Ultrasound Visibility of Needles Used for Regional Nerve Block: An In Vitro Study

Ingeborg Schafhalter-Zoppoth, M.D., Charles E. McCulloch, Ph.D., and
Andrew T. Gray, M.D., Ph.D.

Background and Objectives: Ultrasound visibility of regional block needles is a critical component for safety and success of regional anesthetic procedures. The aim of the study was to formally assess factors that influence ultrasound visibility of needles used in regional anesthesia.

Methods: Regional block needles between 17- and 22-G diameter were inserted in a tissue equivalent phantom at angles from 0° to 65° relative to the phantom surface. For visibility enhancement, the needles were primed with air or water in combination with stylets and different size guide wires. Ultrasound measurements of needle tips and shafts were performed using transversal and longitudinal imaging with a linear 15-MHz transducer. Univariate and multivariate statistical analyses were performed on 719 visibility measurements.

Results: Hustead tip needles exhibited best ultrasound visibility. Ultrasound visibility of the needle tip was increased by insertion of a medium size guide wire. Water or air priming of the needle, insulation, and the insertion of a stylet did not influence needle visibility. Long axis imaging of the needle for shallow insertion angles (<30° in relation to the phantom surface) and short-axis imaging for steep angles (>60°) provided the best ultrasound visibility of the needle tips. Needle visibility decreased linearly with steeper insertion angles ($P < .001$) and smaller needle diameters ($P < .001$).

Conclusions: The results of our in-vitro study suggest a number of factors enhancing ultrasound visibility of regional block needles. The use of needles in the largest possible size inserted with a medium-size guide wire provides the best ultrasound visibility. Analysis of the approach angle favors needle insertion parallel to the transducer. The consideration of these factors may improve safety and success of ultrasound-guided regional blocks. *Reg Anesth Pain Med 2004;29:480-488.*

Key Words: Needle visibility, Peripheral nerve block, Regional block needle, Ultrasound, Visibility enhancement.

Regional anesthesia is especially useful in high-risk surgical patients. Although successful in most patients, this technique often fails in patients with obesity or anatomic deformity. The steady increase in the number of obese people in the United States[1] makes this consideration of crucial importance to our current practice. Established methods for peripheral nerve blockade are techniques based on elicited paresthesia or nerve stimulation. Ultrasound-guided regional anesthesia has recently developed as a new technique[2-5] with potential advantages over these traditional approaches. Real-time visualization of the nerve may reduce the risk of needle-nerve contact and nerve injury. Needle placement can be performed without nerve stimulation–induced muscle contraction, which is especially advantageous in patients with injured extremities.

Ultrasound-guided interventions can be performed freehand or with needle guide.[6,7] The needle can be scanned in short axis (SAX; transverse cross-sectional, out-of-plane) and long axis (LAX; longitudinal, in-plane). With the increased use of in-plane techniques,[2,4,5] ultrasound visualization of the needle is of paramount importance. Limited

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From the Department of Anesthesia and Perioperative Care (I.S.-Z., A.T.G.) and Department of Epidemiology and Biostatistics (C.E.M.), University of California, San Francisco, San Francisco General Hospital, San Francisco, CA.

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Reprint requests: Andrew T. Gray, M.D., Ph.D., Department of Anesthesia and Perioperative Care, Room 3C-38, San Francisco General Hospital, University of California, San Francisco, CA 94110. E-mail: graya@anesthesia.ucsf.edu

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working room and, therefore, steep insertion angles of the block needle make visualization of the needle tip problematic, particularly within echo-rich tissues such as adipose tissue.[8]

A number of investigators have attempted to improve needle visibility with ultrasound. Reported methods include roughening the inner or outer surface of the needle with a sterile ampoule file or wire,[9] roughening the surface of an inserted stylet, coating the needle with Teflon (DuPont, Wilmington, DE) or polymer,[8] retracting the stylet a few millimeters from the tip, and fast in-and-out movement (jiggling) of the needle.[10] Roughening equipment used for regional block may promote nerve injury from the altered needle surface. Staccato movement of the needle may increase the risk of nerve impalement and puncture of vessels. Some studies have examined echogenicity of needles.[11-13] Their protocols differ from the present study in the choice of phantoms, needles, insertion angles, and assessed needle parts. Furthermore, they all studied needle visibility factors in isolation.

The purpose of this study is to perform a controlled assessment of factors that determine ultrasound visibility of equipment used for regional block. We compared regional block needles in vitro and systematically tested how their tip and shaft visibility varies with different insertion angles, needle gauges, tip designs, and needle insulation. These factors were studied over ranges relevant to clinical practice. We included insulated needles because of prior reports combining nerve stimulation and sonographic guidance.[3,6,14] We additionally tested whether insertion of guide wires improves needle visibility. This is the first controlled study of factors affecting ultrasound visibility of needles used in regional anesthesia.

