative analgesia or rehabilitation around the whole shoulder[25], arthroscopy procedures, chronic pain and to improve blood flow in the upper limb, it is also particularly useful in reconstructions, musculocutaneous grafts and reimplantations secondary to trauma of the upper limb due its selective vasodilatation.

Complications: Alain Borgeat[26] reports 0.4%, paresthesia and dysesthesia, pain not related to surgery, cubital fossa syndrome, carpal tunnel syndrome. Peridural block, subarachnoid, unilateral phrenic nerve block in 90% of the cases, superficial cervical plexus block, 0.9%recurrent or vagus nerve block, stellate ganglion block, central nervous system toxicity, cardiac toxicity and pneumothorax among others. It may also present Bezold-Jarisch reflex consisting of severe hypotension and bradycardia, and Horner's syndrome with disorder of 6%[27].

SUPRACLAVICULAR ROUTE

Classic Kulenkampff technique was described in 1911, it has great historical value, and it is practiced in the place where the brachial plexus crosses the first rib to reach the axillary hollow. With the patient in supine position, arms along the body, the head slightly elevated in hyperextension rotated to the opposite side. The shoulder is lowered to release the first rib causing the plexus and subclavian artery highlight on it. The reference points are the clavicular midpoint, or the point at which the external jugular crosses the clavicle, and the subclavian artery is palpable 1 cm above the clavicular midpoint. The brachial plexus is in contact with the rib outside. At this point, a 4 cm 22 G short bevel needle is inserted obliquely downwards, backwards and inwards until obtaining a motor response or until contacting with the first rib, but bearing in mind that goal is to reach the nerve trunks and not the rib[28]. Winnie in 1964 described the technique using the same anatomical references, but using the perivascular concept for the direction of the needle, identifying interscalene space then the index finger slips until touching the subclavian artery and the needle is inserted into the caudal and tangential direction, following the directions of scalenes. The advantage of this technique is a greater travel of the needle within the sheath and lower risk of pleural puncture[29]. Subsequently, other techniques have been described by various authors; Vonguises in 1979 and Dalens in 1987, who described the same puncture site, the difference of these techniques lies in the direction of the needle tip in order to reduce the incidence of pneumothorax, they placed a pillow under the shoulders to approximate the plexus to the surface[30]. In 1988 Brown described the plumb-bob technique, and Korbon described the importance of palpation of the first rib in the technique of this block[31].

The supraclavicular block has a number of advantages, a more complete block is performed, as supraclavicular level is where the nerve elements are close together. The 3 trunks and their divisions -surrounded by a dense fascia- can be blocked requiring less anesthetic volume, with lower latency time, so it has been used effectively in outpatient surgery of the elbow, forearm, wrist and hand. It can be carried out in patients in which arm abduction cannot be performed, is not necessary to mobilize the limb and is feasible in case of infection in other areas of approach. It has been successfully used in obese patients in 455 patients, associating it with minimal complications(32), being risk of pneumothorax the main complication, incidence varying according to different studies, so its application is not advisable in outpatients. This technique should not be carried out by inexperienced anaesthesiologists because of dangerous complications such as puncture of the subclavian artery, which is very frequent (25%), transient Horner's syndrome in 64-90% of cases when using high volumes of 50 mL or more, the phrenic nerve paralysis which is symptomatic in 1% and hoarseness by recurrent nerve paralysis 1-1.3%, rarely subarachnoid or epidural injection, and emphysema in the mediastinum. It is contraindicated in patients with adenopathies in the area and with respiratory failure in ambulatory surgery, and it should not be conducted on a bilateral basis(33). In 1986 Conde Zamora(34) revealed a location technique based on the location of a point of puncture by coordinates.

INFRACLAVICULAR ROUTE

Infraclavicular route was first used by Hirschel in 1911, and subsequently in 1914 Bazy blocked the plexus by infraclavicular approach directing needle in the proximal or distal sense to the clavicle(35). Raj in 1977 made distal approach. With this technique, the deposition of local anesthetic is performed at the level of the cords and branches of the brachial plexus above and below the formation of the axillary nerve and musculocutaneous(36.37). While the patient is in the supine position with his/her head turned toward the contralateral side and his/her arm in abduction of 90°, 3 anatomical references are marked and the line uniting them is considered the route of the brachial plexus: midpoint of the clavicle, Chassaignac's tubercle and humeral artery. A puncture is performed 2-2.5 cm below the clavicular midpoint at 45° angle until finding proximal (elbow) or distal (wrist, hand) motor response. The advantages of this technique are the comfort of the patient's position and an efficacy of 95%, as well as absence of phrenic paralysis, cervical sympathetic block or recurrent nerve paralysis(38).

