

## ANESTHESIOLOGY

## Pregnancy and Labor Epidural Effects on Gastric Emptying: A Prospective Comparative Study

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### EDITOR'S PERSPECTIVE

#### What We Already Know about This Topic

- Gastric emptying is delayed in parturients, and peripartum aspiration has been a great concern
- The lack of reliable data on gastric emptying of solid food during labor has led to some discrepancies between current guidelines regarding fasting for solid food in parturients

#### What This Article Tells Us That Is New

- Gastric emptying after a light meal was delayed in parturients compared with nonpregnant women and term pregnant women not in labor
- However, epidural analgesia commonly used in labor seems not to worsen gastric emptying in parturients, but rather facilitates it

The initial description of aspiration pneumonia in 66 parturients by Curtis Lester Mendelson in 1946 led to advocacy for measures to prevent this complication of general anesthesia, which included strict fasting during labor.<sup>1</sup> The rise of regional anesthesia techniques and advances in obstetric anesthesia, however, have both contributed to a significant reduction in the incidence of peripartum aspiration pneumonia. The mortality rate associated with aspiration is less than 1 in 1 million pregnancies in the United States<sup>2</sup>; therefore, strict fasting during labor has been questioned,

and more liberal practices have advocated for and implemented clear fluids in some countries for more than 20 yr.<sup>3,4</sup>

Current U.S. and European guidelines allow clear fluids during labor,<sup>5,6</sup> although U.S. guidelines are more conservative than European guidelines, allowing only moderate amounts of clear fluids for uncomplicated laboring women. In particular, U.S. and European guidelines differ regarding solid food during labor. While the European guidelines consider the oral intake of low-residue food during labor,<sup>6</sup> guidelines of the American Society of Anesthesiologists (Schaumburg, Illinois)

### ABSTRACT

**Background:** The lack of reliable data on gastric emptying of solid food during labor has led to some discrepancies between current guidelines regarding fasting for solid food in the parturient. This prospective comparative study aimed to test the hypothesis that the gastric emptying fraction of a light meal would be reduced in parturients receiving epidural analgesia and with no labor analgesia compared with nonpregnant and pregnant women.

**Methods:** Ten subjects were enrolled and tested in each group: nonpregnant women, term pregnant women, parturients with no labor analgesia, and parturients with epidural labor analgesia. After a first ultrasound examination was performed to ensure an empty stomach, each subject ingested a light meal (125 g yogurt; 120 kcal) within 5 min. Then ultrasound measurements of the antral area were performed at 15, 60, 90, and 120 min. The fraction of gastric emptying at 90 min was calculated as  $[(\text{antral area}^{90\text{ min}} / \text{antral area}^{15\text{ min}}) - 1] \times 100$ , and half-time to gastric emptying was also determined. For the Parturient–Epidural group, the test meal was ingested within the first hour after the induction of epidural analgesia.

**Results:** The median (interquartile range) fraction of gastric emptying at 90 min was 52% (46 to 61), 45% (31 to 56), 7% (5 to 10), and 31% (17 to 39) for nonpregnant women, pregnant women, parturients without labor analgesia, and parturients with labor epidural analgesia, respectively ( $P < 0.0001$ ). The fraction of gastric emptying at 90 min was statistically significant and lower in the Parturient–Epidural group than in the Nonpregnant and Pregnant Control groups. In addition, the fraction of gastric emptying at 90 min was statistically significant and lower in the Parturient–No-Epidural group than in the Parturient–Epidural group.

**Conclusions:** Gastric emptying in parturients after a light meal was delayed, and labor epidural analgesia seems not to worsen but facilitates gastric emptying. This should be taken into consideration when allowing women in labor to consume a light meal.

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and the Society for Obstetric Anesthesia and Perinatology (Lexington, Kentucky) prohibit any solid food during labor.<sup>5</sup> The main reason for this discrepancy is the lack of reliable data regarding gastric emptying of solid food during labor. Pain due to uterine contractions and administration of opiates may both affect gastric emptying.<sup>7,8</sup> Although gastric emptying remains to a certain degree during labor,<sup>9,10</sup> the gastric volume was larger within the first hour after delivery in women who were allowed solid food during labor compared to those who fasted for solids.<sup>11</sup> However, to date, no study has appropriately assessed the gastric emptying of a light meal in the parturient.

We conducted this study aiming to determine and compare the gastric emptying after intake of a standardized light meal in women in labor with epidural analgesia, women in labor without epidural analgesia, pregnant women not in labor, and nonpregnant women using a reliable, noninvasive ultrasound tool. We hypothesized that the gastric emptying fraction of a light meal measured during a 15- to 90-min period would be reduced by at least 30% in parturients with labor epidural compared with the Nonpregnant Control group and the Pregnant Control group.

