Clinical Efficacy of an Ultrasound-Guided Greater Occipital Nerve Block at the Level of C2

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Background and Objectives: The purpose of this prospective open-label study was to investigate the analgesic effects of an ultrasound-guided greater occipital nerve (GON) block at the level of C2, as the nerve courses superficially to the obliquus capitis inferior muscle.

Methods: Patients with a diagnosis of occipital neuralgia or cervicogenic headache were recruited for the study. Ultrasound-guided GON blocks at the level of C2 were performed by experienced clinicians according to a standardized protocol. Numeric rating scale pain scores were recorded preinjection and at 30 minutes, 2 weeks, and 4 weeks after injection.

Results: A total of 14 injections were performed with a mean procedure time of 3.75 minutes. Anesthesia in the GON distribution was achieved for 86% of patients at 30 minutes postinjection. Compared with baseline, numeric rating scale scores decreased by a mean of 3.78 at 30 minutes (P < 0.001), 2.64 at 2 weeks (P = 0.006), and 2.21 at 4 weeks (P = 0.01). There were no significant adverse events reported during the study period.

Conclusions: This prospective open-label study demonstrated successful blockade of the GON at the level of C2 using a novel ultrasound-guided technique. Significant reductions in pain scores were observed over the 4-week study period, and no adverse events were reported. The observations from this study provide important preliminary data for future randomized trials involving patients with occipital neuralgia and cervicogenic headache.

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The greater occipital nerve (GON) has been implicated in several conditions that prompt referral to pain medicine specialists, including occipital neuralgia and cervicogenic headache. The GON originates from the medial branch of the dorsal ramus of the C2 spinal nerve with variable contribution from the C3 dorsal ramus. After emerging from the suboccipital triangle, the nerve courses cephalad in an oblique trajectory between the semispinalis capitis (SC) and obliquus capitis inferior (OCI) muscles.1,3 This area has been recognized as a potential location for GON injury and entrapment.4,5 The nerve then passes through the trapezius muscle and courses medial to the occipital artery as it ascends to innervate the posterior scalp.1–3

According to the International Headache Society (IHS), a local anesthetic block of the GON can aid in the diagnosis and treatment of occipital neuralgia.9 Moreover, GON blocks have shown efficacy in the diagnosis and treatment of cervicogenic headache.7–9 Many practitioners perform GON injections using a conventional approach, relying solely on superficial bone-based anatomic landmarks to infiltrate local anesthetic and corticosteroid around the nerve at the level of the superior nuchal line. Some clinicians also use fluoroscopy to confirm the location of bony landmarks.7 The ambiguity of these injections poses a risk of anesthetizing adjacent structures or injecting into vessels, such as the occipital artery.7 Very limited research has been done to quantify the risk of these injections, but a complication rate of 5% to 10% has been reported, including headache, dizziness, blurred vision, and syncope.10,11 Ultrasound guidance is increasingly used to mitigate these risks and improve the efficacy of GON injections. Multiple studies have demonstrated successful ultrasound-guided GON blockade at the superior nuchal line and improvement in pain scores compared with nonguided injections.12–14 A cadaveric study by Greher et al3 described a proximal approach at the level of C2, targeting the GON superficial to the OCI muscle. The observations from this study demonstrated a higher success rate of injectate around the GON at the novel site compared with the classic site using ultrasound guidance. Therefore, the primary aim of this prospective open-label study was to investigate the change in pain intensity from baseline to week 4 following an ultrasound-guided GON block at the level of C2 as the nerve courses superficially to the OCI muscle in patients with cervicogenic headache or occipital neuralgia. Secondary aims included investigating (1) the immediate effects of the GON block on pain intensity 30 minutes postprocedure compared with baseline, (2) the change in pain intensity from baseline to week 2 postprocedure, and (3) the occurrence of adverse events.