Wilson(38) through coracoid technique used magnetic resonance imaging in brachial plexus in order to determine the depth and orientation of the needle to contact with the brachial plexus locating in a 2 cm point caudal to the coracoid process. The depth from the skin to the anterior wall of the axillary artery was 4.24 ± 1.49 cm in men and 4.01 ± 1.29 cm in females, other techniques have been described with different angulations of the needle. Sims describes efficacy as a lower and lateral angulation of the needle and Whifler(39) as perpendicular angulation to the skin, inside and below the coracoid process, puncture is performed above the line drawn between the subclavian artery and the apical area of the axillary hollow, at 4 cm depth in this movement there is an increased risk of penetrating the thoracic cavity. Kilka(40) studied 175 patients undergoing upper extremity surgery using infraclavicular technique, by dividing the distance between the jugular fossa and ventral process of the acromion in equal parts and inserting the needle under the clavicle at the midpoint, with the needle in posterior direction(41).

In the infraclavicular approach, complications such as venous puncture occurred in 10.3%, Horner's syndrome in 6.8% and there were no arterial and pleural punctures. This block is performed at the level of divisions and cords of the brachial plexus where the latter is surrounded by the subclavian artery. Like the axillary and supraclavicular block, it is applied in procedures of the elbow, forearm, wrist and hand, there is a rare incidence of pneumothorax, as the presence of pleura at 6.5 cm in deep is showed in studies with magnetic resonance imaging. Other of the advantages is that it is easy to perform, and the injection at this level allows the lock of circumflex and musculocutaneous nerves. Does not require a special position of the arm, for which it is indicated in trauma surgery, and there is a good tolerance for the placement of long-term catheter(42,43).

Single stimulation technique can be used obtaining a motor response of the median, radial or ulnar nerve. The motor response of the musculocutaneous nerve (elbow flexion) is a poor response, it is indicates that the needle is in external position, therefore the latter must be redirected medially and deeply. If the multiple stimulation technique is used, at least two stimuli must be obtained; one stimulus of the secondary posterior trunk and other of secondary lateral trunk. In practice, a stimulus of the median nerve and other of radial nerve, and subsequently a stimulus of musculocutaneous nerve, volume to be injected is from 8 to 10 mL in 5 mL musculocutaneous(44).

The infraclavicular block has proven to be better in surgery of the distal humerus, elbow and hand using the two stimulation technique, in comparison with other techniques such as axillary and humeral where required using the stimulation technique of 3 and 4 nerves. The triple injection of the coracoid block is not really beneficial because patients reported vascular punctures, difficulty in locating the third puncture, and discomfort in patients with respect to the dual technique. The volume of anesthetic used decreases with increasing the number of punctures, using 42 mL of mepivacaine in single puncture, 22 and 14 mL in dual and triple puncture, respectively[45,46].

AXILLARY ROUTE

The block by axillary route is the anesthesia method of brachial plexus most commonly used at present because of the small number of complications associated with its implementation[47]. Terminal nerves of the brachial plexus are contained in a sheath shared with the axillary artery, and it is shown that this neurovascular bundle is pluricompartimental, these septals do not prevent spread of the anesthetics in most cases, but its presence could explain the uneven distribution and failures occurring at certain times[48]. The axillary artery is the most important reference point, the nerves have a predictable orientation with respect to the artery, the median nerve is located above the artery, the radial and anteromedial ulnar is located behind and some outwards. This has been observed in clinical studies, and currently by magnetic resonance imaging and ultrasound it has been observed that axillary, musculocutaneous and circumflex nerves are in outside of this sheath. At axillary level, musculocutaneous nerve has already abandoned the sheath and is included into the coracobrachialis muscle. When using the single volume technique, it is locked in 40-60% of cases, accordingly it is necessary to use high volumes in order to achieve these compartments[49,50]. Another option is to block separately this nerve at axillary level with promoter in the coracobrachialis muscle belly by injecting an average of 5 mL of anesthetic. The intercostobrachial nerve branch of the second intercostal nerve innervates an skin area situated on the inside of the arm, located outside the brachial plexus sheath, which must be blocked by a subcutaneous wheal over the artery, must contact to artery in perpendicular direction, then 5 mL of anesthetic are applied. Generally the latter must be blocked by using a cuff ischemia[51.52].

The easy implementation and safety of the technique as well as easy palpation of the artery allowed that the paresthesia, transarterial and neurostimulation technique have been successfully used in surgery of the elbow, forearm, wrist and hand. The above mentioned contributes to the technique most commonly performed in North America. Winnie perivascular technique described in 1973 identifies the axillary artery pulse that runs in the groove formed by the triceps and coracobrachialis muscles as close as possible to the pectoralis major tendon, with the arm in 90° abduction and forearm flexion on the arm. The index and middle fingers are placed on the artery with the needle in the direction of 30°[53].

This technique is disadvantaged by the possible formation of haematomas, which can obliterate the artery and require a second look operation, in addition to neurotoxicity and cardiotoxicity data resulting from systemic absorption of the used anesthetic. Single or multiple stimulation technique must be used in order to perform the neurostimulation technique. By using Winnie technique with the patient in a described position, it is recommended arm hyperabduction because often the pulse is obliterated and cephalic spread of the anesthetic solution can be prevented.

