The online version of this article is located at http://www.minervamedica.it
Minerva Anestesiologica 2016 May;82(5):543-9

ORIGINAL ARTICLE

Ultrasound evaluation of the stomach and gastric emptying in pregnant women at term: a case-control study

Elisabetta BARBONI [1], Paola MANCINELLI [1], Ubaldo BITOSSI [2], Angelo R. DE GAUDIO [1], Massimo MICAGLIO [2], Flavia SORBI [3], Alessandro DI FILIPPO [1] *

[1]Section of Anesthesia, Intensive Care and Pain Therapy, Department of Health Sciences, University of Florence, Florence Italy; [2]Department of Anesthesia and Intensive Care, Careggi University Hospital; [3]Division of Obstetrics and Gynecology, Department of Biomedical, Clinical and Experimental Sciences, University of Florence, Careggi University Hospital, Florence, Italy

*Corresponding author: Alessandro Di Filippo, Section of Anesthesia, Intensive Care and Pain Therapy, Department of Health Sciences, University of Florence, Careggi University Hospital, Largo Brambilla 3, 50124 Florence, Italy. E-mail: adifilippo@unifi.it

ABSTRACT

BACKGROUND: This study aims to assess the rate of gastric emptying in pregnant women in the third trimester scheduled for elective caesarean section (CS), in view to highlight the aspiration risk.
METHODS: A prospective case-control study, with the approval of the Ethics Committee, was performed. At term pregnant women (group A) scheduled for CS and volunteer controls were recruited (group B). The ultrasonographic measurement of the antral area was performed, after a standardized meal, with a Convex probe. The antrum was displayed in the sagittal or parasagittal projections in the right upper quadrant, medial to the mid-clavicular line. The diameters of the antrum were measured and then the antral area was calculated. The measurements were conducted at 10 (T1), 90 (T2) and 240 (T3) minutes from the meal. Anthropometric data were collected for each patient.
RESULTS: In group B, antrum distention was observed already after 10 minutes from the meal, and then a gradual decrease in the antral area until 4 hours after the meal was registered. On the contrary, in group A (at term pregnant) there was an initial smaller increase of antral area, followed by a greater increase that lasts up to 90 minutes, and finally a delayed and smaller reduction.
CONCLUSIONS: In pregnant women at term, the stomach does not seem to be able to expand immediately after the meal. The transit of food is completed later than in not pregnant women. The ultrasound of the stomach allows identifying delays gastric emptying and highlighting patients at risk of aspiration.

(*Cite this article as*: Barboni E, Mancinelli P, Bitossi U, De Gaudio AR, Micaglio M, Sorbi F, *et al.* Ultrasound evaluation of the stomach and gastric emptying in pregnant women at term: a case-control study. Minerva Anestesiol 2016;82:543-9)

Key words: Anesthesia, obstetrical - Respiratory aspiration - Ultrasonography.

In order to assess the risk of aspiration at the bedside, ultrasound evaluation of the stomach has gained attention in recent years.

Recently, Cubillos *et al.* have suggested ultrasonography as a tool to obtain qualitative and quantitative information about the gastric contents.[1]

Bouvet *et al*. define the risk of aspiration of gastric contents such as the presence of solid material or a volume of gastric fluids greater than 0.8 mL/kg [2]. Moreover they have reported a significant correspondence between the antrum area measurement, antral cross-sectional area (CSA), and the gastric volume. They determined a cut-off of the antral CSA of 340 mm2 for significant risk of aspiration.[2]

It has stated recently that the risk of aspiration in pregnant women at term is low and that the restriction of food during labor is not justified.[3, 4] However, physiological characteristics of pregnant women suggest that ultrasound evaluation of the stomach can help in risk assessment.

In recent years, ultrasound came powerfully into clinical practice of anesthesiologists with many applications. In pregnant women, in whom the degree of filling of the stomach is supposed more than proved, could be a useful method for direct visualization of the gastric contents and for the assessment of the risk of aspiration.

This study aims to assess the rate of gastric emptying in two groups of patients: healthy volunteers of childbearing age and pregnant women in the third trimester scheduled for elective caesarean section (CS). Ultrasound visualization of the size of antral CSA at different times of observation after a normal meal of standard volume was adopted to determine the gastric emptying in both groups.