Methods

Phantom

Because gelatin provides adequate ultrasound penetration and tissue simulation, we used gelatin phantoms as previously described.[15] Briefly, we mixed 630 mL saline, 40 g dry cornstarch, and 340 g gelatin (Knox Company, Parsippany, NJ), following the directions of the manufacturer. The phantoms were cast in rectangular form, so that needles could be inserted at different angles and depth relative to the phantom surface (Fig 1A). In between usage, phantoms were stored in an airtight container and refrigerated at 4°C.

Ultrasound Equipment

Imaging was performed with an Acuson Sequoia C256 ultrasound machine using a 15L8 transducer (both manufactured by Siemens Medical Solutions, Mountain View, CA). Musculoskeletal imaging presetting was used. A single focal zone was placed at 3 cm. No edge enhancement and no persistence were used to control image quality.

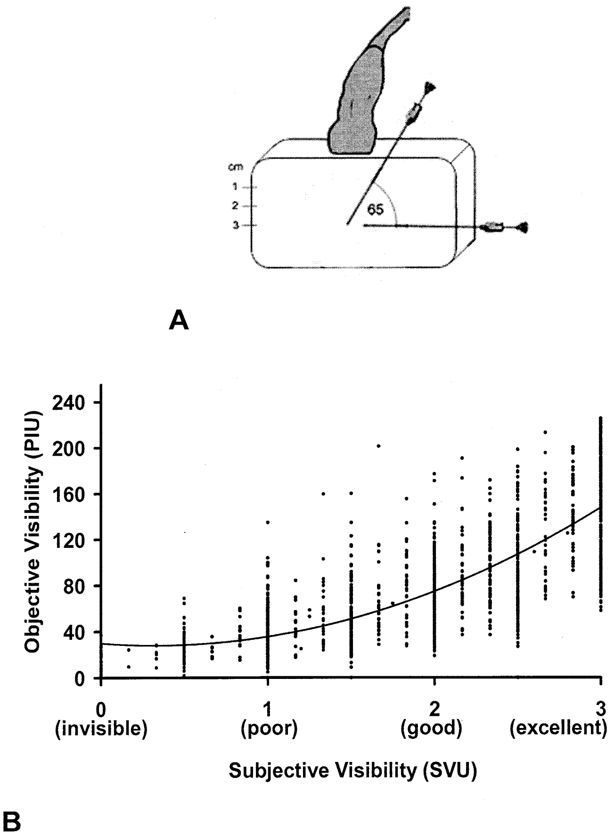

Fig 1. (A) Schematic drawing of the experimental setup. The needles were inserted with the needle tip placed 3 cm below the phantom surface, independent of the insertion angle. The insertion angle was measured in relation to the phantom surface (0° = parallel to the surface). (B) Correlation between objective and subjective visibility of regional block needles. The objective visibility ranges from 0 to 255 gray-scale values and the subjective visibility ranges from 0 (invisible) to 3 (excellent visibility). The best-fit polynomial curve is shown ($R^2 = 0.58$).

Needles

The following needles commonly used for regional anesthesia were tested: (1) 18-gauge Quincke (Becton Dickinson and Company, Franklin Lakes, NJ), (2) 22-gauge Quincke (Becton Dickinson), (3) 17-gauge Tuohy epidural needle (Arrow Epidural Catheterization Set, Arrow International, Inc., Reading, PA), (4) 18-gauge unipolar needle with Tuohy tip (Pajunk Plexolong Tuohy, Pajunk Medizintechnologie, Geisingen, Germany), (5) 20-gauge Tuohy epidural needle (B. Braun Medical

Inc., Bethlehem, PA), (6) 22-gauge Tuohy epidural needle (Braun), (7) 18-gauge Sprotte standard needle (Pajunk Medizintechnologie), (8) 20-gauge Sprotte standard needle (Pajunk Medizintechnologie), (9) 22-gauge Sprotte standard needle (Pajunk Medizintechnologie), (10) 22-gauge pencil-point insulated needle (Mercury Medical, Miami, FL), and (11) 22-gauge Stimuplex insulated needle (B. Braun), and (12) 18-gauge Hustead epidural needle (Braun Perifix Continuous Epidural Anesthesia Set). For each needle, we inserted the stylet of the manufacturer.

