Peripheral nerve blocks are common and effective means for anesthesia for limb surgery. The evaluation of the success of a peripheral blockade is based on the loss of sensation, with no objective means of detecting a successful block. The autonomic innervation to the upper extremity, which controls both the vascular tone and the activity of sweat glands, is supplied by nerve fibers accompanying the somatic nerve fibers. Previous studies have shown changes in both skin temperature and electrical resistance of the skin following brachial plexus block.

We studied 20 patients undergoing hand surgery under infraclavicular brachial plexus block. The electrical resistance of the skin on the palmar aspect of the forearm was continuously recorded on the block arm and on the contralateral arm using a commercial skin resistance monitor. No statistically significant change in the electrical resistance of the skin was observed during 20 minutes after placement of the block. These results strongly suggest that the electrical resistance of the skin cannot be used to predict a successful infraclavicular block.

Keywords: Nerve block, regional anesthesia, skin electrical resistance.

Skin Electrical Resistance Does Not Change Following Infraclavicular Block

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The infraclavicular approach to block nerve conduction in the brachial plexus is a common technique of regional anesthesia for surgery of the forearm and hand. It has a success rate of about 90%, and the practical clinical method to evaluate adequacy of the block for surgery is based on loss of sensory response to painful stimuli, which requires patient cooperation. Several methods have been described for objective assessment of the sensory block; among them is the quantitative evaluation of the blockade of the autonomic innervations to the arm.

The sympathetic nervous system regulates the skin temperature by controlling cutaneous blood flow and secretion from sweat glands, both of which also determine the electrical resistance of the skin. The literature presents contradicting evidence regarding the effectiveness of skin resistance monitoring as a tool for quantification of regional anesthesia. Our study was designed to continuously evaluate the changes in the skin’s electrical resistance at baseline and following an infraclavicular nerve block. The study design was based on the hypothesis that regional anesthesia may affect skin electrical resistance.

Materials and Methods
The study was designed as a prospective observational study and was conducted between July 1 2009, and May 31, 2010, at Rambam Healthcare Campus, Haifa, Israel, a university-affiliated referral center.

After institutional review board approval, patients scheduled for elective surgery of the hand or the arm distal to the elbow, who signed an informed consent, were eligible for the study. Inclusion criteria were American Society of Anesthesiologists (ASA) physical status I or II, weight between 60 and 120 kg, height between 155 and 195 cm, and age between 18 and 80 years. Exclusion criteria were contraindications for regional anesthesia (including patient refusal, local infection and thrombocytopenia, use of anticoagulants or antiplatelet aggregation drugs, and hypersensitivity to local anesthetics), systolic blood pressure above 150 mm Hg or below 100 mm Hg on the morning of the surgery, and hemoglobin concentration lower than 8 mg/dL, as well as open wounds or skin infection at the arms.

Before induction of anesthesia, fentanyl, 50 to 100 µg, and midazolam, 1 to 2 mg, were slowly administered intravenously. Each patient was placed in a supine position, with the hand rested on the bed alongside the trunk. The infraclavicular block was performed using a 22-gauge stimulating needle (Polymedic, te me na SAS, Carrières-sur-Seine, France) under ultrasound guidance (S-Nerve unit, 38 × 38 mm, 6- to 13-MHz linear array probe, SonoSite, Bothell, Washington) in a lateral in-plane, short-axis approach and continuing visualization of the needle.

With use of an aseptic technique, each of the 3 cords of the brachial plexus was visualized and localized by
nerve stimulation. A local anesthetic “cuff” was injected containing 5 to 10 mL, and totaling 15 to 30 mL of 0.25% bupivacaine and 1.5% lidocaine solution without epinephrine.

Before block placement both arms of the patient were rested on the bed slightly abducted. Environmental exposure was similar to both limbs during the measurement periods.

Skin electrical resistance was continuously measured on both hands using 2 commercial skin resistance monitors (ThoughtStream, Mind Modulations, Eastsound, Washington). The monitors were connected to 2 electrocardiography gel electrodes placed 1 cm apart on the long axis of the palmar aspect of the arm, 5 to 7 cm proximal to the tip of the radius—an area somatically innervated by the musculocutaneous nerve. The skin electrical resistance data from the 2 skin resistance monitors were transferred simultaneously every 0.5 second to a personal computer running a designated software program developed by one of the manuscript authors (A.L.), via an RS232 cable. The data were recorded from 15 minutes before the injection of local anesthetics to the brachial plexus to 20 minutes following block termination. Both the skin resistance monitors and the computer software were tested in our laboratory against fixed and changing electrical resistance and proved highly accurate.

Sensory block was evaluated every 5 minutes following injection of the local anesthetics to the brachial plexus using the pinprick technique. A successful block was defined as loss of response to painful stimuli on musculocutaneous, radial, ulnar, and median nerve distribution 30 minutes following local anesthetic injection.

The need for supplemental analgesia and conversion to general anesthesia was documented, and patients with a failure to achieve successful sensory block 30 minutes following injection were excluded from the study.