Materials and methods

This is a prospective case-control study performed at Careggi University Hospital conducted from March 1, 2015 to April 1, 2015. The study has obtained the approval from the Ethics Committee of the University Hospital of Careggi in Florence (prot.n. OSS 15027) and the informed consent by each woman was obtained. Cases (group A) were pregnant women at term scheduled for CS consecutively collected during observation period, aged more than 18 years, ASA I and II with an informed consent in the clinical record.

For each patient, a volunteer control was recruited (group B) according to the following match criteria: BMI (±1), age (±10 years) and childbearing age, female gender.

Exclusion criteria for the study group were: fetal growth retardation and preterm pregnancy.

Exclusion criteria for both cases and controls were: lack of informed consent, patients aged less than 18 years, emergency setting, history of at least one of esophageal disease, functional dyspepsia, gastric ulcer disease, gastrointestinal cancers, autoimmune diseases or diseases of the central nervous system.

The ultrasonographic measurement of the antral CSA, according to method described by Bouvet *et al*.[2] and Arzola *et al*.[5], was performed in each woman.

The measurement was performed by the same doctor who had six months of experience in the procedure; he has used the same ultrasound machine (MyLab™30 Gold - Esaote) with a convex probe in setting abdominal at a frequency of 2.0-5.0 MHz.

Patients were positioned supine and on the right side with the head of the bed rose 45 degrees above the level, similarly to as already reported in previous studies.[2, 5] The antral CSA was displayed in the sagittal or parasagittal projections in the right upper quadrant, medial to the mid-clavicular line. Sonographic landmarks such as the liver, aorta, vena cava, pancreas, and superior mesenteric vessels were used to identify antrum in the scanning area. The diameters of the antrum were measured and then the antral CSA [(D1 x D2 x π) / 4] [6] was calculated.

The measurements were performed after a standardized meal that had been preceded by at least six hours of fasting (dinner). A standardized meal was defined as a pasta dish of 70 g, a main course of meat (150 g) and a salad side dish more 2 glasses of water (300 mL) for an intake of calories equivalent to about 450 kcal, of which 10 g of lipids, 55 g of carbohydrate and 35 g of protein. Women were required to take the meal in a measured time of 10 minutes. The measurements were conducted, by the same investigator with six months experience, at 10 (T1), 90 (T2) and 240 (T3) minutes from the meal (Figures 1-6). This differs from what has been done in other studies: Arzula *et al*. have evaluated pregnant patients with an empty stomach, or who have took only clear liquids or solid foods such as a small muffin and coffee with cream or milk, while Bouvet *et al*. have enrolled adult patients undergoing elective or emergency surgery under general anesthesia.

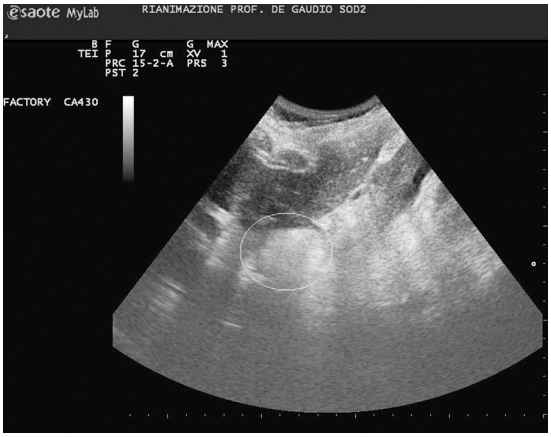

Figure 1.—Antral cross sectional area (CSA) measured with ultrasonography in a pregnant woman (group A) at T1: 10 minutes after a standard meal.

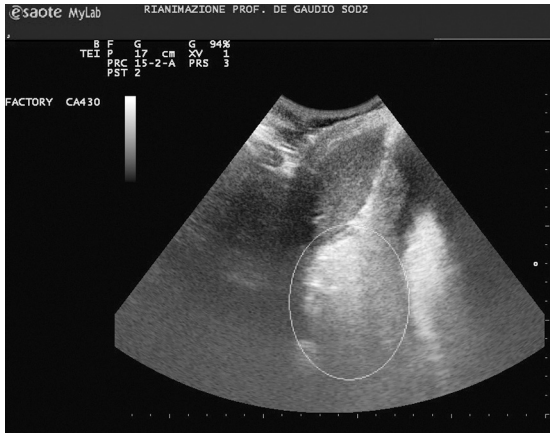

Figure 2.—CSA measured with ultrasonography in a pregnant woman (group A) at T2: 90 minutes after a standard meal. The posterior wall of the stomach, as we expected, is not well viewable.