Guide Wires

To test enhancement in echogenicity, we inserted the following guide wires into the regional block needles (inches indicate wire diameter): (1) 0.018-in Angiodynamics Micro Access Guide wire Stainless Steel (Angiodynamics, Inc., Queensbury, NY), (2) 0.018-in Angiodynamics Micro Access Guide wire Stainless Steel with Platinum Tip, (3) 0.018-in Angiodynamics Micro Access Guide wire Nitinol with Platinum Tip (4) 0.015-in Cook Straight Wire Guide (Cook Inc., Bloomington, IN), (5) 0.018-in Cook Wire Guide, (6) 0.025-in Cook Wire Guide, (7) 0.028-in Cook Wire Guide, (8) 0.035-in Cook Wire Guide, (9) 0.038-in Cook Wire Guide, and (10) 0.035-in Braun Stainless Steel Spring Guide wire. All these wires fit through the 17-gauge and thin-wall 18-gauge needles, 0.015-in to 0.025-in wires fit through 20-gauge needles, and 0.015-in to 0.018-in wires fit through 22-gauge needles.

Study Protocols

Avoiding prior needle traces, needles were inserted into the phantom with the needle tip placed at 3 cm below the surface and needle insertion angles ranging from 0° to 65° relative to the phantom surface (Fig 1A). Needle bevels were oriented to face the transducer. The needles were either air-primed or backfilled with water using a flexible 28-gauge microfilling needle (World Precision Instruments, Inc., Sarasota, FL). For each needle placement, images were obtained in LAX (with transducer parallel to the needle so that the entire needle lies in the plane of imaging) and in SAX (with the transducer transverse to the needle so that the needle crosses the plane of imaging). In SAX, the measurements for needle tip and shaft were recorded separately. The SAX shaft image was recorded 1 cm proximal to the needle tip image. Manual manipulation of the transducer, phantom, and needle were used to produce the brightest possible image on visual inspection, as described before.[16] Needles placed separately were considered independent samples. The angle of placement was estimated in pulse wave Doppler mode.

Measurements

Ultrasound images were digitally recorded and transferred to a PC workstation. Angle estimation was verified with Photoshop (Version 6.0; Adobe Systems, San Jose, CA) before image evaluation. With Photoshop software, a region of interest was defined using the magic wand tool (tolerance 10-35, adapted to background measurements) and pixel intensity was measured (I.S.-Z.; visual inspection). Pixel intensity was defined as the gray-scale value between 0 (black) and 255 (white). The final objective visibility (pixel intensity units [PIUs]) was estimated as the difference in mean pixel intensity between the sample area and adjacent background. Subjective visibility (subjective visibility units, [SVUs]) was described on a scale from 0 to 3 (0 = invisible, 1 = poor, 2 = good, 3 = excellent) with scoring in 0.5 increments.[15-17] Averaged measurements were obtained from 3 recorded images of the same needle placement. In LAX, the needle shaft was defined as ultrasound signal of the parallel needle walls. The needle tip in LAX was considered as the angled shadow of the bevel. In SAX, the needle tip was defined as distal end of the needle. Shaft measurement in short axis was taken 1 cm above the tip measurement. Objective visibility <20 PIU and subjective visibility <0.5 SVU were considered as not visible. Objective visibility >120 PIU and subjective visibility >2.5 SVU were considered as perfectly visible. Objective visibility changed approximately 20 PIU for every 0.5 SVU increment in subjective visibility, and this change was regarded as significant.

Statistical Analysis and Validation of the Model

We used the Student *t* test and analysis of variance for continuous variables; the Mann-Whitney rank-sum test and the Kruskal-Wallis statistic were used for ordinal variables. For multivariate analysis, a multipredictor regression model was fit with JMP (Version 3.0.1; SAS Institute, Inc., Cary, NC) and Intercooled Stata (Version 7.0; Stata Corporation, College Station, TX), including 2-way interactions (annotated with underscore). The following factors were included: needle type (Hustead, Quincke, Tuohy, Pencil-point), insertion angle (0° to 65°), air/water primed, wire primed, needle diameter (17 to 22 gauge), needle insulation, view (LAX, SAX), and the following interaction terms: angle_view, insulation_view, air/water_view, and insulation_needle. Statistically nonsignificant terms were excluded by backward elimination. Statistical significance was regarded as $P < .05$. All reported P values are 2 sided. Continuous variables were described as means ± standard deviation unless otherwise stated.

Results

Objective and subjective visibility were well correlated ($R^2 = 0.58$, $P < .0001$) (Fig 1B).

Tip Shaft

The needle shaft was significantly better visible than the needle tip. When stratified by view, needle tip and needle shaft visibility were better correlated in LAX (objective visibility $R^2 = 0.89$, subjective visibility $R^2 = 0.66$, $P < .001$ for both) than in SAX (objective visibility $R^2 = 0.58$, subjective visibility $R^2 = 0.26$, $P < .001$ for both).