Insulated needles are used with a bevel angle of 30° with a flexible plastic extension to facilitate administration of the anesthetic. With a location of the plexus between 0.5 and 1 mA and a frequency of 1 Hz, needle is advanced until obtaining a satisfactory muscle response, preferably in the setting corresponding to surgery to be performed[52-54]. The volume of anesthetic in single puncture is from 35 to 60 mL of solution. All anesthetics can be used depending on the surgical time and the desired degree of relaxation. In the multi-location technique used in association with Fanelli technique[55], arm is placed in hyperabduction, by placing the hand behind head to palpate the pulse of the most superficial axillary artery. With one single puncture by modifying the direction of the needle, 2 non-anatomical territories are located, an anterior compartment includes the median, ulnar, internal brachial cutaneous and medial brachial cutaneous nerves and other posterior compartment including only the radial nerve. Immediately with the patient in the same position, the first puncture is performed below the artery to locate the radial compartment, 10 mL of the desired anesthetic is applied and subsequently in the same puncture site, but above the artery, at 45° angle until obtaining a distal extensor or flexor response of ulnar and median nerve by injecting 20 mL volume of anesthetic. The use of this technique increases the success rate to 95% and decreases the dose of local anesthetics, thus avoiding toxicity to them. Another advantage is a simple lock, which can be done by few trained anesthesiologists in art, the technique is easy to perform in obese patients.

The main disadvantage is that the position is limited in some patients with splints or certain fractures, as well as a discomfort resulting from multiple stimulations to obtain a proper lock, so that sedation is recommended in patients[56.57]. The choice of local anesthetic is determined according to the type and length of surgery and patient's characteristics, physicochemical and pharmacodynamics properties of anesthetic must also be known. Ropivacaine and bupivacaine are used in prolonged surgery, demonstrating an increased effectiveness with increasing concentrations.

MID HUMERAL ROUTE

In addition to axillary approach, the mid humeral approach is a recently described technique destined to most distal individual responses, when individual branches have abandoned the course of the artery. This approach was first described by Dupré[58] in 1994. The four terminal branches of plexus can be identified with higher definition in this anatomical section, as the radial and musculocutaneous nerve has already been separated from the rest at the humeral canal between the middle and upper third of the hand, exactly where the brachial artery is palpated, the needle is placed tangentially over the skin between the brachial artery and finger palpating in the direction of brachial plexus. Once the needle is placed subcutaneously, prior wheal, the NES is active in frequency and intensity of 2 Hz and 2.5 mA, respectively. After anesthetizing the median with 10 mL of AL, is re-positioned perpendicular to the operating table just medial to the artery, it is advanced in order to locate and anesthetize the ulnar nerve, after the needle is re-positioned just below the biceps muscle and moved 2-4 cm to locate and anesthetize the musculocutaneous nerve. Finally the needle is removed to a subcutaneous position and introduced until the tip is placed behind the humerus where the radial nerve joins the groove. In total 40 mL volume is used. The expected motor responses are the same for each of the 4 terminal branches. Bouaziz et al[59] found that latency is prolonged (10 ± 8 min), as compared to the axillary approach, although there is no difference in regard to success rate. The biggest difference as regards the axillary approach is a most intense motor block with mid humeral approach, perhaps due to selective neurostimulation. This approach is more frequently indicated in surgeries involving the radial nerve, ie wrist surgery. As a continuous technique is preferred for the ease of fixing the catheter in an area free of joint movement. Moreover, it is preferred as a continuous technique due to easy fixing of the catheter in an area free of joint movement. No complications reported with this specific approach.

LUMBAR PLEXUS OR PSOAS COMPARTMENT BLOCK

The lumbar plexus consists of six nerves on either side of the axis neuroaxial, the first of which emerges between the 1st and 2nd lumbar vertebrae, the last nerve emerges from the last lumbar vertebra and the base of the sacrum. As soon as the L2, L3 and L4 nerve roots leaves the intervertebral foramina, they are entered in greater psoas muscle. This is because the psoas muscle is anchored in the lateral surface and transverse processes of lumbar vertebrae. These roots are divided into anterior and posterior division inside the muscle, these divisions come together to form individual nerves of plexus. The larger branches of the lumbar plexus are the genitofemoral nerve, lateral femoral cutaneous nerve, femoral and obturator[60].

The anesthetic technique was originally described by Winnie in 1974, subsequently Chay, Hannah and Parkinson described modifications of the approach[61]. The lumbar plexus runs in front of the plane of the transverse apophyses of the lumbar vertebrae. Its most important branches are located within a fascial compartment produced by the psoas, iliac, square lumbar muscles[62.63]. For performing the lumbar plexus block, as is known, the patient is placed lateral decubitus position with side to be blocked on top and the flexed hip[64].

Following is the description of the different approaches of the lumbar plexus published in the medical literature:

1. L4 (Capdevilla): The midpoint of L4 and intercrest line are identified, a line parallel to L4 passing through the posterosuperior iliac crest is drawn and the point where this line intersects with the intercrest line is the puncture site.
2. L4 (Alternative): A point from 4 cm of the midline of L4 is marked on the intercrest line, and this site is punctured.
3. L4-L5 (Winnie): The midpoint of L4-L5 and intercrest line are identified, a line parallel to L4-L5 passing through the posterosuperior iliac crest is drawn and the point where this line intersects with the intercrest line is the puncture site.
4. L4 (Chaya): L4 is identified and a line of 3 cm caudally and subsequently other line laterally of 5 cm are drawn, this line is the puncture point.
5. L3 (Parkinson): The midline of L3 is located and the needle is introduced laterally 3-4 cm.

