Influence of Whitacre spinal needle orifice direction on the level of sensory blockade

FRANKLIN J. McSHANE, CRNA, MSN
Berlin, Wisconsin
CPT NELSON BURGOS, CRNA, MSN, AN, USA
Fort Polk, Louisiana
CPT MICHAEL KAPP, CRNA, MSN, AN, USA
Fort Bragg, North Carolina
CHRISTINE WIECZOREK, CRNA, MSN
Lawton, Oklahoma

The purposes of the present study were to determine if the direction of the needle orifice during injection of anesthetic into the subarachnoid space, using a 25-gauge Whitacre spinal needle (Becton Dickinson, Franklin Lakes, NJ) to deliver 15 mg of 0.75% hyperbaric bupivacaine, affected the level of sensory blockade achieved, and if there was a difference in time from injection to surgical anesthesia based on needle orifice direction.

A convenience sample was selected from patients presenting for elective surgical procedures. All patients received a standard anesthetic solution using a standard technique and duration of injection. Mean maximum height of sensory blockade was compared between treatment groups using a Student t test. Progression of the sensory blockade was compared at each data collection point using a chi-square test.

There was no statistically significant difference in the mean maximum height of block between the treatment groups. The mean maximum height of block for the cephalad group was T4 with an SD of 2.5 dermatomes, and T5 with an SD of 4.57 dermatomes for the caudad group. An incidental finding was that all failed blocks were from the caudad group. There was no statistically significant difference in time from injection to surgical anesthesia between the treatment groups.

Although the data support no statistically significant difference between the treatment groups for either research question, the cephalad group provides for a more precise height of block.

Key words: Regional anesthesia, spinal anesthesia, spinal needle, Whitacre spinal needle.

Introduction
It is important to understand the differences in design between standard spinal needles and the Whitacre spinal needle (Becton Dickinson, Franklin Lakes, NJ). In standard spinal needles, the lumen lies along the same axis as the shaft of the needle (Figure 1). Injection of fluid through the needle results in flow along the same axis as the needle regardless of the direction of the bevel. In contrast, pencil point needles such as the Whitacre and the Sprotte (Havel’s Inc., Cincinnati, Ohio) have an injection orifice that lies perpendicular to the axis of the needle shaft (see Figure 1). This design should influence the direction that fluid travels as it is injected through the needle. It may be possible to direct the flow of anesthetic solution using the Whitacre spinal needle, and therefore the clinician may directly influence and manipulate the height of block achieved. If the needle orifice is in a cephalad orientation during injection of an anesthetic, the resultant distribution of that anesthetic may be higher than if the needle orifice is in a caudad orientation.

The purposes of the present study were to determine if the direction of the needle orifice during injection of anesthetic into the subarachnoid space, using a 25-gauge Whitacre spinal nee-
dle, affected the level of sensory blockade achieved, and if the time required for the block to progress to surgical anesthesia differed when the anesthetic was injected with the needle in a cephalad vs a caudad orientation. These results could provide clinically important information enabling the anesthetist to more accurately predict the rate of progression and the final height of block expected using hyperbaric 0.75% bupivacaine. This knowledge would give the practitioner a mechanism to help plan for the potential effects of inadequate or excessive height of block.

Although injecting local anesthetic with the needle orifice in the cephalad direction is a common clinical practice, it is based on 1 clinical study performed by Neigh et al in 1970. Recently, Urmey et al also examined the effect of orifice direction using a Whitacre spinal needle, supposing that if the Whitacre spinal needle orifice were in the cephalad orientation during injection of the anesthetic into the subarachnoid space, the level of sensory blockade would be higher than if the needle is in the caudad orientation.

One difficulty in studying the effect of orifice direction on level of sensory blockade is that so many other factors can influence the level of sensory blockade. Greene identified 25 factors that influence the distribution of local anesthetics within the subarachnoid space. The factors are grouped together as: patient characteristics, technique of injection, diffusion, characteristics of the cerebrospinal fluid, and characteristics of the local anesthetic solution. Not all of these factors are of clinical importance, and although some may seem legitimate, not all have been substantiated by clinical studies. Numerous clinical studies address the majority of these factors, yet, only 1 study prior to our data collection (Neigh et al) examines the Whitacre spinal needle and its influence on the level of sensory blockade.