Needle

The Hustead needle tip showed better subjective visibility than the Tuohy and the pencil-point needle tip (2.1 ± 0.6 SVU vs 1.8 ± 0.8 SVU vs 1.5 ± 0.8 SVU; $P < .01$). The visibility of the Quincke tip was comparable to the Hustead needle (1.8 ± 0.7 SVU vs 2.1 ± 0.6 SVU; $P > .05$).

Needle Diameter

Needle tip and shaft of smaller outer diameter (20-G, 22-G) needles were less visible than those of larger outer diameter (17-gauge, 18-gauge) needles (Fig 2A). Between 17-gauge and 22-gauge needles, the difference in tip visibility was 0.4 SVU and 21 PIU; the difference in shaft visibility was 0.5 SVU and 25 PIU.

Insulation

Insulated needle tips were slightly more visible than noninsulated needles (2.0 ± 0.9 vs 1.7 ± 0.8 SVU, $P < .01$; 84 ± 45 vs 73 ± 45 PIU, $P < .05$), especially for higher angles (angle 45: 2.0 ± 0.8 vs 1.1 ± 0.6 SVU; 73 ± 38 vs 38 ± 20 PIU, $P < .001$).

Angle

Needle tip and shaft visibility decreased gradually with steeper angles (Fig 2B). Shaft visibility decreased more sharply than tip visibility (slope shaft = −1.4 vs slope tip = −0.7 for objective visibility). Needle tips were better visible in LAX when inserted at an angle <30° (2.4 ± 0.5 SVU vs 2.1 ± 0.7 SVU, $P < .001$; 121 ± 40 PIU vs 105 ± 40 PIU, $P < .01$). Needle tips were better visible in SAX when inserted at an angle >60° (1.8 ± 0.7 SVU vs 1.1 ± 0.6 SVU, $P < .001$; 61 ± 25 PIU vs 30 ± 17 PIU, $P < .001$).

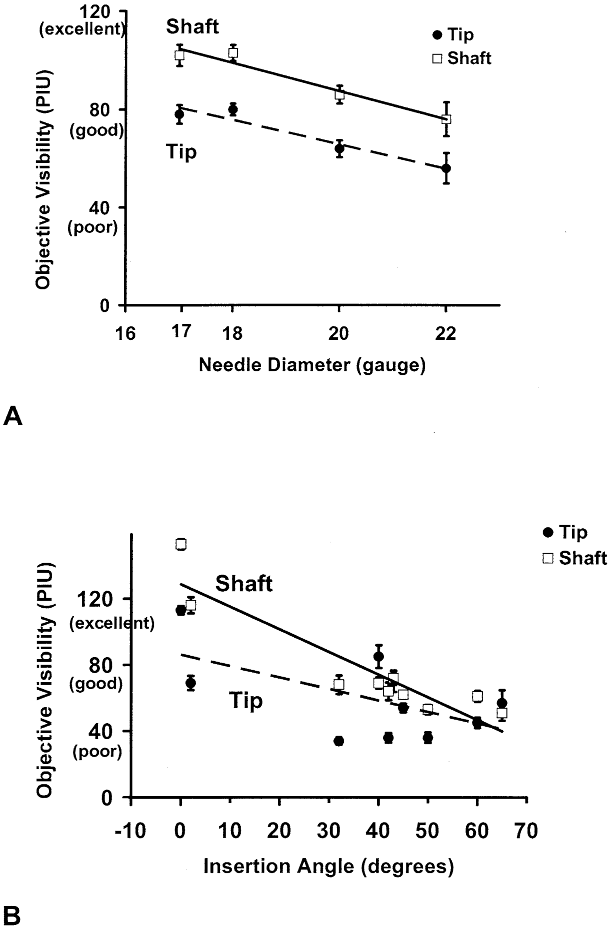

Fig 2. (A) Objective visibility decreases linearly in needles between 17-gauge and 22-gauge diameter. The best-fit linear regression lines are shown for shaft (hollow squares, solid line) and tip (solid circles, dashed line). The values are means ± standard error. (B) Objective needle visibility decreases with steeper insertion angles. The best linear fit is shown for needle tips (solid circles, dashed line) and shafts (hollow squares, solid line). The values are means ± standard error.

Air/Water Prime

Air or water priming did not change needle visibility.

