Nitrous Oxide During Labor: Maternal Satisfaction Does Not Depend Exclusively on Analgesic Effectiveness

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**BACKGROUND:** Evidence on the analgesic effectiveness of nitrous oxide for labor pain is limited. Even fewer studies have looked at patient satisfaction. Although nitrous oxide appears less effective than neuraxial analgesia, it is unclear whether labor analgesic effectiveness is the most important factor in patient satisfaction. We sought to compare the relationship between analgesic effectiveness and patient satisfaction with analgesia in women who delivered vaginally using nitrous oxide, neuraxial analgesia (epidural or combined spinal-epidural [CSE]), or both (neuraxial after a trial of nitrous oxide).

**METHODS:** A standardized survey was recorded on the first postpartum day for all women who received anesthetic care for labor and delivery. Data were queried for women who delivered vaginally with nitrous oxide and/or neuraxial labor analgesia over a 34-month period in 2011 to 2014. Parturients with complete data for analgesia quality and patient satisfaction were included. Analgesia and satisfaction scores were grouped into 8 to 10 high, 5 to 7 intermediate, and 0 to 4 low. These scores were compared with the use of ordinal logistic regression across 3 groups: nitrous oxide alone, epidural, or CSE alone, or nitrous oxide followed by neuraxial (epidural or CSE) analgesia.

**RESULTS:** A total of 6507 women received anesthesia care and delivered vaginally. Complete data were available for 6242 (96%) women; 5261 (81%) chose neuraxial analgesia and 1246 (19%) chose nitrous oxide. Of the latter, 753 (60%) went on to deliver with nitrous oxide alone, and 493 (40%) switched to neuraxial analgesia. Most parturients who received neuraxial analgesia (>90%) reported high analgesic effectiveness. Those who used nitrous oxide alone experienced variable analgesic effectiveness, with only one-half reporting high effectiveness. Among all women who reported poor analgesia effectiveness (0–4; n = 257), those who received nitrous oxide alone were more likely to report high satisfaction (8–10) than women who received epidural analgesia alone (OR 2.5; 95% CI 1.4–4.5; P = .002). Women who reported moderate analgesia (5–7) and received nitrous oxide only were more likely to report high satisfaction compared with the other groups. Among women who reported a high level of analgesic effectiveness, satisfaction with anesthesia was high and not different among groups.

**CONCLUSIONS:** Patients who received nitrous oxide alone were as likely to express satisfaction with anesthesia care as those who received neuraxial analgesia, even though they were less likely to report excellent analgesia. Although pain relief contributes to the satisfaction with labor analgesia care, our results suggest that analgesia is not the only contributor to maternal satisfaction. (Anesth Analg 2017;124:548–53)

Evidence regarding analgesic effectiveness of nitrous oxide for labor pain is limited. Two systematic reviews,1,2 which included a total of 14 studies published from 1961 to 2007, deemed the trials insufficient to draw conclusions concerning analgesic effectiveness, citing unsatisfactory study design and variations in methodology. Most of the studies included subsets of women who chose nitrous oxide and appeared to experience benefit, with some reporting significant analgesic effectiveness and many stating that they would choose it again for a future delivery. Likewise, few studies have examined patient satisfaction with nitrous oxide during labor, and it is unclear whether labor analgesic effectiveness is the most important dimension influencing a parturient’s satisfaction with analgesic modality during her labor and birth experience.2,3

The 2014 review by Likis et al identified only 3 randomized trials assessing patient satisfaction, but all were performed by the same investigators, who compared the effects of nitrous oxide with subanesthetic concentrations of volatile anesthetic drugs.4,7 Study design prevents drawing meaningful conclusions—an anesthesiologist administered inhaled agents continuously using an anesthesia machine, briefly, only for delivery, and half of the parturients in 2 studies received various other analgesics,4,7 whereas subjects in the third study received no analgesia during the first stage.4 Four of 6 nonrandomized cohort6,11 and survey12–14 studies included in the same review were deemed of poor quality.2 In those comparing nitrous oxide and epidural analgesia, women selecting the latter more commonly reported greater satisfaction, consistent with greater reported effectiveness.9–11,13 In a large cross-sectional survey...
study, nitrous oxide was an independent predictor of lower maternal satisfaction.\textsuperscript{12}