Methods

Participants and Setting

The study was approved by the Mayo Foundation Institutional Review Board, and written informed consent was obtained from all study participants. All potential subjects were referred to the Mayo Pain Clinic in Rochester, Minnesota, for a therapeutic GON injection. Inclusion criteria included (1) unilateral headache symptoms attributed to occipital neuralgia or cervicogenic headache as defined by IHS's International Classification of Headache Disorders (second edition)15 and (2) age 18 years or older (no upper age limit defined). Exclusion criteria included (1) bilateral occipital neuralgia or cervicogenic headache symptoms; (2) history of cervical spine surgery, trauma, or surgical procedure involving the head or neck during the last year; (3) use of new analgesic medications within 24 hours prior to study enrollment; (4) evidence of impaired sensation in the GON dermatome region (posterior scalp to the vertex of the cranium) from neurological, dermatological, or other disease process; (5) evidence of cranial defect or other anatomical abnormality near the target injection site; (6) history of bleeding diathesis, coagulopathy, or current use of anticoagulant medications; (7) pregnancy; (8) history of adverse reaction or allergy to local anesthetic agents or corticosteroids; and (9) occipital nerve block within the past 3 months.

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Injection Technique

Subjects were placed in the prone position with head and neck flexed to compensate for normal lordosis of the cervical spine. The external occipital protuberance (EOP) was identified and palpated on each patient. The ultrasound transducer (Phillips CX-50 ultrasound machine, 6–12 MHz high-resolution linear transducer; Philips North America, Andover, Massachusetts) was initially placed in the transverse orientation at midline to identify the EOP (Figs. 1 and 2). The transducer was moved caudally over the location of C1 to locate the C2 spinous process as identified by its bifid appearance. Once C2 was properly identified, the transducer was moved laterally with the lateral edge of the transducer aimed at the transverse process of C1 to identify the OCI muscle. The GON was identified lying superficial to the OCI, traversing the muscle caudal to rostral and lateral to medial. Prior to

FIGURE 1. The illustration on the left depicts relevant cervical anatomy. The 2 images on the right outline proper ultrasound probe positioning for a GON block at the level of C2. 1. Axial over EOP; 2. axial over C2 spinous process; 3. oblique in-plane with OCI muscle.

FIGURE 2. Ultrasound images and corresponding illustrations depicting relevant anatomy over the EOP (A, B), bifid C2 spinous process (C, D), and OCI muscle (E, F).
needle placement, the presence or absence of vascular structures as measured with Doppler ultrasound was recorded. The needle was advanced in-plane with the transducer from medial to lateral under direct ultrasound visualization until the tip was visualized in the fascial plane between the OCI and SC (Fig. 3). A 25-gauge, 2-inch spinal needle was used for all injections. A total of 4 mL consisting of 1 mL of 2% lidocaine, 2.5 mL of 0.25% bupivacaine, and 3 mg of betamethasone was injected. The spread of injectate was visualized as it encompassed the GON between the 2 muscles.

Assessments

Demographic and Clinical Characteristics

Demographic information was collected from each patient, including age, race, sex, height, weight, and body mass index (BMI). Information was also collected regarding the laterality of symptoms, duration of symptoms, and use of analgesic medications.

Determination of Successful GON Block

Thirty minutes following the injection, each patient was examined by a physician not directly involved in the study protocol. A successful block was defined as the absence of light-touch sensation in the dermatome of the GON.

Pain Intensity

Pain intensity was assessed preinjection, 30 minutes postinjection, 2 weeks postinjection, and 4 weeks postinjection using a numeric rating scale (NRS) marked from 0 to 10 with fixed intervals. The preinjection and 30-minute postinjection pain ratings were obtained in the pain clinic. The 2- and 4-week follow-up pain ratings were obtained by telephone.

Adverse Events

At all follow-up time points after the GON block, we inquired about the occurrence of adverse events via telephone. Symptoms
addressed included dizziness, blurred vision, slurred speech, lightheadedness, paresthesias, seizure activity, and headache.

**Statistical Plan**

**Sample Size Calculation**

Based on prior studies validating numerical pain scales, we considered a clinically significant improvement to be at least 2.0 units on a 10-point scale.\(^{12,18}\) We calculated that approximately 15 patients would be needed to detect a mean change of 2.0 units with \(\alpha = 0.05\) and \(\beta = 0.80\), assuming an SD of 2.0 units at each time point.