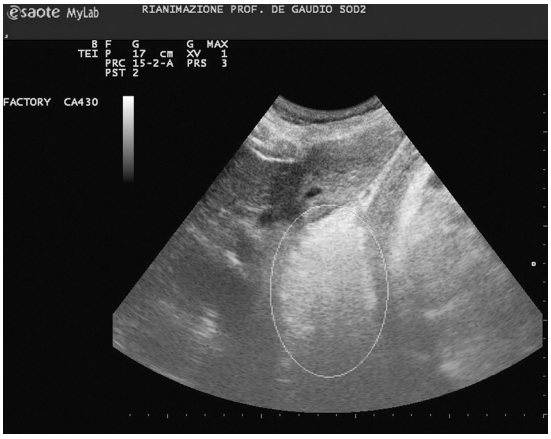

Figure 3.—CSA measured with ultrasonography in a pregnant woman (group A) at T3: 4 hours after a standard meal.

Figure 4.—CSA measured with ultrasonography in a voluntary (group B) at T1: 10 minutes after a standard meal. It is viewable the typical "starry night" appearance.

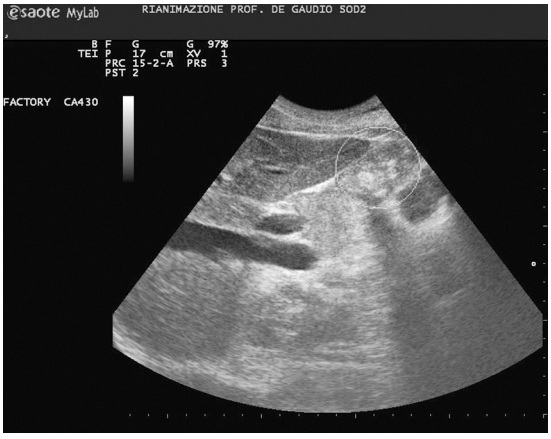

Figure 5.—CSA measured with ultrasonography in a voluntary (group B) at T2: 90 minutes after a standard meal.

Figure 6.—CSA measured with ultrasonography in voluntary (group B) at T3: 4 hours after a standard meal.

TABLE I.—*Anthropometric parameters. Comparison between two group of women. Group A: pregnant women at term scheduled for caesarean section; group B: for each patient, a volunteer control recruited according to the following match criteria: BMI (±1), age (±10 years) and childbearing age, female gender.*

	Group A (pre-pregnancy)	Group B	P
Age (years)	33.7±3.8	31±2.8	NS
Weight (kg)	59.9±6.6	61±5.9	NS
Height (cm)	167.5±9.2	165.3±5.3	NS
BMI	21.4±2.5	22.3±1.9	NS

Anthropometric data (such as age, current and pre-pregnancy weight, height, current and pre-pregnancy BMI), the presence of simultaneous diseases (other than those included in the exclusion criteria) and drugs affecting gastric emptying, were collected for each patient.

Data were reported as mean (±standard deviation). The sample size was calculated with SPSS 10.0 to obtain a power of 90% and a probability of type I error of 0.05 for case-control studies. ANOVA and *t*-Student tests were used to compared continues variables between the two groups. The significance was assigned to P-value lower than 0.05.

Results

Ten pregnant women scheduled for CS and ten volunteers were enrolled.

The two groups of patients did not differ significantly for other as regards the age (group A *vs.* group B: 33.7±3.83 *vs.* 31±2.83 years; P=NS), the weight (pre-pregnancy group A *vs.* group B: 59.9±6.64 *vs.* 61±5.90 kg; P=NS), the height (group A *vs.* group B: 167.50±9.20 *vs.* 165.30±5.27 cm; P=NS) and BMI (pre-pregnancy group A *vs.* group B: 21.41±2.46 *vs.* 22.32±1.90; P=NS) (Table I).

During the observation period no patient was reported to be suffering from any disease or taking drugs that affect gastric emptying times.

