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Research Article

Ultrasound-guided supraclavicular versus infraclavicular brachial plexus nerve block in chronic renal failure patients undergoing arteriovenous fistula creation

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KEYWORDS

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Abstract *Background:* Most patients with chronic renal failure suffer from complications that make brachial plexus block a good choice for providing anesthesia. The use of ultrasonography increases the success rate and decreases complications. We compared the efficacy of ultrasound-guided supraclavicular and infraclavicular brachial plexus block in providing anesthesia for creation of arteriovenous fistula.

Patients and methods: Sixty adult patients with chronic renal failure, scheduled for creation of arteriovenous fistula of the distal upper extremity were randomly divided into two equal groups: **Supra G** (n = 30): ultrasonic guided supraclavicular brachial plexus block was given and **Infra G** (n = 30): ultrasonic guided infraclavicular brachial plexus block was given. For both groups we used 20–25 cm 1:1 volumes of 0.5% bupivacaine and 2% lidocaine. The measured parameters were block performance time and related pain, the degree and duration of sensory and motor block, patient discomfort, first call for analgesics, complications and the patient's satisfaction.

Results: There was no statistically significant difference between both groups as regard the block performance time, the block related pain, the degree of sensory and motor block in the areas

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supplied by the median, radial and musculocutaneous nerves at 10, 20 and 30 min. There was no statistically significant difference as regard the sensory block grade in the area supplied by the ulnar nerve at 10 min, but it was significantly higher in the Supra G than Infra G at 20 and 30 min. No statistically significant difference as regard the motor block grade in the area supplied by the ulnar nerve, the block duration, first call for analgesia, complications and patients' satisfaction.

Conclusion: Both approaches can provide satisfactory sensory and motor block, very good analgesia that extends for a long time postoperatively in patients with chronic renal failure undergoing creation of arteriovenous fistula.

1. Introduction

Patients with chronic renal failure may suffer from serious complications that represent a great challenge to the anesthesiologists. Complications like congestive heart failure, systemic hypertension, electrolyte imbalances, metabolic acidosis, coagulopathy, unpredictable intravascular fluid volume status and anemia obligate the anesthesiologist to avoid general anesthesia with its heroic risks in these patients and to think for alternative methods [1].

Brachial plexus block is often used in chronic renal failure patients to provide anesthesia for the creation or revision of arteriovenous fistula for hemodialysis access. It provides analgesia, sympathetic blockade, optimal surgical conditions and adequate duration of postoperative block that prevents arterial spasm and graft thrombosis. It provides higher blood flow in the radial artery and arteriovenous fistula than is achieved with infiltration anesthesia [2].

Many approaches can be used for brachial plexus block; axillary, supraclavicular and infraclavicular approaches. They were commonly performed by blind techniques or neurostimulation which may be associated with high failure rate and serious complications. Nowadays; the intraoperative use of ultrasonography becomes more popular and much easier. Its use in these blocks increases the success rate and decreases complications [3].

Previous studies had compared ultrasonic guided supraclavicular and infraclavicular block for upper limb surgery in normal patients [3–5]. They hypothesized that the onset in supraclavicular block is fast and the blockade is deep as the nerves are very tightly packed but pneumothorax can occur due to the proximity of the pleura. Pneumothorax can be avoided by ultrasonic visualization of the pleura and by proper technique [6].

They also hypothesized that the infraclavicular block is characterized by compact anatomical distribution of the plexus allowing single injection of local anesthetics and the decreased incidence of pneumothorax. However, it may be associated with patient discomfort and technical difficulty, which can be overcome by the use of ultrasonography [7–9].

In a previous study; ultrasonic guided infraclavicular block was compared with local infiltration anesthesia for creating vascular access for hemodialysis in patients with chronic renal failure [2]. But as far as we know; no study had compared between ultrasonic guided supraclavicular and infraclavicular brachial plexus block in this type of operation. This comparison would help if a local cause prevents the use of either of them like swelling, infection or obesity.

1.1. Aim of work

The aim of work was to compare the efficacy of ultrasound-guided supraclavicular versus infraclavicular brachial plexus block in providing anesthesia for creation of arteriovenous fistula in chronic renal failure patients.