**Data Analysis**

Data analysis for this study was largely descriptive, including percentages and counts for categorical data and medians with 25th to 75th interquartile ranges (IQRs) for continuous data. The primary outcome measure was the change in NRS score from baseline to week 4. The secondary outcomes were the change in NRS score from baseline to 30 minutes postprocedure, change in NRS score from baseline to week 2, and the occurrence of adverse events. The change in NRS scores was assessed using Wilcoxon signed rank tests with the level of significance set at \(P < 0.05\). Data were analyzed using Microsoft Excel (Microsoft, Redmond, Washington).

**RESULTS**

**Demographic and Clinical Characteristics**

The demographic and clinical characteristics are summarized in Table 1. Fifteen patients were initially recruited to participate in the study, one of whom was excluded at the time of preinjection consult because of a cervical fusion present at C2. Of the 14 remaining patients, 50% were male (n = 7), and all were white.

<table>
<thead>
<tr>
<th>TABLE 1. Summary of Demographics and Clinical Presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total No. of Patients</strong></td>
</tr>
<tr>
<td><strong>Sex, n (%)</strong></td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td><strong>Age, y</strong></td>
</tr>
<tr>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Age group, n (%)</td>
</tr>
<tr>
<td>&lt;40 y</td>
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<tr>
<td>41–60 y</td>
</tr>
<tr>
<td>61–80 y</td>
</tr>
<tr>
<td>&gt;80 y</td>
</tr>
<tr>
<td><strong>Race, n (%)</strong></td>
</tr>
<tr>
<td>White</td>
</tr>
<tr>
<td><strong>BMI, kg/m(^2)</strong></td>
</tr>
<tr>
<td>Mean (SD)</td>
</tr>
<tr>
<td><strong>Diagnosis, n (%)</strong></td>
</tr>
<tr>
<td>Occipital neuralgia</td>
</tr>
<tr>
<td>Cervicogenic headache</td>
</tr>
<tr>
<td><strong>Duration of symptoms, mo</strong></td>
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<tr>
<td>Mean (SD)</td>
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<tr>
<td><strong>Side of symptoms, n (%)</strong></td>
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<td>Right</td>
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</table>

The mean age was 61.1 (SD, 17.4) years, and the majority of patients had a diagnosis of occipital neuralgia. Thirty-six percent of patients (n = 5) were taking medications for headache prophylaxis at the time of injection. This included 1 patient using carbamazepine, 1 using topiramate, 1 using gabapentin, and 1 patient using both verapamil and valproic acid. The fifth patient was on prophylactic Botox injections every 3 months. Ninety-three percent of patients (n = 13) were taking short-acting pain medications as needed for symptom control, including acetaminophen (n = 8), nonsteroidal anti-inflammatory drugs (n = 6), triptans (n = 3), combination antimigraine formulations (n = 1), and opioids (n = 1).

**Block Success**

Each procedure took an average of 3.75 (SD, 1.67) minutes to complete after ultrasound visualization of the nerve. A successful block was obtained in 86% of patients (n = 12) as defined by the absence of light-touch sensation in the dermatomal distribution of the GON 30 minutes following the injection.

**Pain Intensity**

Mean NRS pain rating at baseline was 4.71, with a median of 3.50; and IQR of 3 to 6 (Fig. 4). Compared with baseline, the mean NRS score at week 4 was 2.50 (\(P < 0.02\)), with a median of 2 and IQR of 1 to 3.75. Mean NRS scores at 30 minutes and 2 weeks postprocedure were 0.93 (median, 0.50; IQR, 0–1; \(P < 0.001\)) and 2.07 (median, 2; IQR, 0–3.50; \(P < 0.01\)), respectively.

**Adverse Events**

No adverse events related to the injection were reported, including dizziness, blurred vision, slurred speech, lightheadedness, paresthesias, pseudoseizure, hypertension, or headache.