Guide Wires

Insertion of guide wires enhanced the needle visibility significantly for both tip and shaft. Insertion of guide wires into water- or air-primed needles did not alter the visibility enhancement. Experiments with different-size guide wires of the same manufacturer showed better visibility for needles with guide wires smaller than the tightest-fitting size

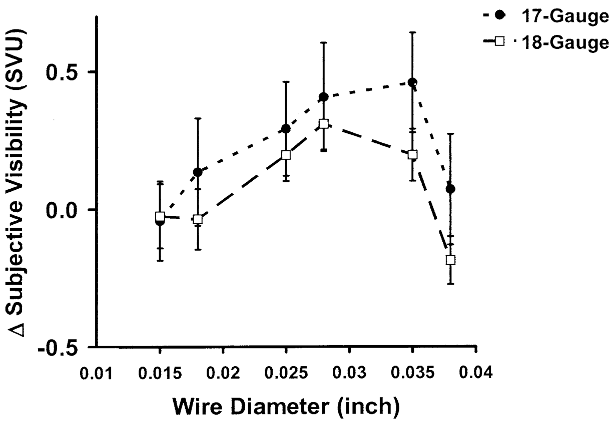

Fig 3. Subjective needle tip visibility changes with the size of the inserted guide wire ("camel hump" phenomenon) showed for 17-gauge (solid circles) and 18-gauge (hollow squares) needles. The Δ subjective visibility is the change of visibility from the baseline measurements (no guide wire). The values are means ± standard error.

guide wire ("camel hump" phenomenon) (Fig 3). Guide wire insertion attenuated the reverberation artifact of the needles.

Stylet

Stylet placement did not change needle tip visibility, neither in the overall assessment or when stratified by view.

View

Needle shafts were better visible in LAX than in SAX, as shown before,[15] especially in the steeper insertion angles. In LAX, steeper insertion angles attenuated the needle tip visibility more than in SAX (see earlier).

Discussion

General Results

We present new data on factors of ultrasound visibility of needles used in regional anesthesia (Tables 1 to 3). Univariate and multivariate analysis of our data show that, in a tissue-mimicking gelatin phantom, needle visibility depends on needle type, needle diameter, insertion angle, and guide wire insertion. Stylet insertion, water priming, and insulation did not indicate clinically significant difference of visibility compared with untreated needles.

Limitations of the Present Study

Our data derived from an in vitro model. There is no standard phantom model for needle visibility experiments.[12] Turkey breast closely resembles body tissue by providing a heterogeneous background of fat and muscles. To perform objective visibility measurements, turkey breast is not sufficiently homogeneous.[12] Furthermore, the fast decay requires multiple specimens and results in variability of the background, especially problematic for subjective visibility assessment. Therefore, we used a gelatin phantom, which gives a homogeneous background suitable for subjective and objective visibility measurements (Fig 4). For our analysis, we used static images at a fixed depth of insertion. We did not formally study other factors that contribute to dynamic visibility, such as ease of alignment and needle flexibility. We inserted the needle with the bevel facing the transducer to provide a larger acoustic surface, as reported before,[18] and did not include bevel orientation as a factor in our model. Not every needle was studied over the full range of diameters because of a lack of commercial availability. The present study was limited to only 1 ultrasound machine, linear array transducer, and set of image quality controls. Although image quality controls can alter overall needle visibility,[19] they are unlikely to change the results of comparisons of the present study.

Needle Type

The Tuohy and pencil-point needle tips show less echogenicity than the Hustead tip. Measurements in anechoic water baths suggest reverberation artifacts produced by Tuohy needles may be a disadvantage.[14] Our findings show these reverberations in all needle types we used. In the pencil-point needle, we did not observe the phenomenon of isotropic diffraction[20] previously described in amniocentesis needles with side ports. The advantage of the Hustead needle tip may derive from the special cut and angle of the bevel providing a better reflection of the ultrasound beam.

Needle Diameter

Factors important for the amount of visibility loss caused by needle size are reflection of the ultrasound beam and its alignment with the needle. Better reflection facilitates the alignment of large needles, especially in unskilled hands, resulting in better ultrasound visibility. Large needles are more rigid, whereas thin needles bend away from their desired paths because of tissue inhomogeneity and shaft deflection.[21,22] Although large needles might be potentially dangerous in blind procedures, their better visibility may eliminate this disadvantage in ultrasound-guided regional anesthetic techniques. Large needles are less comfortable for patients. However, higher safety and better block results may

