A Randomized Trial of Eutectic Mixture of Local Anesthetics During Lumbar Puncture in Newborns

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Objective: To determine the efficacy of a topical anesthetic cream, eutectic mixture of local anesthetics (EMLA), in alleviating pain associated with lumbar puncture in newborns.

Design: Randomized double-blind placebo-controlled trial.

Setting: Neonatal intensive care unit of a university teaching hospital.

Patients: Sixty consecutive newborns (gestational age, ≥34 weeks) undergoing diagnostic lumbar puncture.

Intervention: Topical application of 1 g of EMLA or placebo 60 to 90 minutes before lumbar puncture.

Main Outcome Measures: Heart rate, transcutaneous oxygen saturation level, and total behavioral score recorded on a video camera and graded according to the Neonatal Facial Coding System.

Results: Compared with baseline, all newborns experienced pain as evidenced by increased heart rate, decreased oxygen saturation level, and total behavioral score (all within-groups differences were significant using repeated-measures analysis of variance; \( P < .001 \)) during the procedure. Compared with placebo, EMLA significantly attenuated the pain response as shown by a lower mean ± SE heart rate (per minute), particularly at needle insertion (EMLA: 159.3 ± 2.3; placebo: 175.2 ± 2.7; \( P < .001 \)) and needle withdrawal (EMLA: 153.8 ± 2.6; placebo: 167.3 ± 2.5; \( P < .001 \)), and a lower mean ± SE total behavioral score, again at insertion (EMLA: 4.0 ± 0.3; placebo: 5.0 ± 0.0; \( P = .004 \)) and withdrawal (EMLA: 1.8 ± 0.3; placebo: 3.9 ± 0.3; \( P < .001 \)). There was no statistically significant difference between groups with regard to oxygen saturation level.

Conclusions: Lumbar puncture in newborns produces pain responses. Eutectic mixture of local anesthetics is an efficacious agent for reducing the pain associated with needle insertion and withdrawal during lumbar puncture in newborns.


Lumbar puncture in neonates without the benefits of anesthesia or analgesia is common practice in neonatal intensive care units. This practice is being questioned by recent evidence that neonates are capable of both perceiving and exhibiting reproducible responses to noxious stimulation. Newborns not only experience pain and stress, but their pain responses may even influence their subsequent social and behavioral development. Repetitive painful stimuli have been associated with behavioral and emotional problems during childhood, major psychosis, altered responses to pain, and intractable pain states in later life.1-3 Thus, reducing the pain of needles is imperative in neonatal intensive care treatment protocols.

Local anesthetics such as 40% lidocaine hydrochloride or 20% benzocaine have been used for the relief of procedural pain, but they have produced drawbacks such as local irritation, systemic toxic effects, and inadequate analgesia. A major problem with previous methods of topical anesthesia was that the keratinized epidermis formed an effective barrier to drug penetration; any increase in the concentration of the drug to overcome this obstacle resulted in greater adverse effects. Since the advent of eutectic mixture of local anesthetics (EMLA), a 1:1 oil-in-water emulsion of a low (5%) concentration of lidocaine and prilocaine hydrochloride, effective topical analgesia of intact skin is now feasible without the need for subcutaneous injections or exposure to high concentrations of local anesthetics. The efficacy of EMLA for the treatment of procedural pain in children and adults is well established.4

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In neonates, EMLA has been shown to diminish pain during circumcision, venipuncture, arterial puncture, and percutaneous venous catheter placement. However, the efficacy data for these procedures is limited. Although 3 trials have shown the usefulness of EMLA in alleviating the pain of lumbar puncture in older children, only 1 randomized controlled study has evaluated its use in newborns.

Our study was designed to test the efficacy of topical EMLA in diminishing pain during lumbar puncture in newborns. A control placebo group was included, in keeping with the current practice of not using anesthesia or analgesia for this procedure.

**METHODS**

**PATIENTS**

The study was carried out during a period of 12 months in a 32-bed neonatal intensive care unit of a tertiary care hospital. Sixty consecutive newborns undergoing diagnostic lumbar puncture were enrolled in the study following informed consent from their parents. The criteria for inclusion in the study were postnatal age younger than 4 weeks, gestational age of 34 weeks or older, uncomplicated vaginal or cesarean delivery, 5-minute Apgar score of 7 or higher, no history of maternal medication use, absence of structural neurodevelopmental anomalies, and a rectal temperature of 37°C ± 0.5°C. The neonates should not have been receiving any sedatives or analgesics.