## Materials and Methods

This prospective study received approval from an institutional French ethics committee (Sud Méditerranée V Ethics Committee, Nice, France; No. 18.006) and was registered in the public registry at ClinicalTrials.gov (NCT03490682).

All women received information about the study and gave informed written consent to the investigator before participating in the study. Two groups of volunteers (Nonpregnant Control and Pregnant Control groups) and two groups of term parturients (Parturient–Epidural and Parturient–No–Epidural groups) were studied. The inclusions were carried out between May 17, 2018, and May 25, 2019, for the Nonpregnant Control, Pregnant Control, and Parturient–Epidural groups; between November 13, 2020, and November 12, 2021, inclusion of the Parturient–No–Epidural group was carried out in response to peer review.

## Participants

All volunteers and parturients were 40 yr of age or younger, had no significant medical history (American Society of Anesthesiologists Physical Status I), fasted for at least 6 h for solids and 1 h for clear liquids, and had an empty stomach on first ultrasound examination, as defined in the Protocol section.

Women included in the Nonpregnant Control group had to be confirmed as not pregnant *via* a urine pregnancy test performed on the day of their participation in the study.

Women included in the Pregnant Control group had to be nonlaboring pregnant women in the third trimester (more than 32 weeks of gestation on the day of the study) according to dates and calculation of term established at the start of the pregnancy by an obstetrician.

Women included in the Parturient–Epidural and Parturient–No–Epidural groups had to be in labor in the delivery suite of the Mother and Child Hospital (Bron, France), were more than 38 weeks gestation, and were allowed to ingest solids during labor in accordance with local protocol. Women included in the Parturient–Epidural group had to have effective epidural analgesia (*i.e.*, a verbal pain score less than or equal to 3 on a numerical scale [0 = no pain; 10 = the worst pain imaginable] 1 h after induction of epidural analgesia).

The exclusion criteria common to all groups were refusal to participate and inability to speak French, as well as esophageal, duodenal, or gastric medical or surgical history. Supplemental exclusion criteria for the Pregnant Control group included risk for preterm labor, a multiples pregnancy, and/or pathologic pregnancy. Supplemental exclusion criteria for the Parturient groups were multiples pregnancy, pathologic pregnancy, complications during labor, delivery, and/or admittance of patient for induced termination of pregnancy. The supplemental exclusion criterion for the Parturient–No–Epidural group was the use of systemic opioids for pain relief.

For women in the Parturient–Epidural group, epidural analgesia was provided by an initial bolus of 12 ml followed by a continuous epidural infusion of 3 ml/h and patient-controlled boluses (5 ml with a 15-min lock-out interval) of a mixture 1 mg/ml of ropivacaine and 0.25 µg/ml sufentanil.

## Ultrasound Examination of the Gastric Antrum

In the four groups, ultrasound examinations of the gastric antrum were performed using a portable ultrasound device (FUJIFILM Sonosite, Inc., USA) equipped with an abdominal probe (2 to 5 MHz) in the standardized sagittal plane passing through the abdominal aorta and the left lobe of the liver.<sup>12</sup> Qualitative assessment of antral content was performed. The lack of appearance of any content in a flat antrum with juxtaposed walls corresponded to empty antrum, while hypochoic content in a dilated antrum corresponded to fluid contents, and more echoic content in a distended antrum corresponded to solid or thick fluid contents.<sup>13</sup> A high interrater reliability of qualitative assessment of antral content has been reported in term pregnant women.<sup>14</sup> The maximal diameters (longitudinal D1 and anteroposterior D2) of the antrum were measured from serosa to serosa, between antral contractions. The mean values of three consecutive measurements of D1 and D2 were used for the calculation of the antral cross-sectional area according to the following formula: antral area =  $\pi \times D1 \times D2 / 4$ .<sup>12</sup> This method of measurement of the antral cross-sectional area is highly reproducible in adults, has high intra- and interrater reliability, and is equivalent to the free-tracing method of measure the antral area.<sup>15</sup> A combination of qualitative and quantitative assessments is highly accurate in determining the status of gastric contents in adults.<sup>16</sup>

## Protocol

Each participant was lying in the semi-recumbent position with the head elevated to 45 degrees throughout the study period. An initial ultrasound examination of gastric contents was performed to ensure that the stomach was empty. An *ultrasound-empty stomach* was defined as lacking visualization of any fluid or solid content in the antrum (empty antrum) and having an antral cross-sectional area of less than either 505 mm<sup>2</sup> (in pregnant women) or 340 mm<sup>2</sup> (in nonpregnant women)<sup>11,13</sup>; otherwise, the participant was not included in the study. This baseline value of the antral area was recorded.