Results

Thirty-six patients were enrolled in the study, and 14 patients (38.9%) were excluded because of technical failure of the recording system. The failure was due to either computer software failure (9 cases) or communication failure between the skin resistance monitor and the computer (5 cases); hence, these failures may not have implications about the validity of the measurement.

Two patients (5.6%) were excluded because of failure to achieve a satisfactory block 30 minutes flowing the block. Twenty patients (56%) successfully completed the study, totaling 40 measurements: 20 measurements in the blocked arm of each patient (“block” group) and 20 in the controls (contralateral arm of each patient). None of the patients needed supplemental analgesia or conversion to general anesthesia. The age, weight, and height of each patient who completed the study are displayed in Table 1.

The electrical resistance of the skin ranged widely,

![Graph](image1.png)

**Figure 1.** Representative Recording of a Single Patient’s Changes of Skin Electrical Resistance, by Time (15 minutes before infraclavicular block to 20 minutes afterward)

Time 0 indicates start of block (see arrow); negative values represent minutes before the block; and positive values represent minutes after the block. Solid line indicates skin electrical resistance (× 1,000 Ω) at arm that received infraclavicular block. Dashed line indicates control—skin resistance (× 1,000 Ω) at contralateral arm.

<table>
<thead>
<tr>
<th>Demographic variable</th>
<th>Value a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (no. of men/women)</td>
<td>12/8</td>
</tr>
<tr>
<td>Age (y)</td>
<td>37 ± 14</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>172 ± 16</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>78 ± 17</td>
</tr>
</tbody>
</table>

**Table 1.** Demographic Data

a Values are presented as mean ± SD or median.
from 2,000 ohm (Ω) to 6,000 Ω, on both the blocked hand and the contralateral control hand. Over time, the skin electrical resistance presented a slow but definitive decrease (P < .001, calculated by the Friedman test), which may be related to temperature changes due to environmental exposure. A representative recording of skin electrical resistance of the blocked arm and the contralateral, control arm is presented in Figure 1.

When comparing the changes of the electrical resistance throughout the different time segments in the block group with those of the control group, no significant difference was apparent between the 2 groups (paired t test; Table 2).

The comparison of mean and standard deviation of skin electrical resistance (× 1,000 Ω) of the block and control groups throughout time is presented in Figure 2.

The data were evaluated by SPSS software, version 15 (SPSS Inc, Chicago, Illinois). The change over time of both the block and control did not meet assumptions for repeated-measures analysis of variance (ANOVA); hence, the Friedman test was used. Also, a paired t test was used. P < .05 was considered significant.

Discussion

The electrical resistance of an electrical element measures its opposition to the passage of an electric current. Electrical resistance is measured using an ohmmeter, an electronic device that applies a small voltage to the measured resistance, measuring the resulting current and calculating the resistance according to the Ohm law.

The sympathetic innervation to the arm originates mostly from the T3-T6 level. The preganglionic fibers ascend along the thoracic sympathetic chain, and the postganglionic fibers exit the sympathetic chain at T2-T3 levels and join the nerve roots from C5 to T1 that contain the afferent and efferent fibers.6

Following infraclavicular block, Minville et al7 demonstrated a significant increase of about 3°C in the skin temperature during the first 30 minutes following a successful block. The changes in the temperature were well correlated to the distribution of a successful sensory block of specific nerves.

The surgical destruction of the thoracic sympathetic chain is an effective treatment of upper-limb hyperhidrosis.8 Uchino et al9 described an immediate and significant increase in both skin electrical resistance and skin temperature following thoracic sympathectomy with computed tomography guidance. The literature presents contradicting evidence regarding the effectiveness of skin resistance monitoring as a tool for quantification of regional anesthesia. Kirnö et al3 showed no correlation between skin resistance and induced sympathetic activity, suggesting that skin resistance cannot be used to quantify sympathetic nerve traffic and thus does not express the completeness of sympathetic blockade in regional anesthesia. Smith et al,2 however, have demonstrated a significant increase in the skin electrical resistance following an axillary block using a simple direct-current, industrial ohmmeter.

Werdehausen et al10 reported uniform changes in the skin temperature following peripheral nerve blocks, suggesting a sympatholytic effect that may implicate the skin’s electrical resistance as well.

In contradiction of previously published work,2 no significant change in the skin’s electrical resistance was evident in the sensory distribution of the musculocutaneous nerve following a successful infraclavicular nerve block in the current study.

Additionally, there was a small difference (350 Ω ± 2.4 kΩ) in the baseline resistance, which may originate from either injury or difference in patterns of use between hands. Our findings strongly suggest that the continu-
Figure 2. Mean and Standard Deviation of Skin Electrical Resistance of Blocked and Control (contralateral) Arms in Total Study Population Before and After Infraclavicular Block

Time 0 indicates start of block; error bars mark standard deviation; solid bars mark mean resistance.

ous measurement of the electrical resistance of the skin, alone or compared with the contralateral limb, cannot be used to predict a successful nerve block.

REFERENCES


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