**STUDY DESIGN**

These 60 selected newborns were randomized using a computer-generated simple random-number table. Thirty numbers (generated between 1 and 60) were assigned to the study (EMLA) group; the rest were given to the placebo group. These neonates received either EMLA (Astra Pharmaceuticals, Hertfordshire, England) or the placebo cream in a double-blind manner. Figure 1 depicts the study flowchart. The placebo cream consisted of an inert oil that was not differentiable from EMLA with respect to appearance and odor. Written informed consent was obtained from the parents, and the study was approved by the institutional review board, including ethical clearance.

**PROCEDURE**

The cream (1 g) was uniformly applied to an area of 1 sq in at the site of the procedure and covered with an occlusive dressing 60 to 90 minutes before the scheduled time of the lumbar puncture. The newborn was then placed in a servomechanism-controlled open care system. The dressing was removed immediately prior to the procedure, and any local reactions were noted. The skin was wiped dry, disinfected, and draped according to standard aseptic procedures. The lumbar puncture was performed in the left lateral position with a 24-gauge needle. The procedure comprised the following 8 events: baseline (preprocedural 60 to 90 minutes before EMLA application), preparation, positioning, needle insertion, needle in place, needle withdrawal, 5-minute postprocedural period (5 minutes after needle withdrawal), and 1-hour postprocedural period. All lumbar punctures were carried out by the same person (G.K.).

**OUTCOME VARIABLES**

Physiological responses (ie, heart rate and transcutaneous oxygen saturation level) were quantified and monitored using a compact vital signs monitor (BP-88; Colin Corporation, Komaki, Japan). The measurement accuracy (SD) for the heart rate measurement was ± 1 beat per minute, and the display update was within 1.2 seconds. The measurements could be performed at a particular point in time. It was also possible to generate a trend and list all of the vital parameters of a particular neonate in the last 24 hours. The mean value for each event was used for comparisons between groups.

Facial expressions were recorded during all events on a video camera mounted on a tripod at the newborn's bedside. The camera provided a continuous close-up view of the neonate's face. Videotapes were then coded by a single person in a blinded manner, according to the Neonatal Facial Coding System developed by Grunau and Craig and simplified by Rushforth and Levine. The coding and scoring were carried out using a slow-motion and stop-frame playback system. Four items of facial action (brow bulge, eye squeeze, nasolabial furrow, and open mouth) and the presence of crying were used as measures of behavioral response to pain. Each response was given a score of 1 if present and 0 if absent, for a possible total ranging from 0 to 5.

The physiological and behavioral measures were serially recorded at all 8 events during a single lumbar puncture procedure. Following the procedure, the newborn was closely monitored for a period of 24 hours for the presence of any local or systemic adverse effects linked to EMLA application, particularly central cyanosis suggestive of methemoglobinema.

**STATISTICAL ANALYSIS**

The sample size was estimated according to a formula for hypothesis testing for the difference between 2 population means with an equal sample size in both groups. A mean ± SD heart rate difference of at least 15 ± 15 beats per minute was considered clinically important. Setting an α value of .05 and a β value of .20, 21 newborns per group were needed. Demographic characteristics between groups were compared using an unpaired t test for equality of means and the χ² or Fisher exact test for equality of proportions.

A 1-sample Kolmogorov-Smirnov test was used to investigate whether heart rate and oxygen saturation values were normally distributed. Repeated-measures analysis of variance was fit to the outcome variables (means of heart rate, oxygen saturation level, and total behavioral score), with group (EMLA vs placebo) as a between-subject factor and event (baseline, preprocedural 60 to 90 minutes before EMLA application), preparation, positioning, needle insertion, needle in place, needle withdrawal, 5-minute postprocedural period, and 1-hour postpro-
Sample characteristics for the 60 selected newborns satisfying the inclusion criteria were comparable for both groups. The mean ± SD birth weight was 2219 ± 577 g for the EMLA group and 2190 ± 599 g for the placebo group, and the mean gestational age was 37.4 weeks for the EMLA group and 37.2 weeks for the placebo group. Lumbar puncture was performed at a mean postconceptional age of 3.5 days for the EMLA group and 3.2 days for the placebo group. The male-female ratio was 19:11 in the EMLA group and 13:17 in the placebo group. In the EMLA group, 16 newborns were an appropriate weight for their gestation period as compared with 14 who were small for their gestational age; this ratio was 21.9 in the placebo group.

Mean ± SE heart rate, oxygen saturation level, and total behavioral score for the EMLA group vs placebo group at different events are presented in Tables 1, 2, and 3. Mean ± SD heart rate, oxygen saturation level, and total behavioral score for the 2 groups are pictorially compared in Figures 2, 3, and 4.

Heart rate for both groups was significantly higher from baseline at all events except in resting states; that is, when the needle was placed and at both the 5-minute and 1-hour postprocedural time points (Table 1). Heart rate was significantly different between groups (P < .04) and between events (P < .001). Differences in heart rate ranged from 13 to 16 beats per minute and 12 to 35 beats per minute between groups and events, respectively (Figure 2). The difference from baseline value was significantly lower for the EMLA group compared with the placebo group at insertion and withdrawal of the needle (P < .001).