Participants were then invited to consume a test meal (125 g flavored yogurt: 120 kcal, 3.8 g protein, 2.2 g lipid, 21.2 g carbohydrates) within 5 min. This test meal was ingested 1 h after the initiation of epidural analgesia for the women in the Parturient–Epidural group.

Ultrasound examinations of the gastric antrum with measurement of the antral cross-sectional area were then performed 15, 60, 90, and 120 min after the end of test meal ingestion.

The primary outcome measures were the antral cross-sectional areas measured 15 and 90 min after ingestion of the meal. These measurements enabled calculation of the gastric emptying fraction of the light meal corresponding to the percentage reduction in the antral cross-sectional area from 15 to 90 min after the ingestion of the meal, and used the following formula: gastric emptying fraction<sub>15–90</sub> = [(antral area<sup>90 min</sup> / antral area<sup>15 min</sup>) – 1] × 100.<sup>17</sup> This formula was used to assess gastric emptying of a semisolid breakfast meal (330 kcal) with high reproducibility.<sup>17</sup> Given the low caloric value of the test meal in the current study, we also calculated the gastric emptying fraction between the ultrasound measurements performed at 15 and 60 min after ingestion of the test meal: gastric emptying fraction<sub>15–60</sub> = [(antral area<sup>60 min</sup> / antral area<sup>15 min</sup>) – 1] × 100. The half-time to gastric emptying was also calculated for each group.<sup>18</sup> We also assessed the number of women who had empty stomachs at 90 and 120 min after ingestion of the test meal, using the parameters of an ultrasound-empty stomach previously discussed.

The following data were also recorded: demographic data of the women included in the four groups (age, height, weight, and body mass index [before pregnancy for the women in the Parturient and Nonpregnant Control groups], gestational weight gain, time since last ingestion of solid food, and time since last ingestion of clear fluids), as well as the data relative to the pregnancy of the Parturient and Pregnant Control groups (parity, gestational age, gravidity). For the participants in the Parturient group only, cervical dilation at inclusion, administration of oxytocin during the study period, pain score measured by a numeric rating scale (0 = no pain; 10 = the worst pain imaginable) at each ultrasound examination, cumulative dose of ropivacaine and sufentanil administered *via* epidural catheter at

the time of inclusion and at end of the study, and occurrence of nausea and/or vomiting during the study period were recorded.

## Statistical Analysis

Statistical analysis was performed using MedCalc version 12.1.4.0 for Windows (MedCalc Software, Belgium) and the Statistica version 6.0 computer software package (Statsoft, USA). After data were tested for normality of distribution using the Shapiro–Wilk *W* test, continuous data were expressed as mean ± SD or as median (interquartile range) and were compared using one-way ANOVA, the Kruskal–Wallis *H* test, an independent samples *t* test, or the Mann–Whitney *U* test, as appropriate. Two-way analyses of variance were performed to compare the change in pain score over time among Parturient–Epidural and Parturient–No–Epidural groups, and the change in the antral area over time among the four groups, followed by Bonferroni *post hoc* tests as appropriate. The fractions of gastric emptying and half-time to gastric emptying were compared among the four groups using Kruskal–Wallis *H* tests followed by Conover–Inman *post hoc* tests where appropriate. Effect sizes were calculated as differences in medians according to the Hodges–Lehmann estimator with 95% CI around the differences. The incidence data were expressed as number (percentage) and analyzed using the  $\chi^2$  or Fisher exact test, as appropriate, followed by the Marascuilo procedure as appropriate. All tests of hypotheses were two-sided and *P* < 0.05 was considered statistically significant.

The sample size calculation for the originally designed study compared the gastric emptying fractions in the 15- to 90-min period (gastric emptying fraction<sub>15–90</sub>) of the Nonpregnant Control, Pregnant Control, and Parturient–Epidural groups. We assumed that mean ± SD of the gastric emptying fraction of a light meal at 90 min would be similar in the Nonpregnant Control and Pregnant Control groups (e.g., approximately 60 ± 15%<sup>17</sup>) and that it would be reduced by at least 30% in the Parturient–Epidural group (e.g., approximately 40 ± 15%). To show this with 90% power and 5% risk of type I error using one-way ANOVA, the inclusion of 10 women was required in each group. In the case of premature withdrawal of a participant during the study period, it was determined that the data collected concerning that participant would not be used for analysis; new participants would be included to replace such participants.