2. Patients and methods

The Ethics Committee, Department of Anesthesiology, Faculty of Medicine, Cairo University, approved the protocol of this study. This randomized study was conducted on sixty adult patients with chronic renal failure scheduled for creation of arteriovenous fistula of the distal upper extremity. Patients enrolled in the present study were of both sexes, aged 20–60 years, and with ASA physical status III. Every patient signed an informed consent.

Exclusion criteria included the following: neurological, neuromuscular, psychiatric disorders, hepatic, respiratory, or cardiac diseases; uncontrolled seizures; coagulation disorders; infection at the block injection site; patients with a body mass index more than 30; or patients who refused the procedure.

All the patients included in the study were on chronic hemodialysis and they had a hemodialysis session one day before the block performance. Their routine preoperative laboratory investigations were within normal values especially prothrombin time (PT), partial thromboplastin time (PTT) and international normalized ratio (INR).

Patients were randomized using computer generated number and concealed using sequentially numbered, sealed opaque envelope technique to two groups of 30 patients each:

Supra G (n = 30): Ultrasonic guided supraclavicular brachial plexus block group.
Infra G (n = 30): Ultrasonic guided infraclavicular brachial plexus block group.

In both groups the block was performed using a 50 mm 20 G nerve stimulator needle model (Braun). The needle was inserted in-plane with a linear ultrasonic probe after the nervous and vascular structures were optimally visualized. A depth of 3–4 cm and a frequency of 10–12 Hz was used.

The local anesthetic solution used in both groups consisted of 1:1 volumes of 0.5% bupivacaine and 2% lidocaine (the total volume injected was from 20–25 cm). This solution was administered in increments with repeated aspiration in between and its characteristic distribution around the nerves was observed.

No premedication was given to the patients, since full cooperation during block performance is required.

On arrival to the operating room, an intravenous catheter was placed in the upper limb contra-lateral to the surgical site and saline solution was started at 2 mL/kg/h. Standard anesthesia monitors (ECG, Pulse Oximeter, Non-invasive Blood Pressure) were applied. Supplemental oxygen (via nasal cannula at 4 L/min) was used throughout the procedure.

The patients were positioned in the supine position with the face turned to the contra-lateral side. Proper sterilization of the block area was performed. After proper surgical draping and displaying the area of the block with the ultrasound probe, a local anesthetic (Lidocaine 1%) was injected subcutaneously.

In the supraclavicular group, the ultrasound probe was positioned in the supraclavicular fossa, pointing caudad and moved laterally and medially in order to locate the subclavian artery. The hyperechoic first rib was identified deep to the artery and the pleura was identified and its sliding movement during respiration was noted. The plexus was consistently found with a characteristic "honeycomb" appearance lateral and superficial to the subclavian artery and superior to the first rib.

The needle was introduced through the skin from lateral to medial, in-plane with the transducer, with constant visualization, and directed toward the deep border of the nerve group. Three separate injections were made at various sites in the bundle, tending to start deep, in the "corner pocket" close to the artery, and moving more superficially.

In the infraclavicular group, the arm was abducted to 90° with flexion of the elbow to bring the artery and plexus closer to the skin. The coracoid process was identified by palpating the bony prominence just medial to the shoulder while the arm is elevated and lowered. Scanning was begun just medial to the coracoid process and inferior to the clavicle with the transducer in the parasagittal plane to identify the axillary artery by its thick wall and brisk pulsations. The pectoralis major and minor muscles were identified just above the brachial vessels and plexus. The hyperechoic cords of the brachial plexus and their corresponding positions relative to the artery were identified.

The needle was inserted in-plane from the cephalad aspect, with the insertion point just inferior to the clavicle. The needle aimed toward the posterior aspect of the axillary artery and passed through the pectoralis major and minor muscles. The injectate used to spread cephalad and caudad to cover the lateral and medial cords, respectively. When injection of the local anesthetic with a single injection didn't appear to result in adequate spread, additional needle repositions and injections around the axillary artery were done. The goal of the technique was to inject local anesthetic until it spreads around the artery in a U-shaped pattern.

2.1. Measured parameters

Block performance time which is defined as the interval between the first needle insertion and its removal at the end of the block.

Block performance-related pain was evaluated immediately after removal of the needle by asking the patient to verbally quantify the level of pain using a (VAS) score between 0 and 10, 0 meaning no pain and 10 meaning excruciating pain.