Beginning in June 2011, the anesthesia department at Vanderbilt University Medical Center has offered the option of self-administered 50% nitrous oxide in 50% oxygen (Porter Nitronox, Porter Instrument, Parker Hannifin, Hatfield, PA) to all laboring parturients.\textsuperscript{a} We routinely survey patient’s pain relief and overall satisfaction with labor analgesia when performing postpartum postanesthesia assessments. We analyzed these prospectively gathered data obtained during a 34-month period (June 2011 to March 2014) to compare parturient-reported analgesic effectiveness and overall analgesic satisfaction among women who delivered vaginally using nitrous oxide, neuraxial (epidural or combined spinal-epidural), or both (neuraxial after a trial of nitrous oxide) to test the hypothesis that maternal satisfaction with analgesic care depends on effectiveness of labor analgesia.

METHODS

A standardized survey is used during the follow-up visit with all parturients who have received intrapartum anesthetic care at Vanderbilt University Medical Center. The visits are conducted by anesthesiology staff on the first postpartum day for all women who have delivered between midnight and midnight on the previous day. Patient identifiers, date and time of delivery and of follow up, obstetric procedure(s), and anesthetic technique(s) are recorded. Patients are asked about neuraxial block placement problems, problems during vaginal delivery, and side effects. They are asked specifically about headache, back pain, nausea, and itching. They use a 0- to 10-point scale to rate the effectiveness of their labor pain relief, and they also use a 0- to 10-point scale to rate their overall satisfaction with analgesia care. Finally, they are asked to provide any additional clarifying comments.

Each patient’s responses are entered into her medical record and into a secure database for quality improvement purposes. We queried and evaluated the quality improvement database for all parturients who received intrapartum nitrous oxide and/or neuraxial analgesia for labor and who subsequently delivered vaginally during a 34-month period, from June 1, 2011 (the date nitrous oxide labor analgesia was first offered), to March 31, 2014 (after which postdelivery quality data were no longer systematically collected in a readily accessible database). Parturients whose medical records included both analgesia quality and patient satisfaction scores were included. The study protocol was reviewed by Vanderbilt University institutional review board. Because the purpose of this project was to compare relative benefits of nitrous oxide analgesia and those of neuraxial analgesia alone to improve the quality of care, the requirement for written informed consent was waived by the institutional review board.

Statistical Analysis

Patients were assigned to 3 study groups according to their labor analgesic choices—nitrous oxide alone, neuraxial (epidural or combined spinal-epidural) analgesia alone, and nitrous oxide followed by neuraxial analgesia. Analgesic effectiveness and satisfaction scores, the 2 primary outcomes for the study, were grouped a priori into 3 groups: 8 to 10 high, 5 to 7 intermediate, and 0 to 4 low. Analgesic effectiveness scores were compared among labor analgesia groups with the use of unadjusted proportional odds logistic regression. Anesthesia care satisfaction scores were compared among groups via the use of a similar technique, with adjustment for the level of analgesic effectiveness. The Wald method was used to compute 95% confidence intervals and statistical hypothesis tests. A \( P \) value of .05 was considered statistically significant. No a priori sample size or power analysis was performed. We analyzed every datum available to us, from the beginning of data collection to the last collected into database 34 months later. This manuscript adheres to the applicable Equator guidelines.

RESULTS

Assignment to study groups is presented in Figure 1.\textsuperscript{a} Among laboring women who ultimately delivered vaginally, 19% initially chose nitrous oxide analgesia. Of these, 40% subsequently converted to neuraxial analgesia. This compares to a 63% conversion rate for women who ultimately delivered by cesarean (data not shown). Parturients receiving neuraxial analgesia, whether as the sole modality or after a trial of nitrous oxide analgesia, rated analgesic effectiveness uniformly as high (>90%), whereas those who used nitrous oxide alone reported variable analgesic effectiveness (Figure 2). The median (interquartile range) analgesic effectiveness scores were 10 (9–10) for both neuraxial groups and 8 (5–10) for the nitrous oxide alone group. These findings were supported by ordinal logistic regression analysis. Specifically, among those who received nitrous oxide alone, the odds of high analgesic effectiveness (8–10) were 90% less (odds ratio [OR] 0.10; 95% confidence interval 0.01–0.95).