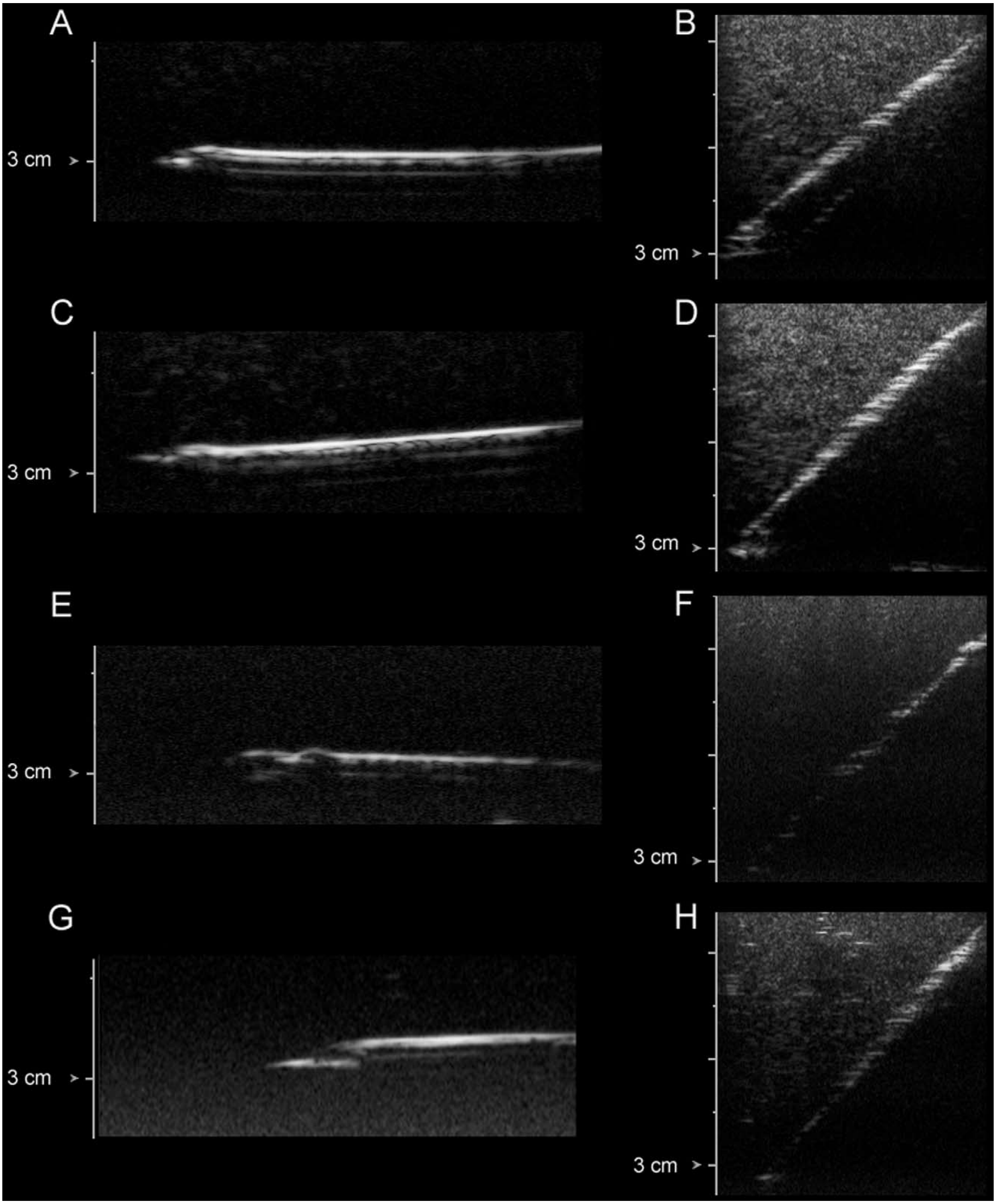

Fig 4. Ultrasound images of different needle types inserted in a gelatin phantom with varying insertion angles (0° and 45° relative to the phantom surface). (A) An 18-gauge Hustead Epidural needle at 0°, (B) 18-gauge Hustead Epidural needle at 45°, (C) 18-gauge UP-needle with Tuohy tip at 0°, (D) 18-gauge UP-needle with Tuohy tip at 45°, (E) 18-gauge Sprotte Standard needle (pencil-point) at 0°, (F) 18-gauge Sprotte Standard needle (pencil-point) at 45°, (G) 18-gauge spinal needle with Quincke tip at 0°, and (G) 18-gauge spinal needle with Quincke tip at 45°. The tips are placed 3 cm below the phantom surface, independent of the insertion angle. The echogenic shadow of the needle turns from a solid line (0°) into a discontinuous shadow (45°). Tickmarks are spaced 5 mm.

