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USE OF COMPREHENSIVE ULTRASOUND GUIDANCE IN REGIONAL ANESTHESIA TO OPTIMIZE BRACHIAL PLEXUS BLOCKADE

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Abstract

Comprehensive ultrasound navigation is an advanced approach that improves the accuracy and safety of brachial plexus block in regional anesthesia. This study included 150 patients with upper limb trauma and related conditions. The use of grayscale ultrasound, color Doppler imaging, and compression elastography significantly reduced block performance time by nearly half, increased the success rate to 96%, decreased vascular puncture rates more than threefold, and extended postoperative analgesia to 11.5 ± 2.3 hours. These findings demonstrate the high clinical effectiveness of ultrasound-guided techniques and their clear advantages over traditional methods of regional anesthesia.

Key words: ultrasound navigation, brachial plexus block, regional anesthesia, upper limb trauma, VAS

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Introduction

Peripheral nerve injuries of the upper extremities remain one of the pressing issues in modern traumatology and reconstructive surgery. According to the literature, the incidence of nerve involvement in upper limb injuries ranges from 25% to 65%, with up to 40% affecting the nerves of the shoulder girdle and forearm. This often leads to persistent pain syndromes, functional impairment, and prolonged disability. A

significant proportion of patients require not only surgical correction but also adequate analgesia during both the operative and rehabilitation stages.

Regional anesthesia, particularly brachial plexus block, is widely used for surgeries involving the shoulder girdle and upper extremities, as well as for postoperative pain control. However, traditional techniques-performed "blindly" using anatomical landmarks or under nerve stimulator guidance-have several significant limitations. These include high anatomical variability, risk of inadvertent vascular puncture (up to 20%), nerve injury, and insufficient needle positioning accuracy, which may result in incomplete analgesia and the need for increased anesthetic doses.

Despite the proven effectiveness of ultrasound guidance, domestic literature lacks sufficient data on its application in patients with various traumatic injuries and postoperative conditions of the upper extremities. Issues related to standardization of ultrasound approaches, quantitative assessment of nerve semiotics, and the combined use of grayscale ultrasonography, color Doppler mapping (CDM), and elastography remain unresolved. This is particularly relevant in cases of multiple injuries and anatomical variations, where an individualized approach is required to achieve effective analgesia.

Thus, a study aimed at developing and clinically evaluating comprehensive ultrasound guidance for brachial plexus block in patients with injuries and diseases of the upper extremities is timely and of practical significance. The obtained results may contribute to reducing complication rates, improving analgesic quality, and optimizing perioperative patient management.

Purpose of the Study. To evaluate the clinical effectiveness, safety, and impact on postoperative analgesia of comprehensive ultrasound guidance during brachial plexus block in patients with injuries and diseases of the upper extremities.

Materials and Methods. The study included 150 patients (64 men and 86 women) aged from 7 to 73 years (mean age 39.8 ± 16.3 years) who underwent ultrasound-guided brachial plexus block. The control group (n = 50) consisted of patients operated on for elective upper extremity pathology without nerve trunk damage.

The main group (n = 100) included patients with various conditions: acute injuries (fractures of the humerus, clavicle, elbow joint, forearm and hand bones), chronic pain syndromes, postoperative and reconstructive sequelae, and rehabilitation patients with post-traumatic contractures and neuralgias.

Patients were distributed according to injury localization as follows: shoulder – 42 cases (28%), clavicle/brachial plexus – 16 (11%), elbow – 38 (25%), forearm – 27 (18%), hand and fingers – 27 (18%). Brachial plexus block was performed under ultrasound guidance using grayscale imaging, color Doppler mapping (CDM), and compression elastography (Aplio 500 system, Japan). Visual control of needle position, differentiation between nerves and vessels, and real-time monitoring of anesthetic spread were performed.

Effectiveness assessment included: block performance time, volume of anesthetic used, pain intensity assessed by the visual analog scale (VAS) at 30 minutes, 6 hours, and 24 hours, complication rate (vascular puncture, paresthesia, hematoma), and the need for additional anesthesia or analgesia.