In each of the approaches, the needle is inserted until contacting with the thorny process of L3, L4 or L5 according to the puncture site, the needle is redirected in a caudal or cranial sense until obtaining a response of femoral quadriceps muscle with respective patellar displacement, ie superior and inferior movement of the patella in the knee. The surgical indications of this advanced block are all procedures in the region of the hip and in combination with sciatic block of the whole pelvic member.

Therapeutic indications such as postoperative pain after knee and hip surgery, post-traumatic hip pain, osteoarthritis pain, hip fracture pain, arterial occlusive disease, complex regional pain syndrome type I and II, post-radiotherapy edema, post-amputation pain, diabetic neuropathy, tumor pain in hip or pelvis[65].

Surgical indications: From 20 to 30 mL of 0.25-0.5% bupivacaine is used without exceeding a dose of 3 mg/kg weight. Additionally, 7.5% ropivacaine can be used with a 20-30 mL volume at maximum dose of 3 mg/kg. For diagnostic and therapeutic procedures, a 20 mL volume is used at 1.5 mg/kg dose of ropivacaine or bupivacaine.

A high rate -approximately 80/10000[66]- of complications occurs in this technique. These complications are: neural injury[67], intravascular injection, subarachnoid or epidural injection, cardiac or neurological toxicity by local anesthetics[68], retroperitoneal hematoma[69], renal puncture, renal hematoma (these renal complications occurs mostly when approach is used on L3[70]), and post-injection pain due to lumbar muscle spasm.

The following Table IV describes the motor responses of lumbar plexus according to the performed block.

SCIATIC NERVE BLOCK

The sacral plexus gives rise to the sciatic nerve (L4, L5, S1, S2, S3, S4). This nerve results from the fusion of two major nerve trunks: the tibial and peroneal nerves. By leaving the pelvis, it joins the posterior cutaneous nerve of the thigh. The choice to address the sciatic nerve depends on the ability to turn the patient without causing inconvenience, the patient's general conditions and the surgical area[71].

Anterior Route: It was described by Beck in 1963 and amended by Chelly. A line is drawn from the anterosuperior iliac spine to the pubic symphysis, a perpendicular line is drawn from the greater trochanter to the lesser trochanter. The first line is divided into thirds and a line joining the medial third with lesser trochanter is drawn, and the intersection point is the site of puncture. Internal rotation of the leg is suggested to facilitate the location of the nerve. Ericksen et al suggests that the approach is made 4 cm down below [72].

Lateral: It was described in 1959 by Ichiyanagi. It is the approach of major difficulty. Greater trochanter is located, a line is drawn under the bottom edge of the femur, and the site of puncture is located at distance from 5 to 6 cm. The mean distance to locate the response is 91 ± 20 mm[73].

Posterior: Classical Approach of Labat described in 1920[74]. The patient is placed in Sims' position. A line is drawn from the posterosuperior iliac spine to the greater trochanter. A second line of 5 cm perpendicular to the first is drawn in the middle of the previous line, this is the site of puncture.

.*Posterior*: Modified approach (Winnie) in Sims' position, lines are drawn for the classical approach, an additional line is drawn from the sacral hiatus to the greater trochanter, the intersection of this line with 5-cm perpendicular line of the classical approach must coincide, this is the site of puncture.

Parasacral: Approach described by Mansour in 1996[75]. the patient is placed in lateral decubitus position with side to be blocked on top position, with the flexed hip and knees, a line is drawn from the posterosuperior iliac spine to the ischial tuberosity, the puncture site is located on this line at 6 cm from the iliac spine[76].

Subgluteus: Approach described in 2001 by Benedetto[77]. In Sims' position, a line is drawn from greater trochanter to the ischial tuberosity, a second line is drawn in caudal sense at 4 cm. Franco[76] recommends to draw this line at 10 cm, as it is more effective for both sexes and different ages. This is the site of puncture, the depth is 45 ± 13 mm[78,79].

Neurostimulation: The motor response in either of their approaches is as follows: Stimulation of the internal popliteal sciatic nerve-fibers induces plantar inversion and flexion of the foot and toes. Dorsal flexion and eversion of the foot are induced when the external popliteal sciatic nerve is stimulated[80]. Tibial motor response is found at a frequency of 52%, peroneal motor response is found at a frequency of 33% and both at a frequency of 12% [81]. The found motor responses is correlated with a shorter latency time and greater effectiveness of the deadlock in this order: inversion, plantar flexion, eversion[82]. The complications of this block are: neurological injury (1.9 per 10,000 blocks)[83] due to intra-

Table IV. Neurostimulation of lumbar plexus.