Table 1. Univariate and Multivariate Results of Important Factors for Ultrasound Visibility of Needles

	SV Tip		OV Tip		SV Shaft		OV Shaft	
	Univar *P*	Multivar *P*	Univar *P*	Multivar *P*	Univar *P*	Multivar *P*	Univar *P*	Multivar *P*
Needle type	<.001	<.01	NS	<.01	<.001	NS	<.05	<.01
Insertion angle	<.01	<.001	<.01	<.001	<.01	<.001	<.01	<.001
Air/water primed	NS	NS	NS	<.001	NS	NS	NS	<.01
Wire primed	<.01	<.001	<.01	<.001	<.01	NS	<.01	<.001
Needle diameter	<.01	<.01	<.01	NS	<.01	<.05	<.01	NS
Needle insulation	<.01	NS	<.01	<.01	NS	<.001	NS	<.001
View	NS	<.001	NS	<.001	NS	NS	<.02	NS

NOTE. Needle type, Hustead, Quincke, Tuohy, or Pencil-point tip; insertion angle was 0°-65°, view was long or short axis; and needle diameter was 17-, 18-, 20-, and 22-gauge.

SV, subjective visibility; OV, objective visibility; Univar, univariate; Multivar, multivariate; NS, not significant.

justify the use of larger needles with ultrasound guidance,[2] although clinical data so far are not available.

Insulation

Insulation did not detract from needle visibility. A comparison of ultrasound visibility of coated and uncoated biopsy needles during thyroid and liver biopsy showed a slightly better visibility of Teflon-coated needles compared with uncoated needles.[17] In our study, insulated needle tips provided a statistically better subjective visibility; these results were within clinically irrelevant sizes. The smooth surface of the Teflon coat seems to provide reflective quality similar to noninsulated needles. Coating material scanned in isolation (Teflon, polyvinyl, polyurethane) showed good to excellent ultrasound visibility.[16]

Air/Water Priming

Previous investigations have reported that injection of small amounts of air (0.3-0.5 mL) into tissue through a biopsy needle can be used to identify the location of the needle tip.[23] In the present study, priming the needle with water showed a trend for increased needle shaft and tip brightness. Tiny amounts of air trapped between the inner surface of the needle and the water may enhance the reflection of the ultrasound beam. Injection of small amounts of air in a wet or water-filled needle can create air-water foam with tiny air bubbles enhancing the needle signal. We observed this phenomenon in our study, but the effect was not consistently reproducible.

Guide Wire Insertion

We showed a dependence of needle visibility on guide wire size and needle size. An acoustic interface between the inner needle surface and the guide wire, resulting in an enhanced reflection of the sound beam, may cause better needle visibility. A tightly fit wire eliminates this acoustic interface and leaves needle visibility unchanged. Prior studies have used guide wires to improve the ultrasound visibility of needles.[16,24] Some investigators speculated that this echogenicity may be related to the spiral windings of the guide wire.[16] A more formal study suggested that spatially modulated wires reflect sound waves into a broad range of angles and are therefore much easier to align with the acoustic beam.[24]

Stylet Insertion

We did not see improved needle visibility when we inserted stylets into needles, contrary to the study of Bondestam.[25] Similar to our guide wire results, the tightly fit stylets did not form any substantial acoustic interface, leaving the ultrasound signal unaffected.

Plane of View

In our study, the plane of image did not affect needle visibility, except when stratified by angle. Needle tips are better visible in LAX at shallow angles but better visible in SAX when inserted in a steep angle. This may be caused by a longer path of the needle tip within the slice plane of the ultrasound beam and/or a different acoustic pattern because of the bevel cut and the bevel angle in steeper angles. The significant interaction between angle and view in the multivariate model confirms this relationship. In a heterogeneous background of soft tissue, the discrimination of the needle signal in SAX from similar dotlike structures can be difficult. However, some practitioners prefer inserting the needle in SAX view (out of plane).[4] They primarily use tissue movement as a surrogate marker to locate the advancing needle.

Table 2. Ultrasound Visibility Characteristics of 719 Regional Needle Needles Measurements