**DISCUSSION**

We demonstrate the safety and efficacy of an ultrasound-guided GON block using a proximal approach to target the nerve at the level of C2 as it courses between the SC and OCI muscles. In this study, the GON was successfully blocked at the time of injection with significant differences in pain scores after 4 weeks. Prior clinical studies demonstrated efficacy of ultrasound-guided GON blocks via the standard approach at the superior nuchal line.\(^{12,14}\) This is the first study to validate the technique described by Greher et al\(^7\) in a clinical setting with patients referred for occipital neuralgia or cervicogenic headache. There were no adverse events.
events reported in our study, although a larger cohort will be
needed to confirm a complication rate lower than the 5% to
10% reported for nonguided blocks.10,11

There were several strengths of this study. The procedures
were performed by clinicians (M.J.P., S.M.M.) who are very expe-
rienced with ultrasound guidance under an established protocol
that ensured standardization. Strict inclusion and exclusion
criteria limited our patient population to those with pain likely at-
tributed to GON pathology. Interestingly, the clinical criteria for
occipital neuralgia and cervicogenic headache have changed since
our study began, with the publication of the third edition of the
IHS’s The International Classification of Headache Disorders,
but the updated criteria would not have excluded any of the pa-
tients who participated in our study.6

There is a growing body of evidence showing improved pa-
tient outcomes with ultrasound-guided approaches for interven-
tional pain procedures.19,20 This has prompted research seeking
to improve injection techniques by visualizing target structures
at more accessible or potentially safer locations. In this case, the
GON is easily visualized at the level of C2 as it courses superficial
to the OCI muscle with no bony artifacts to distort its sonographic
appearance. As the nerve courses distally, it divides into several
smaller branches and pierces the trapezius at variable locations,
which may lead to results that are less reproducible.21 In addition,
many proposed sites of GON compression by vascular, muscular,
or osteogenic causes are at the level of the cervical spine or upper
cervical nerve roots.2,4,22,23 The results of this study suggest that
anesthetizing the nerve at a more proximal location, closer to
these potential areas of compression, may result in improved
analgic effect.

The goal of this study was to demonstrate feasibility and
prompt future research comparing this approach to other standard
techniques. Limited conclusions can be drawn from a small study
without blinding to intervention or a control group. However,
the sample was large enough to demonstrate a significant decrease in
pain, a high success rate of GON blockade, and a lack of signifi-
cant adverse events. The patient population had an average age
older than 60 years and was entirely white, which may limit the
reproducibility of our results in other settings. However, our sub-
jects had an average BMI similar to the figures reported for
American adults.24 Although only 2 cases of cervicogenic head-
ache were included in the study, patients had varying clinical pre-
sentations in terms of duration of symptoms, location of pain, and
medications used.

Other limitations of this study include a follow-up of only 4
weeks following injection, although this is comparable to
similar studies.10,12 We know of 1 patient whose pain recurred
after the study period, suggesting that the improvement in pain
scores seen after 4 weeks may not be maintained long term.
However, this outcome is not unexpected, given our experience
with other corticosteroid injections in which the analgesic ef-
fect wanes over time. We anticipate that injections will need to
be repeated periodically. In addition, our primary outcome
measure of the NRS pain score is subjective and potentially af-
fected by many factors, including comorbid pain conditions,
timing of analgesic medication, and psychosocial factors.

Another relevant consideration is the possibility of local anes-
thetic spread to important structures in close proximity to the OCI.
These structures include both the C1 and C3 primary dorsal rami
and the origin of the third occipital nerve. The incidence of inadver-
tent local anesthetic spread is unknown, but the use of ultrasound
guidance and small volumes of injectate likely mitigate this risk.
In contrast, traditional GON blocks that utilize anatomic landmarks
with higher injectate volumes are likely to anesthetize adjacent
structures, including the lesser occipital and great auricular nerves.2

To further quantify the efficacy of this technique, future re-
search will include a randomized controlled trial comparing it
with traditional nonguided injections at the superior nuchal line.
In order to address the limitations noted previously, we will in-
clude a larger population with a longer follow-up period and a
functional outcome scale to supplement the NRS pain score.
Consideration will be given to broadening the patient population to
include those with bilateral symptoms or with recent procedures
involving the head or neck, which were the primary reasons for
exclusion from this study. The use of abortive or breakthrough
medications will be assessed as a secondary aim to further under-
stand the impact of these interventions.

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