Evaluation of sensory and motor block was performed every 10 min in musculocutaneous, median, radial, and ulnar nerve territories over a 30-min period beginning when the needle was withdrawn from the patient.

Sensory block was evaluated by comparing the cold sensation elicited by ice in the central sensory region of each nerve with the same stimulus delivered to the contra-lateral side. The median nerve block was tested on the skin of the radial half of the palm and palmar side of the lateral 3 digits. The ulnar nerve block was tested on the skin of the medial side of the wrist and hand; skin of the medial 1 digit. The musculocutaneous nerve block was tested on the skin of the lateral side of the forearm. The radial nerve block was tested on the skin of the posterior arm, forearm and hand. **The sensory block was graded as follows: 0** = no difference from the unblocked extremity, **1** = less cold than the unblocked extremity, **2** = no sensation of cold.

Motor block was evaluated using the forearm flexion, thumb abduction, thumb and second digit pinch and finger abduction (for the musculocutaneous, radial, median, and ulnar nerves, respectively). **The motor block was graded as follows: 0** = no loss of force, **1** = reduced force compared with the unblocked extremity, **2** = incapacity to overcome gravity.

Surgical anesthesia was defined as surgery without patient discomfort or the need for supplementation of the block. If a part of the surgical territory was not completely anesthetized at the time of surgery, the block was supplemented with local anesthetic infiltration. If the patient still experiences pain despite supplementation, general anesthesia was used and patient excluded.

The duration of the sensory and motor block was assessed. The duration of the sensory block was defined as the time between the end of the local anesthetic injection and the total recovery of sensation. The duration of the motor block was defined as the time between the end of the local anesthetic injection and the total recovery of motor functions. The first call for analgesics was recorded.

The side effects and complications, such as blood vessel puncture, intravascular injection, overdose, dyspnea, Horner's syndrome, and pneumothorax, were noted.

The patient's satisfaction with the anesthetic technique was assessed after the patient's arrival in the post-anesthesia care unit using a 2-point scale (0 = unsatisfied; 1 = satisfied).

A post-block chest radiograph was obtained routinely after surgery. If a patient complained of respiratory distress or any signs of pneumothorax, a chest radiograph was done using the C arm in OR. All patients were examined after 24 h after surgery for the occurrence of complications (bruises/swellings at the block site, chest pain, breathing difficulty, dysaesthesia, or muscle weakness in the operated extremity). Surgeons were alerted to report any neurological problems not related to surgery during the follow-up visits.

2.2. Power Analysis

A total sample size of 60 patients randomly allocated into two equal groups (30 patients per group) will have 80% power to detect a large effect size (W) of 0.45 (α error = 0.05, β error = 0.2, using Chi-Square test of independence). Statistical power calculations was performed using computer program G*Power 3 for Windows. (Franz Faul, Universität Kiel, Germany).

Table 1 Patients' demographic criteria.

Demographic Criterion	Supra G (n = 30)	Infra G (n = 30)	P value
Age (years)	44.4 ± 11.3	47.83 ± 7.80	0.17
Weight (kg)	81.83 ± 8.29	79.76 ± 6.15	0.27
Sex male/female	18/12	17/13	

Statistically significant between-group difference ($P < 0.05$).

Table 2 Block performance time and block-related pain.

Parameter	Supra G (n = 30)	Infra G (n = 30)	P value
Block performance time (min)	8.13 ± 1.30	7.73 ± 1.17	0.21
Block-related pain (VAS)	2.73 ± 0.90	2.43 ± 1.10	0.25

n = number of patients.
Statistically significant between – group difference ($P < 0.05$).

2.3. Statistical analysis

Statistical analysis of data was performed using Paired – Samples T test for numerical variables and Chi-square test for qualitative variables. $P < 0.05$ was considered statistically significant.

3. Results

This study included 60 adult patients with chronic renal failure scheduled for creation of arteriovenous fistula of the distal upper extremity, divided into 2 groups of 30 patients each: Supra G (supraclavicular brachial plexus block group) and Infra G (infraclavicular brachial plexus block). The block failed in 2 patients in the Supra G and in 3 patients in the Infra G. Those 5 patients were excluded from the study and replaced by others to compensate for failed cases. In the Supra G, one failure was attributed to inability to clearly visualize the subclavian artery and the other failure was due to an incomplete block in the area supplied by the ulnar nerve after 30 min of the block. In the Infra G, 2 failures which included the distribution of the 4 nerves were attributed to a possible subcutaneous injection that was not recognized and the third failure was a partial block that excluded the distribution of both the ulnar and the median nerves.