	Tip Subjective Visibility (0-3)	Tip Objective Visibility (0-255)	Shaft Subjective Visibility (1-3)	Shaft Objective Visibility (0-255)
Needle type (n = 719)				
Hustead (n = 120)	2.1 ± 0.6	83 ± 43	2.5 ± 0.5	112 ± 57
Tuohy (n = 385)	1.8 ± 0.9	75 ± 46	2.3 ± 0.7	96 ± 59
Pencil-point (n = 138)	1.5 ± 0.8	74 ± 46	2.0 ± 0.8	96 ± 56
Quincke (n = 76)	1.8 ± 0.7	65 ± 49	2.3 ± 0.6	93 ± 63
Needle diameter (n = 719)				
17-gauge (n = 176)	1.8 ± 0.8	77 ± 50	2.4 ± 0.7	102 ± 57
18-gauge (n = 384)	1.9 ± 0.8	80 ± 46	2.3 ± 0.7	103 ± 63
20-gauge (n = 94)	1.6 ± 0.7	64 ± 33	2.2 ± 0.5	86 ± 35
22-gauge (n = 65)	1.4 ± 0.9	56 ± 50	1.9 ± 0.8	77 ± 56
Insertion angle (n = 719)				
0-30° (n = 298)	2.2 ± 0.7	109 ± 42	2.7 ± 0.4	149 ± 5.0
30-60° (n = 327)	1.5 ± 0.8	52 ± 34	2.0 ± 0.7	64 ± 32
>60° (n = 94)	1.5 ± 1.7	48 ± 30	1.9 ± 0.8	58 ± 27
View (n = 719)				
Long axis (n = 360)	1.8 ± 0.8	73 ± 50	2.3 ± 0.6	93 ± 59
Short axis (n = 359)	1.8 ± 0.8	78 ± 47	2.2 ± 0.8	104 ± 5.9
Air/water primed (n = 719)				
Water (n = 403)	1.8 ± 0.8	79 ± 46	2.2 ± 0.8	101 ± 62
Air (n = 316)	1.7 ± 0.8	72 ± 46	2.3 ± 0.7	97 ± 56
Wire primed (n = 719)				
Plain (n = 136)	1.7 ± 0.8	69 ± 44	2.2 ± 0.7	95 ± 56
Stylet (n = 77)	1.6 ± 0.8	69 ± 48	2.1 ± 0.7	88 ± 55
Wires				
AngioDynamics 0.018-inch nitinol/platinum tip (n = 20)	1.8 ± 0.8	63 ± 25	2.3 ± 0.9	84 ± 38
AngioDynamics 0.018-inch stainless steel (n = 20)	1.5 ± 0.8	64 ± 29	2.3 ± 0.9	77 ± 38
AngioDynamics 0.018-inch steel/platinum tip (n = 22)	1.7 ± 0.6	55 ± 29	2.3 ± 0.9	83 ± 36
Braun 0.035 inch (n = 22)	1.8 ± 0.6	57 ± 21	2.5 ± 0.5	84 ± 31
Cook 0.015 inch (n = 102)	1.7 ± 0.8	71 ± 47	2.2 ± 0.8	96 ± 61
Cook 0.018 inch (n = 90)	1.7 ± 0.8	73 ± 47	2.2 ± 0.7	99 ± 61
Cook 0.025 inch (n = 76)	1.9 ± 0.8	81 ± 49	2.4 ± 0.6	106 ± 61
Cook 0.028 inch (n = 64)	2.2 ± 0.8	92 ± 52	2.4 ± 0.6	109 ± 64
Cook 0.035 inch (n = 52)	2.1 ± 0.8	90 ± 51	2.4 ± 0.7	113 ± 66
Cook 0.038 inch (n = 38)	1.9 ± 0.7	101 ± 48	2.4 ± 0.7	124 ± 66
Needle insulation (n = 719)				
Yes (n = 134)	2.0 ± 0.8	84 ± 53	2.3 ± 0.7	98 ± 68
No (n = 585)	1.7 ± 0.8	73 ± 47	2.3 ± 0.7	99 ± 56

Perspective

Conventional ultrasound imaging of needle produces reflections that angle away from the probe, relative to the insertion angle. New ultrasound devices can steer the ultrasound beam perpendicular to the needle, thus increasing the reflection that return to the probe (received echo) and enhancing needle visibility at steep insertion angles.[26]

Conclusions and Summary

Optimal needle visibility is important for precision and safety in ultrasound-assisted regional an-

Table 3. Univariate and Multivariate Results of Ultrasound Visibility of Different Needle Tips

	SV Tip				PI Tip			
	Univariate	*P*	Multivariate	*P*	Univariate	*P*	Multivariate	*P*
Needle		<.001		<.01		NS		.01
Hustead	2.1 ± 0.6	<.01	2.1	<.001	83 ± 43	NS	85	<.01
Quincke	1.8 ± 0.7	NS	2.0	<.01	65 ± 40	NS	82	NS
PP	1.5 ± 0.8	<.01	1.7	NS	74 ± 46	NS	82	NS
Tuohy	1.8 ± 0.8		1.8		75 ± 49		75	

NOTE. *P* values of the different needle types in reference to the standard Tuohy needle are shown. The value of the multivariate results are anchored at the univariate value of the Tuohy needle (1.8 SVU).

Abbreviations: SV, subjective visibility; PI, pixel intensity; PP, pencil-point; NS, not significant.

esthesia. Our in vitro study identified and quantified a number of needle- and ultrasound-specific factors that alter needle visibility. Their consideration may be beneficial when performing peripheral nerve blocks. However, the operator's skill in aligning the ultrasound probe and block needle is probably the most important variable influencing needle visibility. Needles and ultrasound devices that enhance the received needle echoes will markedly facilitate ultrasound-guided regional anesthesia in the future.

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