The Safety and Efficacy of Ultrasound Guided Peripheral Nerve Block

A Qualitative Systematic Review

David Lynn Parisian BA, MSIV University of Arizona

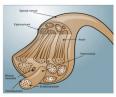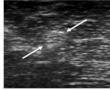THE UNIVERSITY OF ARIZONA — COLLEGE OF MEDICINE PHOENIX

Abstract

The clinical application of regional anesthesia has grown dramatically in recent years, in part due to the increasing adoption of ultrasound imaging for peripheral block placement. Ultrasound technology enables real time visualization of nerves, surrounding structures and local anesthetic spread and therefore offers theoretical advantages over existing methods of nerve localization. This systematic analysis was conducted to assess the current state of evidence for improved block efficacy, safety and other patient comfort related outcomes with ultrasound guided peripheral nerve blockade (UGPNB). A search of the PubMed database was conducted for all randomized controlled trials comparing UGPNB to peripheral blocks performed at the same anatomic site by an alternative method of nerve localization. Forty-four studies, 39 adult and 5 pediatric, were identified for analysis. The results show that there is increasing Level Ib Grade A evidence that UGPNB, when applied by clinicians with the appropriate skill set, can be performed faster than alternative techniques; yielding blocks that are more effective, with quicker onset and longer duration, requiring less local anesthetic, and causing less vascular puncture and greater patient comfort. Improved safety with UGPNB remains largely theoretical due to the low complication rate of all techniques of peripheral nerve block, but there is Level III Grade B evidence to suggest a decrease in neurologic sequelae with UGPNB.

Background

Regional anesthesia (RA) is a method of blocking neural transmission in a limited area of the body and consists of both central and peripheral techniques. Successful peripheral nerve block (PNB) relies on three simple principles: identifying the correct nerve/plexus, placing the needle as close as possible to the target without direct contact and surrounding the nerve/plexus with local anesthetic (LA). With appropriate patient selection PNB used alone or in combination with general anesthesia (GA) can offer several benefits: decreased patient morbidity and mortality, superior postoperative analgesia, improved cost-effectiveness, decreased post operative complications, and an improved postoperative course (decreased use of anti-emetics as well as faster recovery and discharge). The primary complications of PNB are rare and include permanent direct peripheral nerve injury, adjacent tissue and organ injury, local anesthetic systemic toxicity (LAST), and in upper extremity blocks: pneumothorax and hemi-diaphragmatic paresis (HDP). Transient neuropraxias are more common and self limited.
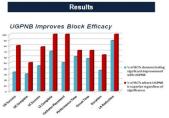

Peripheral Nerve Anatomy

"Honey Comb" Echotexture
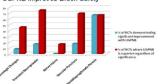

Supraclavicular Block Placement

"Donut" Sign

On cross sectional US images, peripheral nerves have a fascicular echotexture that produces a "honey-comb" appearance and circumferential distribution of LA around nerves produces a "donut sign". While many believe that US guidance will become the new "gold standard" for peripheral nerve localization, it is important to scientifically assess the utility of this new technology. Traditional techniques of nerve localization include electrical nerve stimulation, paresthesia induction and anatomic approaches using transarterial, loss of resistance and landmark endpoints.

Methods

The National Library of Medicine's PubMed and the Cochrane Database for Systematic Reviews were searched for randomized controlled trials (RCTs) that compared UGPNB to alternative methods of nerve localization. Only studies that compared peripheral blocks at the same location and had exclusion criteria consistent with other RCTs were included. Search terms included: "ultrasound guided regional anesthesia", "ultrasound regional anesthesia", "ultrasound-guided peripheral nerve blockade" and ultrasound guided block. In addition, large case series (>500 patients) were included to provide information regarding the frequency of complications related to UGPNB.
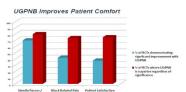
Results

UGPNB Improves Block Efficacy

UGPNB Improves Block Safety

UGPNB Improves Patient Comfort

Table of RCTs Addressing Each Experimental Outcome

	RCTs addressing outcome	RCTs demonstrating significant improvement with UGPNB	% of RCTs demonstrating significant improvement with UGPNB	RCTs where UGPNB demonstrates improvement without statistical significance	% of RCTs where UGPNB is superior regardless of significance	RCTs where UGPNB is significantly worse
Measures of Block Efficacy						
Block Quality						
*UE Block Success	15	5	33%	7	80%	0
*UE Complete Block	10	3	30%	2	50%	0
**Combined UE Quality	25	8	32%	9	68%	0
*LE Block Success	9	4	44%	3	78%	0
*LE Complete Block	10	7	70%	3	100%	0
**Combined LE Quality	19	11	58%	6	89%	0
Catheter Placement	6	3	50%	3	100%	0
Block Performance Time	28	17	61%	3	71%	4
Block Onset Time	14	8	57%	2	71%	1
Block Duration	11	4	36%	3	64%	0
Local Anesthetic	9	8	89%	1	100%	0
Measures of Block Safety						
All Neurologic Changes	24	2	8%	9	46%	1
*Transient Neuropraxias	12	2	17%	7	75%	1
*Nerve Injury	12	0	0%	2	17%	0
Vascular Puncture	23	4	17%	12	70%	0
HD Paresis	3	2	67%	0	67%	0
Horner Syndrome	2	0	0%	2	100%	0
Measures of Pt. Comfort						
Needle Passes/Redirection	10	7	70%	1	80%	1
Skin Puncture	3	0	0%	0	0%	0
Block Related Pain	19	8	42%	6	74%	0
Patient Satisfaction	8	3	38%	3	75%	0

TABLE 1. Key to Evidence Statements and Grades of Recommendations

Statements of evidence
Ia Evidence obtained from meta-analysis of RCTs
Ib Evidence obtained from at least 1 RCT
IIa Evidence obtained from at least 1 well-designed controlled study without randomization
IIb Evidence obtained from at least 1 other type of well-designed quasi-experimental study
III Evidence obtained from well-designed nonexperimental descriptive studies, such as comparative studies, correlation studies, and case reports
IV Evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities

Grades of recommendations
A Requires at least 1 prospective, randomized controlled trial as part of a body of literature of overall good quality and consistency addressing the specific recommendation (evidence levels Ia and Ib)
B Requires the availability of well-conducted clinical studies, but no prospective, randomized clinical trials on the topic of recommendation (evidence levels IIa, IIb, III)
C Requires evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities; indicates an absence of directly applicable clinical studies of good quality (evidence level IV)

Source: US Department of Health and Human Services Agency for Health Care Policy and Research.

Conclusions

The body of evidence demonstrating the benefits of US guidance for PNB in regional anesthesia has increased dramatically during the past decade.

1. **Level Ib Grade A** evidence exists for statistically significant improvements using UGPNB versus alternative methods of nerve localization for the following experimental outcomes:
   - Efficacy
   - Performance time
   - Onset
   - Duration
   - Local anesthetic requirement
   - Needle manipulation
   - Vascular puncture
   - Block related pain
   - Patient satisfaction

2. **Level III Grade B** evidence exists for **decreased incidence of neurologic injury with UGPNB**. This is likely due to the low complication rate associated with PNBs and the large number of patients necessary to resolve significant improvement with UGPNB.

3. Regardless of whether a clinical benefit can be demonstrated, popular preference and its obvious theoretical benefits will likely make US the new "gold standard" of peripheral nerve block.

Acknowledgements