Patients in both groups were of comparable age, weight, and sex (Table 1).

As regard the block performance time and block related pain: the block performance time was less than 10 min in both groups. The mean block performance time was comparable in the Supra G and the Infra G. The block related pain was comparable in the Supra G and the Infra G (Table 2).

As regard the median nerve block grade: the sensory and motor block grades in the area supplied by the median nerve showed no statistically significant differences between the 2 groups at 10, 20 and 30 min measurement times (Figs. 1 and 2).

As regard the ulnar nerve block: The sensory block grade in the area supplied by the ulnar nerve showed no statistically significant differences between the 2 groups at 10 min, but it was higher in the Supra G than the Infra G at 20 and 30 min measurement times. The difference was significant at 20 min and

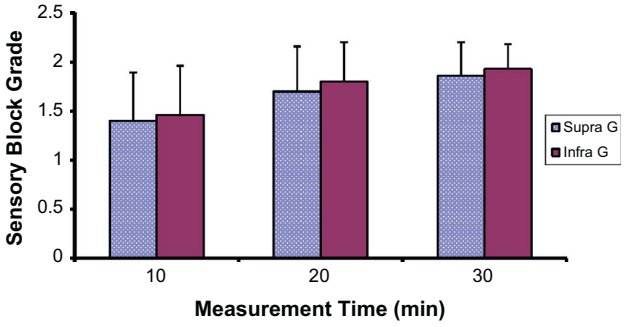

Figure 1 Median nerve sensory block.

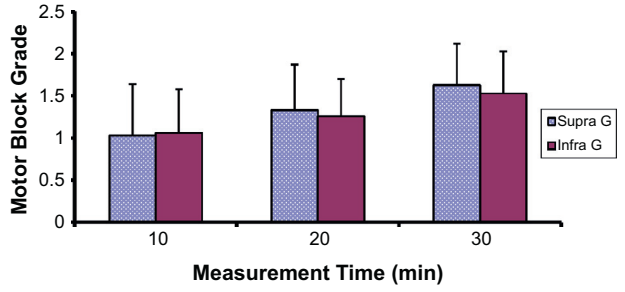

Figure 2 Median nerve motor block.

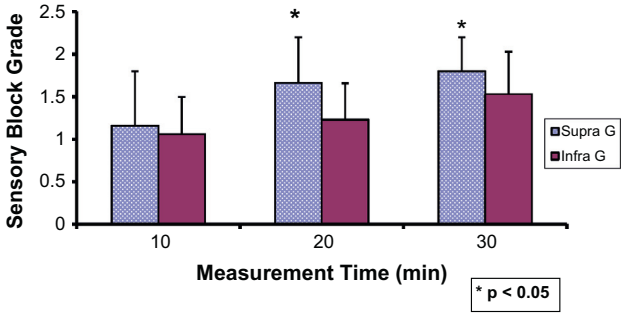

Figure 3 Ulnar nerve sensory block.

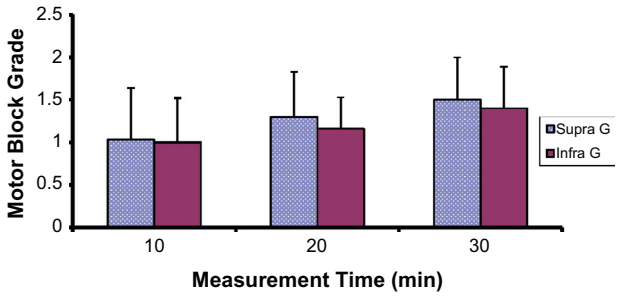

Figure 4 Ulnar nerve motor block.

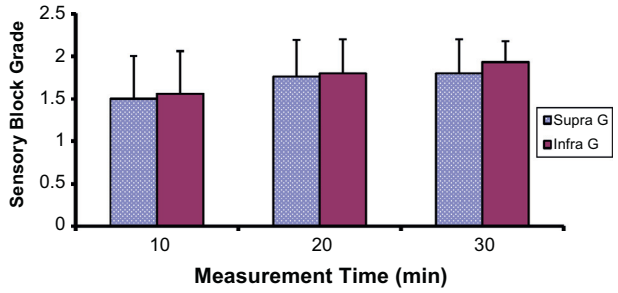

Figure 5 Radial nerve sensory block.