## Results

Forty-three women were included in the study: two women in the Parturient–Epidural group did not complete the session (inconclusive first ultrasound examination [*n* = 1]; gave birth within 120 min of the test meal [*n* = 1]) and one woman in the Pregnant group did not complete the session because her stomach was full at the first ultrasound. These

were replaced by other participants, and thus 40 women (10 per group) were included and analyzed. Women included in the Parturient–No–Epidural group were either women who did not want to receive any labor epidural ( $n = 2$ ) or women who did receive epidural analgesia later in labor after completion of the study ( $n = 8$ ).

There was no statistically significant difference in demographic characteristics and solid food fasting duration among the four groups; the duration of fasting for clear fluids was statistically significantly shorter in the Parturient–Epidural group compared to each Control group (table 1). The median (interquartile range) cumulative doses of ropivacaine and sufentanil in the Parturient–Epidural group were 16 mg (14 to 20) and 4  $\mu$ g (4 to 5), respectively, at time of inclusion, and 39 mg (21 to 41) and 10  $\mu$ g (5 to 10), respectively, at the end of the study. Among ultrasound examinations in the Parturient–Epidural group, the number of participants with pain scores greater than 3 did not change in a statistically significant way (1 of 10 at first ultrasound; 2 of 10 at last ultrasound;  $P = 0.754$ ); for ultrasound examinations in the Parturient–No–Epidural group, those with pain scores greater than 3 did not change in a statistically significant way (6 of 10 at first ultrasound; 10 of 10 at penultimate and last ultrasounds;  $P = 0.080$ ). Two-way ANOVA of pain scores over time in both Parturient groups found a statistically significant between-group difference ( $P < 0.001$ ), with, at each time point, a mean pain score statistically significantly higher in the Parturient–No–Epidural group than in the Parturient–Epidural group, and no statistically significant difference over time ( $P =$

0.063; fig. 1). Two women in the Parturient–Epidural group and four women in the Parturient–No–Epidural group had nausea; however, no participants vomited during the study period.

Two-way ANOVA of the repeated measurements of the antral areas among the four groups found a statistically significant difference over time with significant time  $\times$  group interaction ( $P < 0.001$ ; fig. 2). For Nonpregnant and Pregnant Control groups, *post hoc* analysis found a statistically significant increase in the antral areas measured at 15 and 60 min after the test meal compared to baseline values; there was no statistically significant difference between measurements performed at 90 and 120 min after the test meal and those performed at baseline. In the Parturient–Epidural group, *post hoc* analysis found a statistically significant increase in the antral areas measured at 15, 60, and 90 min after the test meal in comparison with baseline values; there was no statistically significant difference between measurement made at 120 min after the test meal and those made at baseline. In the Parturient–No–Epidural group, *post hoc* analysis found a statistically significant increase in the antral areas measured at 15, 60, 90, and 120 min after test meal in comparison with baseline values; furthermore, antral area measurements performed at 90 min after the test meal in the Parturient–No–Epidural group were statistically significant and higher than those in the Pregnant Control and Nonpregnant Control groups at 90 min after the test meal, and the antral area measurements taken at 120 min after the test meal in the Parturient–No–Epidural group were statistically significant and higher than those

**Table 1.** Main Characteristics of the Participants

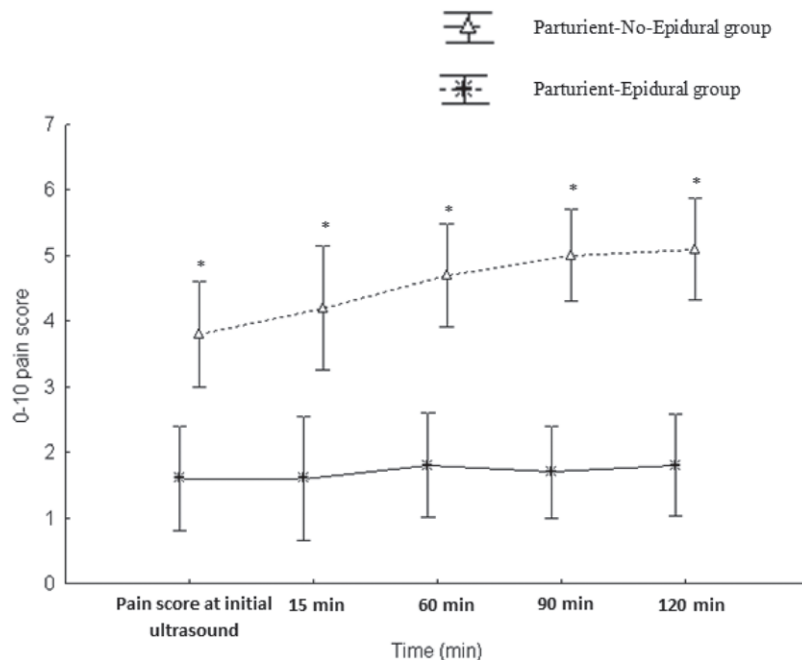
	Nonpregnant Control (n = 10)	Pregnant Control (n = 10)	Parturient–Epidural (n = 10)	Parturient–No–Epidural (n = 10)
Age, yr	29 $\pm$ 3	31 $\pm$ 3	32 $\pm$ 4	29 $\pm$ 5
Height, cm	167 (162–170)	165 (160–169)	168 (160–174)	164 (160–169)
Weight, kg	56 (54–65)	64 (55–76)	58 (56–68)	61 (52–68)
Body mass index, kg/m <sup>2</sup>	21 (19–22)	23 (21–27)	22 (19–24)	21 (19–23)
Weight gain during pregnancy, kg	Not applicable	10 (9–11)	12 (11–13)	13 (12–13)
Fasting duration for solids, h	10 $\pm$ 3	11 $\pm$ 2	11 $\pm$ 4	10 $\pm$ 3
Fasting duration for liquids, h*	9 $\pm$ 3	8 $\pm$ 4	5 $\pm$ 3†	6 $\pm$ 3
Parity				
0	Not applicable	5	6	6
1	Not applicable	5	1	4
$\geq 2$	Not applicable	0	3	0
Gravidity				
1	Not applicable	4	6	6
2	Not applicable	2	2	3
$\geq 3$	Not applicable	4	2	1
Gestational age‡	Not applicable	35 $\pm$ 2§	40 $\pm$ 1	40 $\pm$ 1
Cervical dilation at inclusion, cm	Not applicable	Not applicable	3 $\pm$ 1	3 $\pm$ 2
Oxytocin augmentation of labor	Not applicable	Not applicable	4	2