In group B, antrum distention was observed already after 10 minutes from the meal, and then a gradual decrease in the volume until 4 hours after the meal was registered (Figure 7).

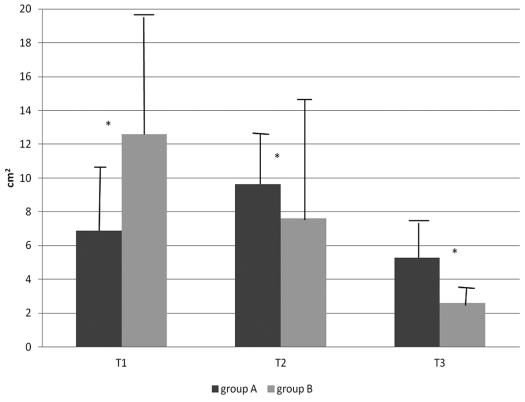

Figure 7.—Antral cross sectional area measured with ultrasonography after standard meal in two groups of women. Group A: pregnant women at term, group B voluntaries in childbearing age; T1: 10 minutes after the meal, T2: 90 min after the meal, T3: 4 hours after the meal. *P<0.05.

On the contrary, in group A there was an initial smaller increase of antral CSA (group A *vs.* group B, T1: 12.59±7.33 *vs.* 6.89±3.48 cm²; P<0.05), followed by a greater increase that lasts up to 90 minutes, and finally a delayed and smaller reduction (T2: group A *vs.* group B: 7.62±7.09 *vs.* 9.64±3; P<0.05; T3: group A *vs.* group B: 2.60±0.86 *vs.* 5.27±2.13 cm²; P≤0.05) (Figure 7, Table II).

Concerning antral CSA differences between the two groups at each time-lapse, significant differences were observed during the first 90 minutes and during the entire period of observation (group A *vs.* group B: antral CSA Δ T2-T1=-4.98±6.39 *vs.* -2.74±3.2 cm², P<0.05; Δ T3-T2=-5.01±6.89 *vs.* -4.37±3.05 cm², P<0.05; and Δ T3-T1=-9.99±7.38 *vs.* -1.62±3.89 cm²; P<0.05) (Figure 8, Table II).

Discussion

Due to the physiological changes of pregnancy, pregnant women are considered, by definition, "with a full stomach" regardless of the hours of fasting. In particular, the modifications of the gastrointestinal system are related to the growth of the uterus, mainly on the right side. As a result, the stomach and the intestinal loops are pushed cranially at the top and to the left side. The lifting and rotation of the stomach reduces the effect of "valve narrowing" at

TABLE II.—*Differences in antral cross sectional area measured with ultrasonography after standard meal in two groups of women. Group A: pregnant women at term; group B: voluntaries in childbearing age; T1: 10 minutes after the meal, T2: 90 min after the meal, T3: 4 hours after the meal.*

Antral area difference	T2-T1	T3-T2	T3-T1
Group A (cm²)	-4.98±6.39	-5.01±6.89	-9.99±7.38
Group B (cm²)	-2.74±3.2	-4.37±3.05	-1.62±3.89
p	P<0.05	P<0.05	P<0.05

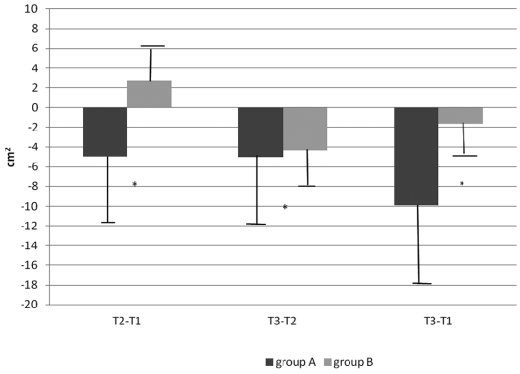

Figure 8.—Differences in antral cross sectional area measured with ultrasonography after standard meal in two groups of women. Group A: pregnant women at term, group B voluntaries in childbearing age; T1: 10 minutes after the meal, T2: 90 min after the meal, T3: 4 hours after the meal. *P<0.05.

the esophagus-gastric junction, with less hindrance to reflux.