Block	Muscular response to search	Articulation	Component
Lumbar plexus	Quadriceps contraction	Hip	L1-L3, L4L5 S1
Femoral	Quadriceps contraction	Knee	L3, L4
Sciatic	Tibial: plantar dorsiflexion and investment foot Superficial peroneal: foot abduction Deep peroneal: eversion of the foot		L3-L5
Popliteus	Same responses of sciatic	Ankle	L4L5
Saphenous	Same responses of sciatic	Foot	L5S1

neural injection[84], hematoma formation mainly in classical and parasacral approaches. Urinary incontinence in bilateral parasacral approach manifests as enuresis, perineal and gluteal anesthesia[85].

FEMORAL NERVE BLOCK

Femoral or crural nerve block was described in 1973 by Winnie as an inguinal paravascular technique which he denominated as "3-in-1" block, as it was thought that obturator, cutaneous femoral lateral-and femoral nerve block could be obtained by using high volumes and applying pressure distally to the needle for a few minutes, but various studies have failed to demonstrate the effectiveness of these procedures[86].

The femoral nerve, which is a branch of the lumbar plexus, together with the lateral femoral cutaneous nerve and the obturator nerve are the most important nerves for surgery of the lower extremity.

The femoral nerve is formed by dorsal divisions of the anterior branch of second, third and fourth lumbar nerves, this nerve enters the posterior thigh and inguinal ligament and there is located, it situated lateral and posterior to the femoral artery. It is divided into an anterior and a posterior branch in the thigh, the anterior branch gives off the medial and cutaneous nerves innervating the skin of the medial and anterior surface of the thigh, as well as muscular branches to the sartorius and pectineal muscle and articular branches to the hip. The posterior division gives off the saphenous nerve which is the longest cutaneous branch of the femoral nerve, muscular branches to the quadriceps muscle and articular branches to the knee. Moreover, 60% of analgesia in the knee is provided by the femoral nerve, 25% by the sciatic nerve and 15% by the obturator nerve.

The indications for the femoral nerve block includes anesthesia for procedures of the anteromedial side of the thigh, knee and medial side of the calf, is highly useful in procedures such as arthroscopy including: meniscectomy, joint lavage, retinacular releases and plicatures[87,88]. Additionally, its use and benefit as an analgesic method in surgery of cruciate ligament reconstruction[89.90], knee prosthesis[91] and femur fractures is also known (92). It is important to note that this block must be combined with a sciatic nerve block when using cuff ischemia, by which is also possible to perform surgeries such as repair of *Hallux valgus* and other foot surgeries (Table V).

The femoral nerve block is performed with the patient in supine position, with your legs extended, feet at an angle of 90 degrees with the horizontal plane and with the slight slightly in abduction. The most important reference points are to be determined: the inguinal ligament, the femoral fold and femoral artery. In the literature several methods have been proposed to facilitate the location of the injection point, one of which is mentioned in a study in cadavers by Vloka et al.[93], in which he found that inserting the needle in inguinal fold and immediately laterally to edge of the femoral artery produced the greatest number of contacts between the needle and the nerve. The (New York School of Regional Anesthesia)[94] NYSORA method describes the position of structures in the order they are in the area, and to this end, they propose mnemonics "VAN" (vein, artery, nerve) from medial to side. Another method based on acupuncture points has also proposed, this method proposes a measurement of thumb at the distal interphalangeal joint said measurement is defined as 1CUN, a correlation with weight and height is also performed, additionally they suggest that this system is superior to conventional marks to locate the nerve with 1 or 2 cm lateral to the artery[95].

Once located the point, asepsis and antisepsis of the region is practiced, the site of puncture is infiltrated and the location of the nerve is started with a single short-bevel 5 cm needle and peripheral nerve stimulator. The needle direction is skull at an angle of approximately 60 degrees. It begins with a voltage of 1 mA until locating the expected response corresponding to the quadriceps muscle contraction and patellar displacement (patellar dance), decrease of the voltage is then started until 0.5 mA, this response must be remained, which will indicate that we are in the right place and it is then safe to apply the chosen anesthetic. Remember that it is important to properly sedate the patient in order to carry out these techniques. The recommended volume is 25 to 30 mL, but Fanelli et al[96] recommends 15 to 21 mL in the selective neurostimulation technique in multiple doses.

Contraindications are similar to those of any regional anesthetic technique, some of absolute contraindications are patient's refusal, infection at the site of puncture, local hematoma, and distorted anatomy, and relative contraindications include coagulopathies and preexisting neurological disorders.

Complications associated with peripheral nerve blocks are rare.

Complications related to several factors associated with systemic toxicity by local anesthetics have been mentioned, this toxicity in theory should be high due to the generally higher dose used in these lock types. However in a study by Casati et al[87] involving 2175 patients with combined femoral and sciatic block, no adverse reactions due to local anesthetic were reported. Most of the toxic reactions typically occur during or immediately after the injection, suggesting that the mechanism of these events is often an unintentional intravascular injection of anesthetic applied to circulation. Vascular puncture during femoral nerve block has been reported with a frequency of 5.6%[96], although complications are rare. There are no reports of infection cases after single injection in lower extremity nerve block. There are few published reports related to nerve damage associated with the peripheral nerve block with neurostimulation, and may be related to a variety of factors, some related to the block including trauma by the needle, intraneural injection and neuronal ischemia. But it is also important to investigate other causes due to surgical factors (position, use of spacers and hematoma formation)[97].