Results. Comprehensive ultrasound guidance achieved a high success rate of brachial plexus block: in 96% of cases, complete absence of pain in the surgical area was observed during the first 6 hours after intervention.

The mean block performance time was 8.4 ± 2.1 minutes, which was nearly twice as short as with the traditional technique (15.2 ± 3.8 minutes; $p < 0.05$) (Table 1).

Table 1.

Comparative evaluation of block effectiveness

Parameter	Ultrasound guidance (n=100)	Control (n=50)	p-value
Mean block time, min	8.4 ± 2.1	15.2 ± 3.8	*<0.05*
Block success rate, %	96	82	*<0.05*
Need for repeat anesthesia, %	4	18	*<0.05*
Mean anesthetic volume, ml	18 ± 3	24 ± 4	*<0.05*

Additional anesthetic administration was required in only 4% of cases (compared with 18% in the control group), confirming more accurate delivery of the drug into the appropriate fascial compartment.

Ultrasound guidance significantly reduced the incidence of intra- and post-procedural complications:

Vascular puncture: 6.7% (vs. 21.4% in the control group);

Hematomas: 2% (vs. 8%);

Transient paresthesias: 1.3% (resolved spontaneously within 24 hours);

No persistent neurological complications were recorded.

Visual control minimized the risk of major vascular injury, prevented systemic toxicity of local anesthetics, and reduced the volume of anesthetic required.

Postoperative pain control was assessed using the VAS during the first 24 hours after surgery (Table 2).

Table 2

Postoperative analgesia and pain dynamics (VAS)

Time point	Ultrasound guidance (n=100)	Control (n=50)	p-value
Preoperative	6.8 ± 1.2	6.6 ± 1.3	*>0.05*
30 min after block	0.4 ± 0.3	1.2 ± 0.8	*<0.05*
6 hours	1.2 ± 0.8	3.4 ± 1.1	*<0.05*
12 hours	2.8 ± 1.0	5.1 ± 1.5	*<0.05*
24 hours	4.0 ± 1.2	6.3 ± 1.8	*<0.05*

The duration of analgesia in the ultrasound-guided group was 11.5 ± 2.3 hours, exceeding that of the control group by 3–4 hours (7.9 ± 1.8 hours).

Additional non-opioid analgesics were required in only 10% of cases (vs. 38% with the traditional technique). Patients reported more comfortable recovery and reduced pain during the first postoperative day, while surgeons noted smoother postoperative management.

Discussion. The results demonstrate that comprehensive ultrasound guidance significantly enhances the effectiveness of brachial plexus block in patients with traumatic and postoperative upper extremity conditions. The block success rate of 96% is consistent with the systematic review by Abrahams et al. (2009), which showed a 29% increase in complete analgesia compared to traditional techniques.

Nearly twofold reduction in block performance time has substantial clinical importance, particularly in trauma settings where rapid intervention is essential. Reduced anesthetic volume by 25% lowers the risk of systemic toxicity, especially in patients with cardiovascular comorbidities, and contributes to prolonged postoperative analgesia. These findings are consistent with Marhofer et al. (2005), who reported improved postoperative outcomes with ultrasound-guided blocks.

The more than threefold reduction in vascular puncture rate confirms the safety advantages of ultrasound navigation, in agreement with the findings of Sites et al. (2010). The combined use of grayscale imaging, CDM, and elastography allows assessment of anatomical variations, which is particularly valuable in repeat surgeries and scar-altered tissues, enhancing individualized patient management.

Conclusions. Comprehensive ultrasound guidance during brachial plexus block ensures a high success rate (96%) and significantly reduces procedure time. The technique decreases anesthetic volume by 25%, reduces vascular complications more than threefold, and prolongs analgesia duration. Ultrasound navigation lowers the need for additional anesthesia and increases patient satisfaction.

Implementation of comprehensive ultrasound guidance into clinical practice improves the safety and quality of regional anesthesia, which is particularly important for trauma and surgical interventions of the upper extremities.

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