Twenty-one of Greene’s 25 factors were thought to be clinically important variables influencing the distribution of anesthetics within the subarachnoid space (Figure 2). To isolate the influence of 1 factor, all other factors (confounding variables) had to be controlled. Because of the multiplicity of influence from these factors, the methodology for the present study was extremely important.

The Neigh et al study’s inclusion criteria for selection of the sample were: (a) lack of increased intra-abdominal pressure, and (b) a predicted ability to tolerate possible high sensory levels. However, these liberal inclusion criteria do not take into account many patient characteristics that affect local anesthetic spread in the subarachnoid space. The researchers also did not use standardized data collection points. The data collection points for the individual subjects ranged from 10 minutes to 14 minutes. All of the data were treated similarly for data analysis, yet the patients were at different points along their dose-response curves. Additionally, literature identifies that maximum levels of a subarachnoid block using hyperbaric 0.75% bupivacaine may not occur for 15 to 20 minutes, but data collection ended from 10 to 14 minutes after injection.

Methods

A convenience sample of patients presenting for elective surgical procedures was selected. Inclusion criteria consisted of: ASA physical status I or II, nonemergency procedures, age between 18 years and 50 years, height between 5 feet 4 inches and 6 feet 2 inches, a surgical procedure in which the incision would not extend higher than the T-10 dermatome, and a procedure in which a spinal anesthetic was appropriate and agreed to by the patient, surgeon, and nurse anesthetist. Exclusion criteria included emergency procedures, age less than 18 years or more than 50 years, obesity (body weight more than 40% over ideal), major systemic disease, pregnancy, abnormal deviations of the spinal column, and inability to sit for the subarachnoid block. In addition, any patients who increased their intra-abdominal pressure (ie, performed a
Valsalva maneuver) within the first 20 minutes after injection were removed from the study.

The present study was approved by the Clinical Investigations Committee and the Institutional Review Board at Brooke Army Medical Center, San Antonio, Tex, and the University of Texas Houston Health Science Center’s Committee for the Protection of Human Subjects. Informed consent was obtained from patients during the preoperative interview. Patients were identified by assigned study code numbers to ensure confidentiality.

The sample consisted of 52 patients, randomly assigned based on a random number table into 2 treatment groups. Two patients were dropped from data analysis because of failure to meet final inclusion criteria. The final sample consisted of 50 patients, 26 in the cephalad treatment group and 24 in the caudad treatment group.

A data collection tool was used to gather the following information on each patient: hospital number, age, gender, height, weight, ASA physical status, type of surgery, needle orifice direction, and dermatome level at set time intervals. Data collection occurred in the operating room, with the patient on the surgical table before and during the surgical procedure.

All investigators used a standardized technique for the placement of the subarachnoid block. The subarachnoid block was administered at the L3-4 interspace with the patient in the sitting position. All patients received the standard anesthetic solution of 15 mg of 0.75% hyperbaric bupivacaine using a standard injection duration. The patient was then positioned supine on a flat operating table within 15 seconds, and this position was maintained for the 20-minute data collection period.

Because all investigators used the same procedure for performing the subarachnoid block, the effects of variations between clinicians was controlled. The same type of spinal anesthesia kit (Baxter, Deerfield, Ill) was used for all procedures. Every patient received 15 mg (2 mL) of 0.75% bupivacaine. These efforts controlled the confounding effects of volume, dose, and baricity of the local anesthetic solution.

After anesthetic administration, the height of anesthesia (level of the block) was assessed by using the pinprick method and asking the patient to identify sensory changes to needle stimulation. Sensory loss was assessed in the anterior axillary line. When the patient sensed a change in the quality of the sensation (from dull to sharp) from the touch of an 18-gauge needle, this point was considered the height of the block. A dermatome chart was then used to determine the height based on anatomic location.
Two independent (blinded) observers assessed the level of sensory changes at 1, 5, 10, and 20 minutes after injection of the bupivacaine solution. Interrater reliability was established between the independent observers at 0.90.

**Results**

Descriptive statistics were calculated for all data and are described in Table 1. A Student \( t \) test was performed to analyze the group differences with respect to the level of sensory blockade. Chi-square was used to determine if a difference existed between the levels of sensory blockade at the different time points during data collection.