Data are expressed as mean  $\pm$  SD, median (interquartile range), or n. For women in the Pregnant Control, Parturient–Epidural, and Parturient–No–Epidural groups, weight and body mass index refer to before pregnancy.

\* $P = 0.012$  in one-way ANOVA. †Significant statistical difference ( $P < 0.05$ ) between Parturient–Epidural group and each of the control groups according to *post hoc* analysis.

‡ $P < 0.001$  in one-way ANOVA. §Significant statistical difference ( $P < 0.05$ ) between Pregnant Control group and each of the parturient groups according to *post hoc* analysis.





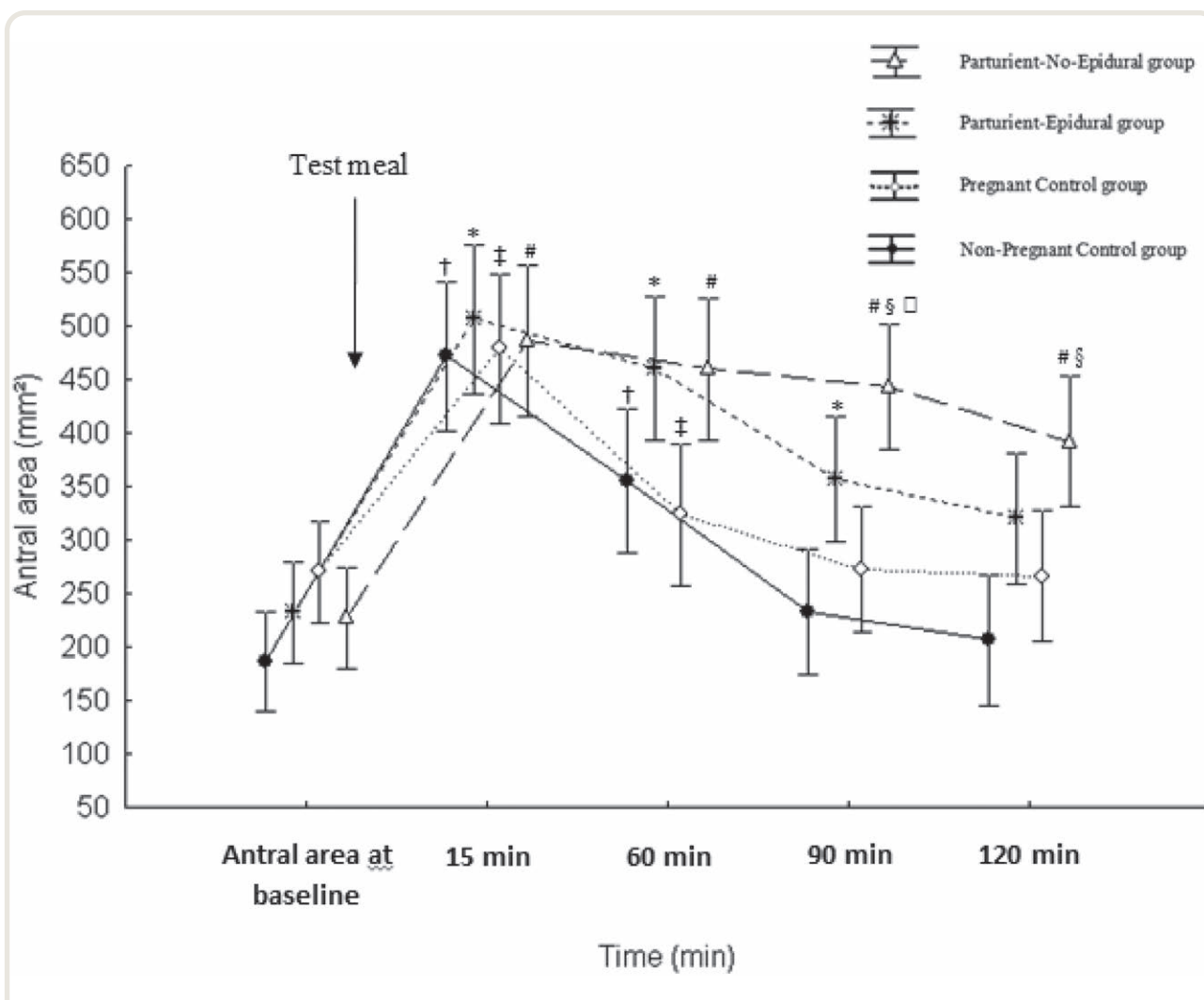
**Fig 1.** Pain score in parturients with labor epidural and parturients without labor epidural.  $P = 0.279$  for time  $\times$  group interaction.  $*P < 0.05$  compared to pain score measured at the same time in the Parturient–Epidural group. Vertical bars denote 95% Bonferroni corrected CI.