Oxygen saturation level (Table 2) was significantly different between events (P < .001) but comparable between groups (P = .35). The magnitude of the mean difference between events ranged between 7% and 17% (Figure 3). Both groups showed significant decreases in oxygen saturation level across all events from baseline except for the postprocedural time points (Table 2). The percentage change

### Table 1. Heart Rate in EMLA Group vs Placebo Group Before, During, and After Lumbar Puncture in Newborns*

<table>
<thead>
<tr>
<th>Event</th>
<th>EMLA Group (n = 30)</th>
<th>Placebo Group (n = 30)</th>
<th>Mean Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Preprocedural (1 h before)</td>
<td>144.0 ± 2.69</td>
<td>140.6 ± 2.36</td>
<td>3.43 (−3.73 to 10.6)</td>
</tr>
<tr>
<td>2. Preparation</td>
<td>153.3 ± 2.15</td>
<td>164.5 ± 2.75</td>
<td>−12.6 (−15.5 to −9.7)</td>
</tr>
<tr>
<td>3. Positioning</td>
<td>164.9 ± 2.21</td>
<td>171.0 ± 2.96</td>
<td>−6.07 (−13.4 to 1.27)</td>
</tr>
<tr>
<td>4. Needle insertion</td>
<td>159.3 ± 2.34</td>
<td>175.2 ± 2.66</td>
<td>−15.93 (−23.0 to −8.8)</td>
</tr>
<tr>
<td>5. Needle in place</td>
<td>144.8 ± 2.61</td>
<td>147.2 ± 2.59</td>
<td>−2.4 (−9.77 to 4.97)</td>
</tr>
<tr>
<td>6. Needle withdrawal</td>
<td>153.8 ± 2.57</td>
<td>167.3 ± 2.49</td>
<td>−13.47 (−20.63 to −6.31)</td>
</tr>
<tr>
<td>7. Postprocedural (5 min after)</td>
<td>144.8 ± 2.61</td>
<td>147.2 ± 2.59</td>
<td>−2.4 (−9.76 to 4.97)</td>
</tr>
<tr>
<td>8. Postprocedural (1 h later)</td>
<td>140.9 ± 2.40</td>
<td>139.0 ± 1.85</td>
<td>1.9 (−4.17 to 7.97)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; EMLA, eutectic mixture of local anesthetics.

*Data are presented as mean ± SE unless otherwise indicated. Between-subjects effects were calculated using repeated-measures analysis of variance (P < .001 for overall differences within groups; P = .04 for overall differences between groups). Events 2, 3, 4, and 6 are significantly different (P < .05) from respective baseline (event 1) values in both the EMLA and placebo groups. Additionally, events 5 and 7 are significantly different (P < .05) from event 1 in the placebo group.

### Table 2. Oxygen Saturation Level in EMLA Group vs Placebo Group Before, During, and After Lumbar Puncture in Newborns*

<table>
<thead>
<tr>
<th>Event</th>
<th>EMLA Group (n = 30)</th>
<th>Placebo Group (n = 30)</th>
<th>Mean Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Preprocedural (1 h before)</td>
<td>96.0 ± 0.53</td>
<td>95.6 ± 0.51</td>
<td>0.47 (−1.01 to 1.95)</td>
</tr>
<tr>
<td>2. Preparation</td>
<td>86.8 ± 1.04</td>
<td>85.8 ± 1.42</td>
<td>0.97 (−2.54 to 4.48)</td>
</tr>
<tr>
<td>3. Positioning</td>
<td>83.9 ± 1.56</td>
<td>80.2 ± 1.62</td>
<td>3.70 (−0.79 to 8.20)</td>
</tr>
<tr>
<td>4. Needle insertion</td>
<td>83.7 ± 1.80</td>
<td>78.6 ± 2.13</td>
<td>5.07 (−0.92 to 10.66)</td>
</tr>
<tr>
<td>5. Needle in place</td>
<td>85.1 ± 1.63</td>
<td>84.0 ± 1.50</td>
<td>1.07 (−3.37 to 5.50)</td>
</tr>
<tr>
<td>6. Needle withdrawal</td>
<td>89.0 ± 1.64</td>
<td>84.9 ± 1.51</td>
<td>4.13 (−0.33 to 8.60)</td>
</tr>
<tr>
<td>7. Postprocedural (5 min after)</td>
<td>94.5 ± 0.68</td>
<td>93.6 ± 0.74</td>
<td>0.87 (−1.14 to 2.88)</td>
</tr>
<tr>
<td>8. Postprocedural (1 h later)</td>
<td>95.8 ± 0.53</td>
<td>96.0 ± 0.52</td>
<td>−0.13 (−1.62 to 1.35)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; EMLA, eutectic mixture of local anesthetics.