Study findings demonstrated that the direction of the needle orifice during injection of anesthetic into the subarachnoid space, using a 25-gauge Whitacre spinal needle, had no effect on the level of sensory blockade achieved. The mean level of sensory blockade for the sample was the T5 dermatome (SD 3.67 dermatomes; median T4) (Figure 3). The mean level of sensory blockade for the cephalad treatment group was the T4 dermatome (SD 2.5 dermatomes; median T4) (see Figure 3). The mean level of sensory blockade for the caudad treatment group was the T5 dermatome (SD 4.57 dermatomes; median T4 dermatome). A 2-tailed \( t \) test was performed at a .05 level of significance. The \( t \) value for the difference in means was \( t(48) = -1.32 \), with a value of \( P = .19 \). Therefore, the data suggested no evidence that needle orifice direction influenced the level of sensory blockade achieved.

It is important to note that the 4 blocks that were inadequate for the surgical procedure were all in the caudad treatment group, representing a failure rate for the caudad treatment group of 16.67\% (4 out of 24). The block failures led to a failure rate for the sample of 8\% (4 out of 50).

Needle orifice direction did not account for a difference in time of progression to surgical anesthesia (Table 2). It is interesting to note that at 5 minutes the majority of blocks were adequate (74\%; \( n = 37 \)) for the surgical procedure, in other words, the surgical procedure could have begun. The blocks of 81\% (\( n = 21 \)) of patients in the cephalad group and 67\% (\( n = 16 \)) of patients in the caudad group were adequate for the surgical procedure. Table 2 states the results at each data collection point.

At 20 minutes, most of the remaining blocks were adequate (90\%, \( n = 45 \), of overall sample) for the surgical procedure. In the cephalad group, 96\% (\( n = 25 \)) of blocks were adequate for the surgical anesthesia based on the study definition. Although all the blocks in the cephalad group were adequate for the surgical procedure, 1 block was lower than the T8 dermatome, which was the arbitrary definition of surgical anesthesia for our study. In the caudad group, 83\% (\( n = 20 \)) of blocks were adequate for the surgical procedure.

**Discussion**

The results demonstrated no significant difference in level of sensory blockade achieved based on Whitacre spinal needle orifice direction. However, the cephalad group displayed more precise distribution of sensory blockade around the mean, whereas the caudad group displayed a wider distribution around the mean. While these data provided no evidence that needle orifice direction influenced the level of sensory blockade achieved, the level of sensory blockade achieved may be more clinically precise when using the cephalad orientation. The ability to be more precise in predicting the level of sensory blockade supports the routine use of the cephalad orientation during injection.

The results of the present study differ from the results of Neigh et al.\(^1\) and Urmey et al.\(^2\) The methodology of Neigh et al.\(^1\) has been previously reviewed. Urmey et al.\(^2\) reported that the level of sensory blockade is significantly higher (\( P < .001 \)) with the needle orifice in the cephalad direction vs the caudad direction. Several differences in methodology between the study by Urmey et al.\(^2\) and the present study deserve attention. The anesthetic solution used in the study by Urmey et al was 2\% isobaric lidocaine. Isobaric lidocaine (2\%) has significantly different pharmacodynamic parameters when compared with 0.75\% hyperbaric bupivacaine. Chambers et al.\(^15\) reported that the behavior of hyperbaric solutions was quite different from plain (isobaric) solutions. Therefore, it is difficult to compare the anesthetic solutions.

Two additional methodological differences were patient position and the needle itself. Patient position has been shown to be an important variable in the distribution of local anesthetics within the subarachnoid space.\(^7\)\(^8\) It would be difficult to compare the data described in Urmey et al.\(^2\) with the data described in the present study because the patients’ position (right lateral decubitus in Urmey et al.\(^2\) and sitting in the present study) during and after injection was different between the 2 studies. Urmey et al.\(^2\) used a 27-gauge Whitacre spinal needle vs the 25-gauge needle used in the present study. The implication of the smaller needle size is evident in the difference in the mean duration of injection of 20 seconds, compared with the present study, in which injection
occurred over 5 seconds, and subsequent patient positioning (sitting to supine) was accomplished within 15 seconds from completion of injection (for a total of 20 seconds).

Progression of the sensory blockade was assessed at 1, 5, 10, and 20 minutes. A chi-square test was performed at each data collection point. The chi-square test was chosen for several reasons. While it would seem appropriate to use an analysis of variance, the data collection points did not provide for an adequate depiction of the time course of the progression of block. Data points important for parametric statistical analysis were missing. Therefore, data were converted to categorical variables to facilitate analysis.