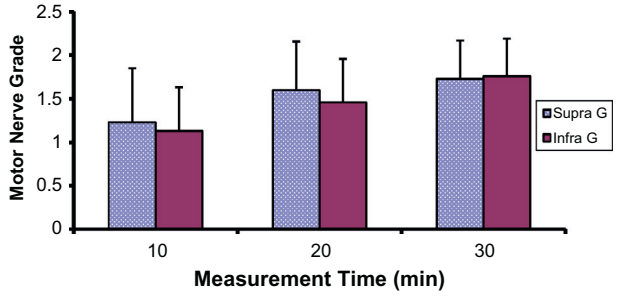

Figure 6 Radial nerve motor block.

30 min. The motor block grade in the area supplied by the ulnar nerve was comparable in the 2 groups at 10, 20 and 30 min measurement times (Figs. 3 and 4).

As regard radial nerve block: The sensory and motor block grades in the area supplied by the radial nerve showed no statistically significant differences between the 2 groups at 10, 20 and 30 min measurement times (Figs. 5 and 6).

As regard musculocutaneous nerve block: The sensory and motor block grades in the area supplied by the musculocutaneous nerve showed no statistically significant differences between the 2 groups at 10, 20 and 30 min measurement times (Figs. 7 and 8).

As regard the motor block duration, sensory block duration and first call for analgesia: they were comparable in Supra G and Infra G (Table 3).

Regarding patients' satisfaction, 90% and 87% of patients were satisfied in the Supra G and the Infra G respectively. The difference between the 2 groups was not statistically significant. Three patients in the Supra G were unsatisfied, 2 were unhappy about the idea of being awake during the surgery and one was unhappy with the pain that accompanied the

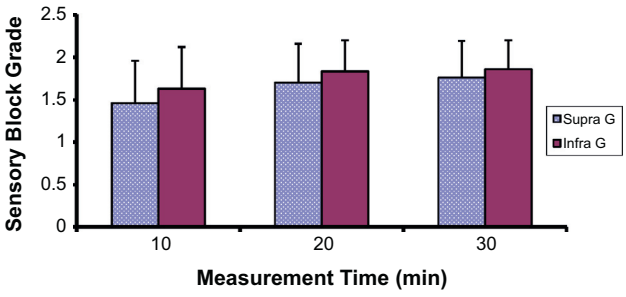

Figure 7 Musculocutaneous nerve sensory block.

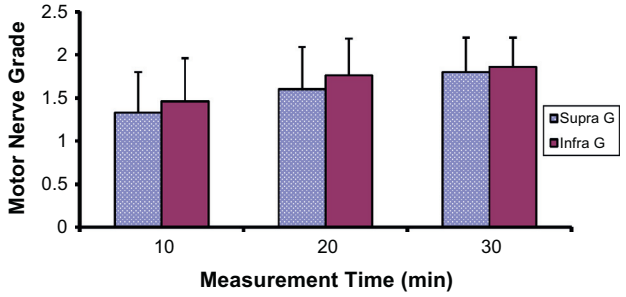

Figure 8 Musculocutaneous nerve motor block.

block performance. Four patients in the Infra G were unsatisfied, 2 patients were unhappy with the pain that accompanied the block performance and 2 patients did not like the feeling of being unable to move their limb for a long time (Table 4).

None of the patients in both groups had intravascular injection or developed local hematoma or pneumothorax. Surgeons did not report dysaesthesia, or muscle weakness in the operated extremity in the 1 week follow up visit of the patients.

4. Discussion

In our current study both the ultrasound-guided supraclavicular and infraclavicular approaches to the brachial plexus have been compared in patients with chronic renal failure scheduled for creation of arteriovenous fistula of the distal upper extremity.

The results of this study showed that the block performance time was less than 10 min and was comparable in both groups.