in the Nonpregnant Control group at 120 min after the test meal.

There was a statistically significant difference among the four groups in the 15- to 90-min gastric emptying fraction (gastric emptying fraction<sub>15-90</sub>; table 2). The median gastric emptying fraction at 90 min in the Parturient–Epidural group was statistically significant and lower than that in the Nonpregnant Control and Pregnant Control groups. The median gastric emptying fraction at 90 min in the Parturient–No–Epidural group was statistically significant and lower than in the Parturient–Epidural, Nonpregnant Control, and Pregnant Control groups. There was a statistically significant difference among the four groups with regards to the gastric emptying fraction at 60 min. The median gastric emptying fractions at 60 min in the Parturient–Epidural and Parturient–No–Epidural groups were statistically significant and lower than in the Nonpregnant Control and Pregnant Control groups (table 2; Supplemental Digital Content 1, <http://links.lww.com/ALN/C787>), without any statistically significant differences between the Parturient–Epidural and Parturient–No–Epidural groups. Half-time to gastric emptying was more than 120 min for six women in the Parturient–No–Epidural group; the remaining four participants in the Parturient–No–Epidural group had half-time to gastric emptying times ranging from 93 to 104 min. Therefore, data from the Parturient–No–Epidural group

were not considered for statistical analyses of gastric emptying half-time. The median half-time to gastric emptying was statistically significant and shorter in the Nonpregnant Control and Pregnant Control groups compared to that in the Parturient–Epidural group (table 2; Supplemental Digital Content 1, <http://links.lww.com/ALN/C787>).

Six participants in the Nonpregnant Control group had empty stomachs at 90 min after the meal; four Pregnant Control, three Parturient–Epidural, and zero Parturient–No–Epidural participants had empty stomachs at 90 min after the meal ( $P = 0.036$ ). There was a statistically significant difference between the Parturient–No–Epidural and the Nonpregnant Control groups. Solid food was seen in the gastric antrum 90 min after the meal in three participants from the Nonpregnant Control group, four from the Pregnant Control group, five from the Parturient–Epidural group, and seven from the Parturient–No–Epidural group ( $P = 0.319$ ). At 120 min after the meal, the stomachs of nine Nonpregnant Controls were empty, as well as those of eight Pregnant Control, six Parturient–Epidural, and one Parturient–No–Epidural participants ( $P = 0.0012$ ), with statistically significant differences between the Parturient–No–Epidural and both Control groups. Solid food was seen in the gastric antrum at 120 min after the meal in one participant in the Nonpregnant Control group, two in the Pregnant Control group, three in the Parturient group, and five in the Parturient–No–Epidural group ( $P = 0.224$ ).



**Fig. 2.** Antral cross-sectional area after a light meal in nonpregnant women, pregnant nonlaboring women, parturients with labor epidural, and parturients without labor epidural.  $P < 0.001$  for time  $\times$  group interaction. \* $\dagger\#\#P < 0.05$  compared to baseline value of antral area within each group.  $\$P < 0.05$  compared to antral area measured at the same time in the Nonpregnant Control group.  $\square P < 0.05$  compared to antral area measured at the same time in the Pregnant Control group. Vertical bars denote 95% Bonferroni corrected CI.