POPLITEAL SCIATIC NERVE

The block of this nerve was originally described by Labat around 1923. Since its introduction, it has proved to be useful in interventions on the lower two thirds of the leg and foot. As with other peripheral troncular nerve locks, this block has as advantage the production of well anesthesia with few hemodynamic and respiratory disturbances, rendering it useful in patients with cardiorespiratory pathologies[98-100]. This nerve is branch of sacral plexus, which is formed within the pelvis by the union of the ventral branch of the fourth and fifth lumbar nerves and the first 3 or 4 sacral nerves. It has three anatomical and functional parts: the posterior cutaneous nerve of the thigh, the tibial nerve and common peroneal nerve. Techniques of proximal block for this nerve provide motor block of semitendinosus muscles and flexor and extensors muscles of the ankle and toes. The sensory block includes the thigh, knee, calf on its back side and foot as well as part of the knee joint. Distal approaches (popliteal fossa) allow free semitendinosus muscles and sensations of the posterior muscle[100].

Indicated in foot and ankle surgery, it may be used as single anesthetic technique, where required to avoid techniques related to side effects and complications, where it is convenient to prevent hemodynamic or respiratory disturbances, it is also very convenient for outpatients. It is important to note that many of the surgical procedures on the foot and ankle cause severe pain, and these techniques provide suitable analgesic effects for postoperative pain control. The components of the sciatic nerve can be blocked in the popliteal fossa by two routes: posterior and lateral. The patient's supine (with legs bent on the hip and knee) or lateral, prone position can determine individually the optimal approach for each patient. The classical posterior approach is performed with the patient in prone position.

Traditionally, the sciatic nerve is located 5 cm above the popliteal fossa, although it is recommended nerve block before its division at 7 cm and 10 cm distance[101]. This access has the disadvantage that also involve an additional discomfort for the patient, can cause substantial disturbances in obese patients, as well as in patients suffering of lung and heart disorders, and polytraumatized patients can cause pain and/or displacement of fractures, which may hinder obtaining the proper position.

To solve the above problem, new routes of approach have been sought for some years, the lateral route has been the most popular option, this route is performed with the patient in supine position[98]. The block of the sciatic nerve in the popliteal fossa is associated with a high variable success rate of up to 90%. The stimulation needle often finds first common peroneal nerve, as it is located more superficially than the tibial nerve. In case of *posterior approach*: the apex of the popliteal fossa is located (determined by the point crosses the femoral biceps, and semitendinosus and semimembranosus muscles), as assessed by manual palpation. The puncture site is marked at 0.5 cm, below the apex, of the medial side of the biceps femoral muscle, this is a modified posterior approach described by Blumenthal and Borgeat[102], who reported that the mean depth of the nerve was 4.5 cm, and the average distance from knee skinfold to the apex of the popliteal fossa was 9 cm. In the traditional approach, the sciatic nerve is located 5 cm above the popliteal fossa, but as above mentioned, it is recommended to perform puncture 7 cm and 10 cm above the fossa before the nerve is divided.

The *lateral approach* is performed with the patient in supine position and with his/her extended legs, the foot's long axis at an angle of 90 degrees to the operating table, the needle is inserted into a horizontal plane at 11 cm cephalic to the more prominent of lateral epicondyle, into the groove between the femoral biceps and the vastus lateralis muscle until it makes contact with the femoral bone. Once obtained this contact, the needle is removed and subsequently redirected at an angle of 30 degrees to the horizontal plane until obtaining an response.

The expected responses to this block, and taking into account that the sciatic nerve at this level is split into its two components that are the tibial nerve and common peroneal nerve, will be those corresponding to these nerves. The plantar flexion and inversion of the foot seems to be the best response to predict a successful block, as due to the stimulation of both components and dorsiflexion it is considered ideal. It has been suggested that to improve the success rate in this block is therefore desirable to seek the response both of the tibial and peroneal nerve using a double injection technique. The stimulation technique is similar to the femoral nerve technique, considering that a sustained response with a voltage of 0.5 mA is indicative of the needle tip proximity to component nervous. The recommended volume is from 20 to 30 mL. Contraindications are not different from those mentioned above. They are extremely rare but possible, contraindications includes neuritis and dysesthesia, intravascular injection and formation of hematomas.

SAPHENOUS NERVE

In the cutaneous distribution of saphenous nerve, anesthesia is frequently required for surgical procedures below the knee. Various techniques to anesthetize this nerve have been described, but there is few published data on their effectiveness(103). The saphenous nerve is a purely sensory nerve, which results from the posterior division of the femoral nerve and corresponds to its longer cutaneous branch. It innervates the skin of the anteromedial, posteromedial and medial region of lower leg, from the area below the knee to the level of the tibial malleolus, and some persons the medial part of the first toe. Along with the sural nerve, the lateral sural cutaneous and medial plantar nerves are responsible for whole sensitivity below the knee.