This result is consistent with many previous studies. In a prospective randomized study comparing ultrasound-guided infraclavicular versus supraclavicular block, Arcand and his colleagues [3] reported that although ultrasonic visualization was more rapid in the infraclavicular region than in the supraclavicular region, block performance times were similar: (4.0 ± 3.3) min and (4.7 ± 4.0) min for infraclavicular group and supraclavicular group respectively. In a more recent study, Koscielniak-Nielsen and his colleagues [5] compared ultrasound-guided supraclavicular and infraclavicular blocks for upper extremity surgery and showed similar block performance times for both approaches: (5.0 ± 1.6) min in the infraclavicular group and (5.7 ± 1.6) min in the supraclavicular group.

Studies on ultrasound-guided supraclavicular block showed block performance time of 9 min in a study done by Chan and

Table 3 Block duration and first call for analgesia.

Parameter	Supra G (n = 30)	Infra G (n = 30)	P value
Duration of motor block (h)	6.26 ± 0.98	5.86 ± 0.97	0.11
Duration of sensory block (h)	7.36 ± 0.99	6.86 ± 0.97	0.05
First call for analgesia (h)	9.33 ± 1.02	8.86 ± 0.93	0.07

n = number of patients.
Statistically significant between – group difference ($P < 0.05$).

Table 4 Patients' satisfaction.

	Supra G (n = 30)	Infra G (n = 30)
Satisfied	27/30 (90%)	26/30 (87%)
Unsatisfied	3/30 (10%)	4/30 (13%)

his colleagues [10] and 5 min in a study done by Williams and his colleagues [6].

For the performance of an infraclavicular block, Sandhu and Capan [11] used 10 min, Dingemans and his colleagues [12] used 3.1 min, Gurkan and his colleagues [13] used 7.1 min, and Sauter and his colleagues [14] used 4.1 min.

Concerning the block related pain, it was thought that the infraclavicular block has not gained clinical popularity because of uncertain surface landmarks and the perception that it is a more painful block [7].

The block related pain in our study was comparable in the Supra G and the Infra G, VAS was (2.73 ± 0.90) and (2.43 ± 1.10) in the Supra G and the Infra G respectively. This is consistent with the results of Arcand and his colleagues [3] in which VAS pain score was (2.0 ± 2) min and (2.0 ± 2) min for infraclavicular group and supraclavicular group respectively. The reliability of ultrasonic landmarks may also have contributed to minimizing patient discomfort.

In the current study, we did not assess the onset of the block but we assessed the sensory block grade and the motor block grade every 10 min in the areas supplied by the median, ulnar, radial, and musculocutaneous nerves over a 30-min period beginning when the needle was withdrawn from the patient. The results showed no statistically significant differences in the sensory or the motor block grades between the two groups at 10, 20 and 30 min measurement times in the areas supplied by the median, radial, and musculocutaneous nerves. The sensory block grade in the area supplied by the ulnar nerve showed no statistically significant differences between the 2 groups at 10 min, but it was significantly higher in the Supra G than the Infra G at 20 and 30 min measurement times. The motor block grade in the area supplied by the ulnar nerve was comparable in the 2 groups at 10, 20 and 30 min measurement times.

The results also showed comparable first call for analgesia in both groups. Regarding patients' satisfaction; 90% and 87% of patients were satisfied in the Supra G and the Infra G respectively. The difference between the 2 groups was not statistically significant.

These results are consistent with the results of Arcand and his colleagues [3] who carried out a study on 80 patients to compare ultrasound guided supraclavicular block and infraclavicular block. They concluded that single injection ultrasound-guided infraclavicular block can be performed as rapidly and results in the same success rate for surgical block as ultrasound-guided supraclavicular block and that ultrasound guidance results in supraclavicular and infraclavicular blocks that are both reliable and quickly performed. However, their results showed a block quality (in terms of partial or complete sensory block of all nerve territories) that tended to be better in the supraclavicular group than in the infraclavicular group, mostly because of radial sparing in the infraclavicular group. They explained this by the fact that although the cords of the brachial plexus are compactly arranged around the axillary artery, yet the posterior cord is deeper from the point of entry of the needle than the lateral or median cords, which may explain why a single injection technique, such as the one they used, resulted in incomplete block of the radial nerve.

Ootaki and his colleagues [8], used ultrasound guided infraclavicular block, in which the anesthetic was placed using 2 injection sites to completely surround the axillary artery, achieved surgical blocks in 95% of patients and complete sensory block of the radial territory in 95% of patients.

Sandhu and Capan [11], used a triple injection ultrasound guided infraclavicular block, achieved 90% surgical blocks without supplementation in 126 patients undergoing upper extremity surgery.