**Table 2.** Gastric Emptying Fractions and Half-time Gastric Emptying in Four Participant Groups

	Nonpregnant Control (n = 10)	Pregnant Control (n = 10)	Parturient-Epidural (n = 10)	Parturient-No-Epidural (n = 10)	P Value
Gastric emptying fraction at 90 min, %	52 (46–61)	45 (31–56)	31 (17–39)*	7 (5–10)†	0.0001
Gastric emptying fraction at 60 min, %	27 (15–36)	34 (22–52)	9 (2–17)*	4 (3–8) *	0.003
Half-time to gastric emptying, min	43 (32–64)	35 (22–49)	72 (54–130)*	Not applicable‡	0.008§

Data are expressed as median (interquartile range).

\* $P < 0.05$  compared with Nonpregnant and Pregnant Control groups. † $P < 0.05$  compared with Nonpregnant Control, Pregnant Control, and Parturient-Epidural groups. ‡Half-time to gastric emptying was  $>120$  min in six women for whom it could not be estimated; the remaining four women ranged from 93 to 104 min. §Statistical analysis was performed among the Nonpregnant Control, Pregnant Control, and Parturient-Epidural groups.

## Discussion

The main findings in this prospective study were the statistically and clinically significant lower gastric emptying fractions

and longer half-times to gastric emptying of a light meal in parturients receiving epidural analgesia compared with those fractions in nonpregnant and pregnant participants. Another important finding was the statistically significant lower gastric

emptying fraction in parturients not receiving epidural analgesia compared to parturients receiving epidural analgesia, as well as the nonpregnant and pregnant controls.

In the current study, we assessed the gastric emptying of a light meal using real-time gastric ultrasound with repeated measurement of the antral cross-sectional area for the calculation of the gastric emptying fraction at 90 min, according to a method that was previously validated and highly correlated to gastric scintigraphy in healthy volunteers and patients with diabetes.<sup>17,19</sup> Antral ultrasound is a noninvasive and nonionizing tool that allows for assessment of gastric emptying, irrespective of meal composition; its use was particularly appropriate in the setting of this study. In contrast, an acetaminophen absorption test only assesses the gastric emptying of fluids and requires venous blood samples to be drawn,<sup>20</sup> and scintigraphy, while the accepted standard, involves exposure to ionizing radiations and is not feasible in the delivery room.

The gastric emptying fraction in the 60 min after meal ingestion and half-time to gastric emptying were assessed in addition to the gastric emptying fraction at 90 min. The latter has been described for gastric emptying of the 330-kcal test meal<sup>17</sup>; however, it is well known that gastric emptying depends on meal composition and caloric content.<sup>21–24</sup> It could therefore be assumed that a light test meal of only 120 kcal would have been totally emptied from the stomach 90 min after ingestion,<sup>21,24</sup> affecting the comparison based on the gastric emptying fraction at 90 min among the four groups of patients. In the current study, we found statistically significant lower median values of the gastric emptying fraction at 90 min and the gastric emptying fraction at 60 min in the Parturient–Epidural group compared with the Nonpregnant Control and Pregnant Control groups, as well as a statistically significant longer half-time to gastric emptying in the Parturient–Epidural group compared with the Nonpregnant Control and Pregnant Control groups. These results are consistent with, and allow for, the estimation that gastric emptying of a light meal is 1.5 to 4 times slower in laboring women receiving epidural analgesia than in nonpregnant and pregnant women.

Furthermore, we found a statistically significant higher median gastric emptying fraction at 90 min in the Parturient–Epidural group than we found in the Parturient–No–Epidural group. Until now, the overall effect of epidural labor analgesia on the gastric emptying of a solid meal was unclear. Epidural analgesia may affect gastric emptying of a meal in two opposite ways: on the one hand, it minimizes the acute pain related to gastroparesis *via* pain relief, and on the other hand, it reduces gastric motility and delays gastric emptying due to the epidural opioid infusion.<sup>7,8,10</sup> In our study, pain scores were significantly higher in the Parturient–No–Epidural group than they were in the Parturient–Epidural group at each time point. Taken together, the results of the current study suggest that patient-controlled epidural analgesia with a low concentration of ropivacaine and sufentanil significantly

improves gastric motility and emptying compared to that seen in natural labor without analgesia.