\textsuperscript{a}Excluded from analysis were 3831 women who underwent cesarean delivery during the study period and 1082 parturients who delivered vaginally without nitrous or neuraxial analgesia. Nurse-administered parenteral opioids are not administered during active labor, and patient-controlled intravenous opioids are not offered on our unit.

\textsuperscript{a}Per institution policy, nitrous oxide is not administered to parturients who received parenteral opioids during the 2 hours before the request for nitrous oxide.

Figure 1. Patients included in the study analysis, and study group assignments. CSE indicates combined spinal epidural; SVD, spontaneous vaginal delivery.
interval [CI] 0.08–0.12; \( P < .001 \) than those who received neuraxial analgesia. There was no evidence that the effectiveness of the analgesic differed significantly across neuraxial anesthesia groups (\( P = .13 \)).

Despite variability in the effectiveness of the analgesic, overall analgesia satisfaction scores were uniformly high (Figure 3). For all 3 groups, the median (interquartile range) satisfaction score was 10 (10–10). This finding was, again, corroborated by ordinal logistic regression analysis. Specifically, among parturients who reported poor analgesia effectiveness (0–4; \( n = 257 \)), those who received nitrous oxide as the sole analgesic modality were more likely to report high overall satisfaction than those who received neuraxial analgesia alone (OR 2.5; 95% CI 1.4–4.6; \( P = .002 \)). There was insufficient evidence to draw a similar conclusion for those who received nitrous oxide alone versus neuraxial analgesia after nitrous oxide (OR 1.6; 95% CI: 0.5–5.4; \( P = .46 \)). Among women who reported moderate analgesia effectiveness (5–7; \( n = 536 \)), however, those who received nitrous oxide alone reported high satisfaction more often than women in either neuraxial analgesia group (neuraxial only: OR 2.2; 95% CI 1.3–3.8; \( P = .005 \) and neuraxial analgesia after nitrous oxide: OR 4.4; 95% CI 1.65–11.6; \( P = .003 \)). Among women who reported a high level of analgesia effectiveness, there was uniformly high satisfaction with anesthesia care, and thus no evidence of significant differences among groups. There was no evidence that women who chose neuraxial analgesia differed from those who converted to neuraxial analgesia after a trial of nitrous oxide, with regard to analgesia effectiveness or overall satisfaction.

**DISCUSSION**

This was a retrospective analysis of prospectively gathered patient-reported rating scores for analgesic effectiveness and overall satisfaction with analgesic care. Unlike a randomized trial, group assignment was determined by each parturient’s choice of labor analgesic modality, not only initially, but through delivery. On a labor and delivery unit where nitrous oxide routinely is offered among other labor analgesic modalities, all of which are presented and discussed at the time of admission, 1 in 5 women who requested labor analgesia, and who ultimately delivered vaginally, initially chose nitrous oxide. Of these, 60% (753 of 1246) went on to deliver with nitrous oxide alone, the remainder switching to neuraxial analgesia. We introduced a nitrous oxide program in mid-2011 to meet a perceived need for systemic analgesic alternatives to neuraxial analgesia among a subset of women who desired a less invasive

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**Figure 2.** Proportion of parturients in 3 analgesic regimen groups who rated their analgesic effectiveness as low (0–4), intermediate (5–7), or high (8–10). Analgesia effectiveness was variable among women who received nitrous oxide alone but uniformly high among those who received neuraxial analgesia.

**Figure 3.** Proportion of parturients in 3 analgesic regimen groups who rated overall satisfaction with analgesia care as low (0–4), intermediate (5–7), or high (8–10). Satisfaction was uniformly high, despite variable analgesia effectiveness among women who received nitrous oxide alone.
modality. The proportion of women who chose nitrous oxide remained stable over nearly 3 years, suggesting that nitrous oxide meets the pain relief needs of a subset of laboring women in this tertiary North American medical center.