Its indications include surgical procedures on the leg including the use of cuff ischemia (remembering that the tibial and peroneal nerves must also be blocked). It is recommended in outpatients, in case of postoperative analgesia or as a supplement to incomplete block of the sciatic nerve or femoral. Being this is a purely sensory nerve, reported approaches are based on field infiltrations below the knee, where the nerve emerges from behind tendon of the sartorius muscle, and it is located under the skin(104) and infiltrations like a fan to form a subcutaneous rash on the medial condyle of the femur(102) (paracondilar field block).

In the *transarterial approach*, a pediatric 20 gauge Tuohy needle is introduced through belly of the sartorius muscle until it does not find resistance, then local anesthetic is injected(105). In paravenous approach, the saphenous vein is identified using a tourniquet on leg and then a subcutaneous injection performed around the vein(106).

The approach *through neurostimulation* is performed with a 22 gauge 5-cm insulated needle, which is inserted into the prominence of the medial femoral condyle in order to find paresthesia in the vicinity of the internal malleolus. Patient is placed in supine position with knee slightly bent, and tuberosity of the tibia, medial head of gastrocnemius muscle is identified.

A 22 gauge 5-cm insulated needle is used, which is inserted 3.5 cm posterior to the center of the prominence of the medial femoral condyle. The search at 2 mA is started, until finding paresthesia in the area of medial malleolus and is gradually decreased, considering a sustained response at 0.4 mA(105) as suitable with a volume from 5 to 10 mL. Complications are rare but frequently when paresthesias-based location methods are used.

Table V. Therapeutic indications to apply blockades by neurostimulation in lower extremity.

Blockade type	Surgery
Lumbar plexus	Hip
Lumbar plexus	Femur fractures
Lumbar plexus	Acetabular fracture
Lumbar plexus + sciatic	Amputation above of roller
Sciatic-femoral	Knee arthroscopy
Sciatic-femoral	Amputation below of knee
Sciatic-femoral or saphenous	Anckle surgery
Sciatic-femoral or popliteus	Foot surgery

CATHETER TECHNIQUE FOR CONTINUOUS INFUSION

Continuous catheters already were using since 1946 by Ansboro FP(107). The limitation of the continuous catheters was the absence of a simple, safe and consistent method their insertion. Singelyn et al(108) reported well results, but also difficulties in the insertion technique in 66% of cases in the moment of insertion by Seldinger technique. Ganapaty et al(108) showed radiographically that 40% of the catheters are poorly placed.

The primary objective of continuous peripheral nerve block is the insertion and placement of a catheter within the perineural space. For continuous nerve block, peripheral catheters are used involving and exciting a specific area, they are used especially as a tool in the postoperative analgesia. Given the growing clinical interest and advancement of technology, most current publications are descriptions of some patients or a number of cases of healthy patients under outpatient surgery.

Currently there is a kit of catheter with current transmitting tip (Arrow®) and thanks to this technology it is known where catheter tip is placed by using neurostimulator as guide. To improve our knowledge, have recently been introduced catheters transmitting electricity to the tip for neurostimulation techniques, which can verify and confirm the placement of these catheters with success rates of 94%. Some features of this technique have been described in general for example, motor responses found with the needle sometimes differ from those found with the catheter due to the different positions where the catheter is placed.

In the axillary block, the catheter stimulation is started with the median nerve followed by the musculocutaneous nerve, this may be that as the catheter advances in the perineural compartment it becomes more distal or proximal to portion of the plexus. Incorrect positions make difficult the handling of the catheter. In the intersternocleidomastoid block, the catheter passes easily when the introducer needle stimulates the middle trunk of the brachial plexus, from this position the catheter passes more easily within a infraclavicular position.

During the femoral block, easy passage of the catheter until 15 cm is combined with the lack of response at this depth, the final position of the catheter tip is uncertain. It is more difficult to find aberrant positions of the catheters transmitting electrical power at the tip(110). The lack of appropriate equipment contributes to the difficulty of placement. This latter has contributed to the lack of a wide diffusion or restricted use in certain hospitals where the equipment is placed assembled. Current systems use a 18- or 17- gauge Tuohy needle with a connection system to the neurostimulator, the needle is insulated and covered with Teflon. In proximal point, the needle has a luer-lock adapter, allowing the aspiration of blood, injection of the local anesthetic and the passage of the catheter No. 20 without changing the needle position or disconnect the tube(111). The main complications include hematoma, nerve injury and potential infection, no significant relationship among them. The infusion rate depends on the nerve to be infused, the most studied agent available in Mexico is 0.2-0.375% ropivacaine in any continuous infusion device (Table VI).