The mechanical alterations are associated with changes in hormonal status typical of the pregnancy. Progesterone and estrogen produced by the placenta lead to a reduction in muscle tone of the entire gastrointestinal tract.[7] Particularly, the gestational hormonal status relaxes the smooth muscle of the lower esophageal sphincter, reducing the pressure barrier that normally prevents acid reflux. Furthermore, there is a higher concentration of gastrin, a hormone able to increase the volume and acidity of gastric secretions, due to an ectopic production form the placenta.

Although most authors agree in defining the slowing gastric emptying as typical of pregnancy, there are studies that do not confirm this theory.[8, 9] Furthermore, literature data report the risk of aspiration in pregnant women as low [3] and, as a result, it has been stated that the food restriction during labor is not justified.[4]

On the contrary, the data collected in our study confirm that gastric emptying in women at the end of pregnancy is slowed down. This is, in our opinion, the major finding of the study.

Unfortunately, the calculation methods of the gastric volume [10] do not apply to pregnant women because of the position of the uterus that changes the anatomical site of the stomach. Nevertheless, the ultrasound evaluation of the antral area, in the light of our results, appears to give meaningful information on gastric emptying times and on dynamics of digestion in women at term pregnancy. These results are significant because they highlight the need for caution on the part of anesthesiologists in the management of pregnant women in respect of risk of aspiration.

In fact, in the study group we have observed a late gastric emptying that occurred in a slow and incomplete manner: four hours after the meal antral area was significantly greater than that of non-pregnant women (Figure 7) and the area reduction between T3 and T1 was only 1.62 cm² in pregnant women against 9.91 cm² reduction observed in the control group (Figure 8).

The data collected confirm that the mechanical push of the uterus on the stomach may result in a delayed gastric emptying after the meal and that women at term of pregnancy should be considered "at full stomach" after a few hours after eating (at least for the 4 hours).

Therefore, our results confirmed the need to allow only small volumes of clear liquids during labor, as previously stated,[11] and, especially in patients at increased risk of operative delivery or CS.

The conduction of this study has confirmed what has been observed in the literature:[1, 12-20] the ease of implementation and the utility of the ultrasound analysis of the times of gastric emptying. In particular, the difference observed between emptying times in non-pregnant women and those in pregnant, emphasiz-

es that the gastric ultrasonography should be part of the anesthesiologists armamentarium in order to evaluate the state of filling of the stomach before general anesthesia for CS and, whether the risk of aspiration is too high, prepare the anesthetic techniques more indicated to minimize the risk.

In fact, even if the spinal anesthesia is the most suitable technique in cesarean section, remaining rare indications to general anesthesia in which the risk of aspiration is urgent.

The technique of gastric ultrasound is not simple and must still be learned through a training which requires the execution of at least 30 investigations.[21] Therefore, learn this technique should be a common goal in order to reduce the risk of aspiration even in the rare cases of general anesthesia.

Some limitations of this study exist. The visualization of an empty stomach can be difficult, and its measurement impossible. We have therefore chosen not to measure the gastric antrum on an empty stomach. The number of measurements is small but the difference of the measures in the two groups of patients at the observation times was so evident as to reach the significance even with a small sample.

Future researches are needed to improve the imaging technique and correlate the degree of filling the stomach with the actual risk of inhalation. These studies should also consider the type of meal assumed (in terms of caloric intake and nutrients) in order to highlight a more accurate correlation between the type of meal assumed and gastric emptying times; this could be useful in future to advise pregnant women about the type of feeding to follow.

Conclusions

The ultrasound of the stomach is a diagnostic tool for the anesthesiologist at the end of pregnancy. It allows identifying delays gastric emptying and highlighting patients at risk of aspiration in the course of cesarean delivery.

Key messages

— The ultrasonographic assessment of the stomach allows us to highlight indirectly the presence of gastric contents.

— Detect the presence of gastric contents can be particularly useful in pregnant women that have to be subjected to surgical procedures.

— Our study showed that gastric emptying in pregnant women is significantly slowed down.

— The ultrasound study of the stomach could be a valuable aid for anesthesiologists in the evaluation of pregnant women.