Nitrous Oxide: Variable Analgesic Effectiveness

Not unexpectedly, nitrous oxide was less effective in alleviating labor pain than neuraxial modalities, the latter of which most parturients (92%) reported as very effective (scores 8–10). This finding is consistent with studies that compared analgesic effectiveness between nitrous oxide and neuraxial modalities. In a postpartum survey study of 2482 parturients, 80% rated epidural analgesia as very effective, compared with 44% among those who were using nitrous oxide. Of note, effectiveness scores reported by women in our study who delivered solely with nitrous oxide were more heterogeneous compared with those reported by the neuraxial groups. One-half of those who delivered while receiving nitrous oxide reported high analgesic effectiveness scores, the remainder split between intermediate (27%) and low (21%) scores.

Similar heterogeneity of nitrous oxide analgesic effectiveness has been observed in several nonrandomized observational studies. In a study of 833 Finnish parturients, epidural analgesia was superior to nitrous oxide during the first stage of labor (pre-versus postintervention pain scores). On the third postpartum day, 94% of women receiving epidural analgesia reported good analgesic adequacy, 6% moderate, and 0% poor. In contrast, only 33% of women receiving nitrous oxide reported analgesia as good, 39% as moderate, and 28% as poor. In an additional study of 663 women who delivered vaginally with nitrous oxide, meperidine, or both, 31% of those who received nitrous oxide alone (n = 130) reported no pain relief, 18% slight, 47% satisfactory, and 4% complete analgesia. Dammer et al studied 60 women who chose nitrous oxide after implementation of an inhalation analgesia program in a German hospital. Median pain scores ranged from extremely low to extremely high, and two-thirds of women reported being likely to use nitrous oxide again for labor. Other randomized trials compared the effects of nitrous oxide with those of subanesthetic concentrations of volatile agents also reported heterogeneity in analgesic effectiveness. Factors predictive of nitrous oxide analgesic effectiveness have yet to be reported.

Of note, parturients in our study who opted for neuraxial analgesia after a trial of nitrous oxide reported labor analgesic effectiveness similar to those who chose neuraxial analgesia without a trial of nitrous oxide. Effectiveness scores were solicited from parturients on the first postpartum day, and our database did not separate scores they might assign to the nitrous oxide trial before receiving neuraxial analgesia. However, insufficient analgesia is the most common, albeit not sole, reason for switching. Some women switch because of unpleasant side effects of nitrous oxide (dysphoria, sedation, dizziness, nausea). Furthermore, the rate of conversion from nitrous oxide to neuraxial analgesia among laboring women who went on to deliver by cesarean (not included in analysis) was 62.5%, compared with 40% among nitrous oxide users who delivered vaginally. Thus, although not proven, limiting our analysis to women who deliver vaginally likely underestimates the proportion of women using nitrous oxide who experience poor analgesic effectiveness.

Nitrous Oxide: High Satisfaction, Regardless of Analgesic Effectiveness

Although nearly half of the women in our study who delivered with nitrous oxide analgesia alone reported low or intermediate analgesic effectiveness, satisfaction scores were uniformly high in this group, with only a minority (48, or 7%) reporting a satisfaction score <8. These women were as likely to express high satisfaction with anesthesia care as those who received neuraxial analgesia. Of note, they also made the choice to continue with nitrous oxide, despite the availability of neuraxial modalities on demand. Such paradoxical findings have not been reported previously.

In an observational study at a Malaysian University Center, 123 healthy women in early labor were offered epidural analgesia. Those who declined (n = 68) received scheduled meperidine and self-administered 50% nitrous oxide. More women in the epidural group (69%) were satisfied with their choice and would choose it again compared with the meperidine/nitrous oxide group (35%). Dissatisfaction with pain relief was reported by 3 (5.5%) and 31 (45.6%), respectively. Analgesic effectiveness and satisfaction were not compared directly, and it is unclear whether women using nitrous oxide were allowed to subsequently switch to epidural analgesia.

Of 278 Swedish parturients (48% nullipara) experiencing labor who were surveyed 4 hours to 7 days postpartum, most reported experiencing severe pain and underestimated the intensity of labor pain. Most (219, or 79%) received nitrous oxide labor analgesia, whereas fewer (95, or 34%) received epidural analgesia. Satisfaction was not measured; however, when considering a future birth, more women reported wishing to have epidural analgesia, and fewer nitrous oxide. The same investigators conducted a 2-month postpartum, in-depth written survey of 1111 parturients, including the examination of hospital delivery data, to identify factors that predicted a negative overall birth experience. Nitrous oxide analgesia was an independent predictor of a less positive birth experience (OR 0.52; 95% CI 0.38–0.72), as were labor augmentation, instrumental vaginal delivery, cesarean delivery, and nulliparity. Yet, mothers in this study continued to labor using nitrous oxide, declining available neuraxial modalities.