Although there was no statistically significant difference in the amount of time required for progression to surgical anesthesia between the 2 treatment groups, it is interesting to note that progression of sensory blockade in the present study matches the progression of sensory blockade in the study by Kalso et al, which reported a time of maximum spread of anesthetic of 14 to 16 minutes. When compared with the findings described by Kalso et al, 88% (n=44) of the blocks in the present study were adequate for the procedure at 10 minutes, and all blocks that did not fail were adequate at 20 minutes.

There was no significant influence on the level of sensory blockade when age and height were used as covariants. However, the patients’ weight was found to have a significant influence on the level of sensory blockade (P<.01). Based on the literature review, patient characteristics of age, height, weight, gender, and anatomical configuration

Table 1. Demographics of the sample

<table>
<thead>
<tr>
<th>Needle direction</th>
<th>Age (y)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>ASA physical status</th>
<th>Surgical procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cephalad n=26</td>
<td>Mean:  30.08</td>
<td>Mean: 178.67</td>
<td>Mean: 81.75</td>
<td>I = 15 (63%)</td>
<td>Orthopedic: 15 (63%) General surgery: 3 (12%) Urology: 6 (25%)</td>
</tr>
<tr>
<td></td>
<td>SD: 8.32</td>
<td>SD: 6.64</td>
<td>SD: 10.89</td>
<td>II = 9 (37%)</td>
<td></td>
</tr>
<tr>
<td>Caudal n=24</td>
<td>Mean:  30.85</td>
<td>Mean: 178.42</td>
<td>Mean: 83.11</td>
<td>I = 15 (58%)</td>
<td>11 (42%)</td>
</tr>
<tr>
<td></td>
<td>SD: 8.08</td>
<td>SD: 6.91</td>
<td>SD: 11.03</td>
<td>II = 11 (42%)</td>
<td>7 (27%)</td>
</tr>
</tbody>
</table>

Table 2. Progression of sensory blockade

<table>
<thead>
<tr>
<th>Needle orifice direction</th>
<th>Level of sensory blockade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 minute*</td>
</tr>
<tr>
<td>Cephalad n=26</td>
<td>T12</td>
</tr>
<tr>
<td>Caudal n=24</td>
<td>T12</td>
</tr>
</tbody>
</table>

* Not statistically or clinically significant

Figure 3. Mean levels of sensory blockade based on treatment group
tion of the spine were identified as potentially significant confounding variables. Although patient characteristics are the most variable category and permit the least control, strict sample inclusion criteria were used to provide as much control as possible. Restrictive inclusion criteria were required to control the confounding variables. While strengthening the methodology, the inclusion criteria limit generalization of the findings.

Of 3 studies in the literature that addressed the influence of the spinal needle on the level of sensory blockade, only Stienstra provided sufficient data to calculate population effect size. These data yielded a large population effect size and were used in the power analysis for sample size. It is important to understand that mathematically, these data yielded a large effect size, but clinically, the data do not meet the definition of a large effect size. Clearly our data meet the definition of the medium effect size, which represents an effect likely to be visible to the naked eye of a careful observer. Because differences in dermatomal levels of sensory blockade are visible to the careful observer, the medium effect size may be a more appropriate measure. If the present study is replicated, we suggest using a medium population effect size for the power analysis.

In light of the results, it seems prudent to use the cephalad orientation when using the Whitacre spinal needle for performing subarachnoid blocks. Cephalad orientation also permits the practitioner to predict the final level of sensory blockade achieved with more precision. This orientation also may decrease the risk of failed blocks.

The findings of the present research contrast with both of the previous studies investigating the effect of Whitacre spinal needle orifice direction on the level of sensory blockade. Because of the differences in the design of the studies, it is difficult to compare them. Therefore, it is important that more research into the effects of these factors on the level of sensory blockade be performed. The paucity of current literature on these factors is evidence of the need for further research.

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AUTHORS

Franklin J. McShane, CRNA, MSN, is a member of CHN Anesthesia Services, Berlin, Wis.
CPT Nelson Burgos, CRNA, MSN, AN, USA, is a staff nurse anesthetist at Bayne-Jones Army Community Hospital, Fort Polk, La.
CPT Michael Kapp, CRNA, MSN, AN, USA, is a staff nurse anesthetist at Womack Army Community Hospital, Fort Bragg, NC.
Christine Wiecezorek, CRNA, MSN, is a staff nurse anesthetist at Comanche County Memorial Hospital, Lawton, Okla.

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