A more recent study by Koscielniak-Nielsen and his colleagues [5], compared ultrasound-guided supraclavicular and infraclavicular blocks for upper extremity surgery in 120 patients. Their results showed that infraclavicular block had a faster onset and a higher surgical effectiveness, which was due to better analgesia of the median and the ulnar nerves. Supraclavicular block resulted in better analgesia of the axillary nerve. The infraclavicular approach also resulted in a better motor block. After 30 min, in the infraclavicular group 93% of patients were ready for surgery compared with only 78% of patients in the supraclavicular group. The authors speculated that the poorer efficacy of the supraclavicular blocks in their patients was caused by lower experience with this approach and a higher number of colleagues performing the block. In their institute, the standard blocking technique for hand and/or forearm surgery was the infraclavicular and obese patients mostly received supraclavicular or axillary blocks. They considered this as a major drawback of their study. The targets for local anesthetic injections were also different in both groups, and so some parts of the plexus in the supraclavicular group might have not been visualized and not surrounded by the local anesthetic. The authors reported that they might have missed anatomical variations of the inferior trunk described by Royse and his colleagues [15], in up to 15% of the volunteers. This could explain the poorer analgesia of the ulnar and the median nerves, which originate from this cord, in supraclavicular group patients.

Three previous studies of the supraclavicular approach reported success rates between 85% and 95%, defined as surgical anesthesia without supplementation [10,6,3].

Previous studies of the infraclavicular approach reported success rates of 80% [3], between 86% and 95% [12–14], and between 90% and 99% [8,9].

A recent study by Fredrickson et al. [4] compared an ultrasound guided supraclavicular block using multiple injections with ultrasound guided triple injection infraclavicular block. They reported that the corner pocket supraclavicular and infraclavicular brachial plexus block were associated with similar onset times and sensory blockade at 30 min.

A more recent study by Yang and his colleagues [16], compared infraclavicular and supraclavicular approaches to the brachial plexus using neurostimulation in 100 patients. Their results showed no significant differences in the evolution of the sensory block over 50 min in the two groups but the sensory block was significantly better in the supraclavicular group at 20 min in the ulnar nerve territory. The progression of the motor block paralleled that of the sensory block and there were no significant differences in the evolution of the motor block with time. There was no significant difference in the proportion of the complete sensory or motor block over time. There were no significant differences between the two groups in the duration of the sensory and motor block. There were no significant differences in the level of patients' satisfaction between the two groups. The authors concluded that both the supraclavicular and infraclavicular approach to the brachia plexus had similar clinical efficacy.

As regards the possible complications in the current study, none of the patients in both groups had intravascular injection or developed local hematoma or pneumothorax. Surgeons did not report dysaesthesia, or muscle weakness in the operated extremity in the 1 week follow up visit of the patients.

Perlas and his colleagues [17], reported that an ultrasound-guided supraclavicular block was associated with a high success rate and low complication rate with no pneumothorax in a series of 510 consecutive patients. They suggested that ultrasound-guided supraclavicular block might reduce the risk of pneumothorax because the pleura and first rib are often easy to visualize.

Arcand and his colleagues [3] mentioned that no pneumothorax has been reported in any study of supraclavicular or infraclavicular block using ultrasound guidance.

Koscielniak-Nielsen and his colleagues [5], who compared ultrasound-guided supraclavicular and infraclavicular blocks for upper extremity surgery reported Horner's syndrome in 29% and suspected diaphragmatic paresis in 12% of patients in the supraclavicular group. Diaphragmatic paresis was seen as a change in the breathing pattern and/or coughing difficulty. The incidence of vascular punctures was 2% in both groups.

5. Conclusion

The results of the current study showed that both supraclavicular and infraclavicular approaches to the brachial plexus were comparable in providing very satisfactory sensory and motor block in patients with chronic renal failure undergoing creation of arteriovenous fistula of the distal upper extremity. Both blocks provided very good analgesia that extended for a long time postoperatively. Patients were satisfied with both blocks and no complications were reported.

The anesthesiologist can use either supraclavicular or infraclavicular blocks satisfactorily. This helps a lot when a local cause like swelling, infection, or obesity prevents the use of either of them. So, the other approach would work.

Conflict of interest

No conflict of interest.

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