What Matters? Analgesia, Other Factors, or Both?

Pain relief clearly contributes to the satisfaction with labor analgesic care, especially with neuraxial modalities; however, our results, and those of others, suggest that satisfaction with labor analgesia is not determined solely by analgesic effectiveness. In a study of women with a priori plans to use labor epidural analgesia, effective analgesia, and timely access to it, emerged as central to the birth experience, important in regaining self-control and the ability to focus, think, and participate in the birth. Women identified other important factors, such as preservation of bodily sensations of labor, mobility, and strength. A systematic review of reports investigating factors influencing parturients’ satisfaction with childbirth experiences, identified personal expectations,
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caregiver support, quality of the relationship with her care-
giver, and involvement in decision making.22 In a survey study
of more than 700 European women, prelabor expectations of
severe pain, experienced pain greater than expectations, and
drug use (nitrous oxide, 69%; meperidine, 53%; epidural,
10%) associated with lower overall birth experience satisfac-
tion, but independent predictive factors were not analyzed.26
Finally, a qualitative analysis of 2005 national survey data
from 1573 US parturients identified the importance of timely
and effective neuraxial analgesia for those who requested it,
but analgesia was only one among many other factors identi-
fied by women who were asked open-ended questions about
the best and worst aspects of their birth experience.25

In summary, under the conditions of the present study,
in our practice and patient population, nitrous oxide
was less effective in treating labor pain than neuraxial anal-
gesia. These women reported high levels of satisfac-
tion, despite variable labor analgesic effectiveness. Nitrous
oxide, offered in addition to neuraxial labor analgesia, con-
sistently has served the needs and preferences of a small
subset of parturients at this high-risk academic center.  

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Name: Michael G. Richardson, MD.  
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REFERENCES

1. Rosen MA. Nitrous oxide for relief of labor pain: a systematic


3. King TL, Wong CA. Nitrous oxide for labor pain: is it a laugh-

index to measure the quality of neuraxial labour analge-
sia: exploring the perspectives of childbearing women. Can J

5. Hodnett ED, Gates S, Hofmeyr GJ, Sakala C. Continuous sup-
port for women during childbirth. Cochrane Database Syst Rev.
2015;7:CD003766.

6. Abboud TK, Shidner SM, Wright RG. Enflurane analgesia in

7. Abboud TK, Gangolly J, Mosaad P, Crowell D. Isoflurane in


Jouppila R. Parturients’ assessment of water blocks, pethidine,
nitrous oxide, paracervical and epidural blocks in labour. Int J

A comparative study of transcutaneous electrical nerve stimula-
tion (TENS), entonox, pethidine + promazine and lumbar epidural

11. Leong EW, Sivanesaratnam V, Oh LE, Chan YK. Epidural anal-
gesia in primigravidae in spontaneous labour at term: a pro-


13. Henry A, Nand SL. Intrapartum pain management at the Royal

in labour of pethidine and 50 per cent nitrous oxide in oxygen

nitrous oxide and oxygen for pain management during
labour—evaluation of patients’ and midwives’ satisfaction.

16. Waldenström U, Irestedt L. Obstetric pain relief and its associ-
ation with remembrance of labor pain at two months and one

17. Jones PL, Rosen M, Mushin WW, Jones EV. Methoxyflurane and
nitrous oxide as obstetric analgesics. I. A comparison by con-

18. Jones PL, Rosen M, Mushin WW, Jones EV. Methoxyflurane and
nitrous oxide as obstetric analgesics. II. A comparison by self-

19. Waldenström U, Bergman V, Vasell G. The complexity of labor

20. Collis RE, Davies DW, Aveling W. Randomised comparison of
combined spinal-epidural and standard epidural analgesia in

and experiences of labour pain and analgesia: a multicentre

22. Hodnett ED. Pain and women’s satisfaction with the experi-

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