References

1. Cubillos J, Tse C, Chan VW, Perlas A. Bedside ultrasound assessment of gastric content: an observational study. Can J Anesth 2012;59:416-23.
2. Bouvet L, Mazoit JX, Chassard D, Allaouchiche B, Boselli E, Benhamou D. Clinical assessment of the ultrasonographic measurement of antra area for estimating preoperative gastric content and volume. Anesthesiology 2011;114:1086-92.
3. Singata M, Tranmer J, Gyte GM. Restricting oral fluid and food intake during labour. Cochrane Database Syst Rev. 2010 Jan 20;(1):CD003930
4. Maharaj D. Eating and drinking in labor: should it be allowed? Eur J Obstet Gynecol Reprod Biol 2009;146:3-7.
5. Arzola C, Cubillos J, Perlas A, Downey K, Carvalho JCA. Interrater reliability of qualitative ultrasound assessment of gastric content in the third trimester of pregnancy. Br J Anaesth 2014;113:1018-232.
6. Bataille A, Rousset J, Marret E, Bonnet F. Ultrasonographic evaluation of gastric content during labour under epidural analgesia: a prospective cohort study. Br J Anaesth 2014;112:703-7.
7. Shah S, Nathan L, Singh R, Fu YS, Chaudhuri G. E2 and not P4 increase NO release from NANC nerves of the gastrointestinal tract: Implications in pregnancy. Am. J Physiol Regul Integr Comp Physiol 2001;280:R1546-R1554.
8. Murray FA, Erskine JP, Fielding J. Gastric secretion in pregnancy. J Obstet Gynaecol Br Emp 1957;64:373-81.
9. Wong CA, McCarthy RJ, Fitzgerald PC, Raikoff K, Avram MJ. Gastric emptying of water in obese pregnant women at term. Anesth Analg 2007;105:751-5.
10. Perlas A, Mitsakakis N, Liu L, Cino M, Haldipur N, Davis L *et al*. Validation of a mathematical model for ultrasound assessment of gastric volume by gastroscopic examination. Anesth Analg 2013;116:357-63.
11. American Society of Anaesthesiologists. Practice guidelines for obstetric anesthesia: An update report by the American Society ofAnaesthesiologists Task Force on Obstetric Anesthesia. Anesthesiology 2007;106:843-63.
12. Sijbrandij LS, Op den Orth JO. Transabdominal ultrasound of the stomach: a pictorial essay. Eur J Radiol 1991;13:81-7.
13. Perlas A, Chan VW, Lupu CM, Mitsakakis N, Hanbidge

A. Ultrasound assessment of gastric content and volume. Anesthesiology 2009;111:82-9.
14. Bouvet L, Miquel A, Chassard D, Boselli E, Allaouiche B, Benhamou D. Could a single standardized ultrasound measurement of antral area be of interest for assessing gastric contents? A preliminary report. Eur J Anesthesiol 2009;26:1015-9.
15. Sporea I, Popescu A. Ultrasound examination of the normal gastrointestinal tract. Med Ultrason 2010;12:349-52.
16. Perlas A, Davis L, Khan M, Mitsakakis N, Chan VW. Gastric sonography in the fasted surgical patient: a prospective descriptive study. Anesth Analg 2011;113:93-7.
17. Cubillos J, Tse C, Chan VW, Perlas A. Bedside ultrasound assessment of gastric content: an observational study. Can J Anaesth 2012;59:416-23.
18. Fujigaki T, Fukusaki M, Nakamura H, Shibata O, Sumikawa K. Quantitative evaluation of gastric contents using ultrasound. J Clin Anesth 1993;5:451-5.
19. Bouvet L, Mazoit JX, Chassard D, Allaouchiche B, Boselli E, Benhamou D. Clinical assessment of the ultrasonographic measurement of antral area for estimating preoperative gastric content and volume. Anesthesiology 2011;114:1086-92.
20. Jacoby J, Smith G, Eberhardt M, Heller M. Bedside ultrasound to determine prandial status. Am J Emerg Med 2003;21:216-9.
21. Arzola C, Carvalho JC, Cubillos J, Ye XY, Perlas A. Anesthesiologists' learning curves for bedside qualitative ultrasound assessment of gastric content:a cohort study. Can J Anaesth 2013;60:771-9.

Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Article first published online: November 10, 2015. - Manuscript accepted: November 6, 2015. - Manuscript revised: October 8, 2015. - Manuscript received: July 9, 2015.