NEUROSTIMULATION IN PEDIATRICS

August Bier in early 1899 was the first to report the use of spinal anesthesia in children(112). The resurgence of regional anesthesia was from the 80s, with studies by Shandling and Steward(113), in which they demonstrated the effectiveness of combining general anesthesia with regional anesthesia for postoperative pain relief in children. The use of caudal anesthesia in children was described in the urological literature in the 30s(114). In Mexico the first report of neurostimulation in children was conducted in 2005 for blocking the brachial plexus by axillary route(5). In children, the myelination is completed until the age of 12, however, for practical purposes it is considered that between 2 and 3 years it is now virtually complete. The myelination degree affects conduction velocity of nerve impulse. The nerve conduction velocity in the newborn is half of that of the adult due to incomplete myelination. Incomplete myelination, reduced internodal distance, small size of nerve fibers and minor thickness of the myelin coating cause that the conduction speed is lower in newborns and infants. Thus, to obtain complete blocks, lower concentrations of local anesthetics are required as compared to adults. Therefore, concentrations of 1% lidocaine and 0.25% bupivacaine are considered sufficient in patients younger than 8 years(115).

Peripheral nerve blocks require the identification of a nerve as precise as possible and apply an adequate volume of local anesthetic close to the nerve. The location of a peripheral nerve can be difficult in pediatric patients, mainly in infants. There is wide variation in the relative depths of the anatomical structures used as reference in the child's growth period. Topographical references are less developed than in adults and it is difficult to identify through the variable thickness of the tissues and the elasticity of them, mainly in infants(116).

The distribution of subcutaneous fat in infants may hinder the peripheral nerve blocks(117).

The ideal method for regional anesthesia in the pediatric patient is the use of the neurostimulator by which the nerve motor component is located. Muscle contractions must be provoked with electrical stimuli from 1.0 to 0.5 mA, from 1 to 5 Hz with pulses from 50 to 100 ms when most of the blocks are performed with deep sedation or slight general anesthesia. Under these conditions, muscle contractions occur when we are less than 1 mm of distance.

Children with sequelae of paralytic poliomyelitis require higher stimulation currents (2.0 to 2.5 mA). The degeneration of motor neurons responsible for innervation of this muscle group is responsible for this phenomenon. Neurostimulation techniques are preferable for children. In axillary block, the multiple stimulation does not have advantages over single stimulation in pediatric patients due to that greater diffusion of local anesthetics into the perivascular sheath makes frequency of incomplete blocs is lower than in adults(118). Perineuro-vascular sheaths surround strongly nerve fibers on children and offer the advantage of a greater diffusion of local anesthetics through single infiltration(119). In infants, the interscalene block presents the risk of ipsilateral diaphragmatic paralysis due to the proximity of the phrenic nerve

Table VI. Infusion rate to continuous catheters placed by neurostimulation.

Approach	Infusion rate mL/h
Lumbar plexus	8-10
Femoral-sciatic blocks	8-10
Axillary	5-12
Infraclavicular	5-10
Supraclavicular	5-8

and this can lead to severe respiratory failure, for this reason the axillary approach is preferred in these patients[119]. This technique has been performed with high success rates, by following a neurostimulation of single injection, volumes from 0.7 mL -1 mL x kg under sedation whether both intravenous and inhalational sedation, obtaining an excellent postoperative analgesia[6]. In general, the regional anesthesia techniques under neurostimulation in pediatric patient presents the disadvantage of the lack of patient cooperation, regardless of ease of use and similarity with techniques for adults (ie the same equipment, and perhaps with the same output power and frequency).

Even with adequate anxiolysis is very difficult for a child not perceiving the needle as an aggression. This is why the neurostimulation in regional anesthesia must be performed with deep sedation or light general anesthesia. The greatest change in adults occurs in the doses, concentrations and volume of drugs to be used. In the international literature there are not many reports in the pediatric population of these techniques, for this reason, there is a field open to the investigation of regional anesthesia in the pediatric patient.

CONCLUSIONS

Fundamental aspects must take into account such as: anatomy, considering the existence of anatomical variants; position of the patient; feel and define structures of reference. Always keep in mind the possible immediate and mediate complications, as well as their convenient resolution. If various punctures are performed in the plexus, nerve damage can be caused and result in severe consequences (transient neurological symptoms):

- Appropriate choice of patient and surgeon.
- Appropriate selection of surgery and type of lock.
- Communication with the patient (expectations) and acceptance.
- Conduct a careful surface marking.
- Have the equipment and specialized assistance.
- Effective Sedation. Wilson Scaling II.
- Slow administration with frequent aspiration of the local anesthetic.
- Have the time required for carrying out the procedure.
- Assess the block quality the end of latency, never before. (4P's Technique)
- Remember that only we learn if we perform the procedures.

TEN GOLDEN RULES OF REGIONAL ANESTHESIA

According to Dr. Raw, University of Iowa, California.

I. Do not block the wrong side
II. The patient must know the most important side effects
III. Do not inject the wrong drug
IV. Use neurostimulation
V. Do not inject into areas that have no distension: ulnar and common peroneal nerve
VI. No quick injections
VII. Avoid drugs with condoms
VIII. Being able to treat local anesthetic toxicity: direct Intralipid 1 mL/kg IV
IX. Avoid intravenous injection
X. With prior neurological abnormalities:
    - Attend them pre-and postoperatively
    - inform the patient
    - Similar volumes at low concentrations
    - consider the use of ultrasound
    - consider defensive medicine

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