*Data are presented as mean ± SE unless otherwise indicated. Between-subjects effects were calculated using repeated-measures analysis of variance (P < .001 for overall differences between groups; P = .05 for overall differences between groups). Events 2, 3, 4, and 6 are significantly different (P < .05) from respective baseline (event 1) values in both the EMLA and placebo groups.
from the initial baseline value was found to be smaller in the EMLA group compared with the placebo group during positioning, needle insertion, and needle withdrawal; differences were not statistically significant. The maximum dip in oxygen saturation level compared with baseline was observed at needle insertion, the magnitude being 12% in the EMLA group and 17% in the placebo group.

Total behavioral score, comprising facial actions and crying, was significantly different between groups (range, 15%-35%; \( P < .001 \)) and events (range, 22%-95%; \( P < .001 \)) (Table 3). Behavioral score for both groups was significantly higher from baseline at all events except the 2 post-procedural periods (5 minutes and 1 hour). Behavioral score was significantly higher from baseline for the placebo vs EMLA group at needle insertion, needle in place, and needle withdrawal (\( P < .001 \)). The maximum response for all 5 behavioral parameters was seen during positioning and needle insertion in the placebo group; whereas

### Table 3. Total Behavioral Score in EMLA Group vs Placebo Group Before, During, and After Lumbar Puncture in Newborns*

<table>
<thead>
<tr>
<th>Event</th>
<th>Total Behavioral Score</th>
<th>Mean Difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EMLA Group (n = 30)</td>
<td>Placebo Group (n = 30)</td>
</tr>
<tr>
<td>1. Preprocedural (1 h before)</td>
<td>0.70 ± 0.15</td>
<td>0.27 ± 0.08</td>
</tr>
<tr>
<td>2. Preparation</td>
<td>3.50 ± 0.33</td>
<td>4.27 ± 0.27</td>
</tr>
<tr>
<td>3. Positioning</td>
<td>4.20 ± 0.28</td>
<td>4.97 ± 0.03</td>
</tr>
<tr>
<td>4. Needle insertion</td>
<td>4.00 ± 0.32</td>
<td>5.00 ± 0.00</td>
</tr>
<tr>
<td>5. Needle in place</td>
<td>1.87 ± 0.31</td>
<td>3.60 ± 0.34</td>
</tr>
<tr>
<td>6. Needle withdrawal</td>
<td>1.83 ± 0.30</td>
<td>3.90 ± 0.33</td>
</tr>
<tr>
<td>7. Postprocedural (5 min after)</td>
<td>0.70 ± 0.20</td>
<td>0.90 ± 0.24</td>
</tr>
<tr>
<td>8. Postprocedural (1 h later)</td>
<td>0.13 ± 0.06</td>
<td>0.07 ± 0.04</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; EMLA, eutectic mixture of local anesthetics.

*Data are presented as mean ± SE unless otherwise indicated. Between-subjects effects were calculated using repeated-measures analysis of variance (\( P < .001 \) for overall differences within groups; \( P < .001 \) for overall differences between groups). Events 2, 3, 4, 5, and 6 are significantly different (\( P < .05 \)) from respective baseline (event 1) values in both the EMLA and placebo groups.

Figure 2. Comparison of mean ± SD heart rate between the eutectic mixture of local anesthetics (EMLA) group and placebo group before, during, and after lumbar puncture in newborns.
in the EMLA group, the maximum response was seen during positioning only (Figure 4). Another interesting observation was the presence of 100% positivity in the placebo group during needle insertion for all 5 parameters; in the EMLA group, none of the events were characterized by the presence of all 5 behavioral parameters.

No adverse effects, either local (except temporary blanching of the skin observed during removal of the occlusive dressing) or systemic, were observed with EMLA or placebo. Lumbar puncture was traumatic on the first attempt in 2 and 3 cases in the EMLA and placebo groups, respectively. No case required more than 2 attempts.

COMMENT

This study substantiates the previous observations: lumbar puncture is a stressful procedure, and neonates exhibit demonstrable pain responses in the form of increased heart rate, decreased oxygen saturation level, and presence of facial responses and crying during the proce-
Reducing procedural pain in newborns is gaining recognition. Eutectic mixture of local anesthetics, a topical agent, has been successfully used during circumcision and in obtaining vascular access in newborns. However, its efficacy in reducing the pain of needles during lumbar puncture is unproven.

This study establishes that EMLA is an efficacious agent for reducing the pain associated with needle insertion and withdrawal during lumbar puncture in newborns, evidenced by lower heart rate and less facial actions and crying in the intervention group.

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REFERENCES