Previous studies have assessed the gastric emptying of various liquids in term pregnant women and parturients, indicating that gastric emptying of liquids is not delayed during pregnancy.<sup>25,26</sup> Using antral ultrasound and acetaminophen absorption techniques, Wong *et al.*<sup>27,28</sup> found that gastric emptying was not delayed after ingesting 300 ml water compared to 50 ml water in both obese and nonobese term pregnant women. In parturients, acetaminophen absorption tests indicate less delayed gastric emptying of clear fluid in women receiving epidural analgesia than in those receiving no pain relief<sup>8</sup>; they also showed that gastric emptying of clear liquids had a statistically significant delay after systemic administration of narcotic analgesics and after epidural infusion of fentanyl with cumulated doses greater than 100 µg.<sup>7,29–31</sup> More recently it was reported that gastric emptying of maltodextrin is faster than that of both orange juice and coffee with milk in laboring women.<sup>21</sup> However, gastric emptying of solids differs from that of fluids.<sup>32,33</sup> It was previously shown that solid food remained in the stomach for many hours after the onset of labor in two thirds of laboring women who received epidural analgesia and that gastric volume was higher in the immediate postpartum period in women who were allowed solid food during labor compared with those who were fasted.<sup>11,34</sup> More recent studies suggest that some gastric motility and emptying persist in laboring women receiving epidural analgesia<sup>9,10</sup>; however, trials have appropriately assessed neither gastric emptying of a standardized, solid, light meal in parturients nor the effect of epidural analgesia during labor on the gastric emptying of such a meal. Barboni *et al.*<sup>35</sup> recently reported that gastric emptying of a standardized 450-kcal solid meal composed of pasta and meat was delayed in term pregnant women scheduled for cesarean delivery compared with nonpregnant volunteers. Such a meal is probably not desired by most women in labor,<sup>36</sup> and current European guidelines suggest allowing low-risk women to consume only easily digestible foods during labor.<sup>6</sup> Therefore, we believed that it was relevant to assess the gastric emptying of a semisolid light meal rather than that of a calorically higher solid meal in parturients with and without epidural analgesia.

The proportions of women with empty stomachs at 90 and 120 min after the test meal differed in a statistically significant way among the four participant groups, with a statistically significant lower proportion of empty stomachs at 120 min after the test meal in the Parturient–No–Epidural group compared with the Nonpregnant and Pregnant Control groups. However, no statistically significant difference was found between the Parturient–Epidural and other groups, despite the statistically significant delay in gastric emptying in the Parturient–Epidural group compared with the Pregnant and Nonpregnant Control groups. This result may be explained by insufficient sample size and thus lack of power to find a statistically significant difference regarding this secondary outcome. Nevertheless, only three women

had solid contents at 120 min after the test meal in the Parturient–Epidural group, while 9 of 10 laboring women without epidural analgesia had solid contents at the same time point. Thus, permitting laboring women to ingest a light meal during labor should be dependent on the use of epidural analgesia, as well as the consideration of delayed gastric emptying during labor. Results suggest that a solid light meal could probably be allowed in uncomplicated laboring women with labor epidural and low foreseeable risk for operative delivery within at least the next 2 h; likewise, a solid light meal could probably be allowed in women without epidural labor analgesia at the start of labor who are at low estimated risk of receiving general anesthesia within at least the next 4 h. Furthermore, gastric ultrasound could be useful for monitoring gastric content in parturients, as well as for guiding the decision to fast or feed during labor.

### Limitations

This study does have some limitations. Ultrasound examinations of the gastric antrum were performed by an investigator who could not be blinded to the study group. However, repeated standardized measurements of the antral area are reported to have high reproducibility and low intra- and interrater variability for the measurement of gastric emptying.<sup>17</sup> Similarly, high interrater reliability of qualitative ultrasound assessment of gastric contents has been reported in third-trimester pregnant women.<sup>14</sup> Another limitation was that accurate assessment of the gastric emptying of the light meal required that only parturients with empty stomachs be included. It can therefore be assumed that we included and selected parturients in whom some gastric motility persisted, and that our results may be neither extrapolated nor generalizable to all parturients. In particular, only nonobese women were included; the impact of obesity on gastric emptying of a light meal in parturients remains uncertain and should be assessed further as the prevalence of obesity exceeds 35% in the United States and affects an increasing part of the world's population.<sup>37</sup>

### Conclusions

To conclude, the gastric emptying of a light meal was delayed in a clinically significant way for parturients receiving epidural analgesia, and was further delayed in parturients not receiving epidural analgesia in comparison with pregnant and nonpregnant women. These results should lead anesthesiologists to remain cautious about permitting solid foods during labor, especially when no epidural analgesia is used. Gastric ultrasound could be useful for monitoring gastric contents, as well as for guiding the decision to fast or feed during labor.

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### Competing Interests

The authors declare no competing interests.

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