NPO during labor: Is there any scientific validation?

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Nil by mouth (NPO) policies were introduced into the labor wards of many Western countries in the 1940s and 1950s because of the belief that this would reduce the incidence of pulmonary aspiration of gastric contents should general anesthesia be required. These policies were maintained by successive generations of obstetric anesthesiologists and supported by obstetricians, midwives, and other caregivers. Recently the support from some obstetricians and increasing numbers of midwives has waned. Pulmonary aspiration is increasingly rare in Western practice, and few midwives or obstetricians have had to witness the devastating sequelae [1]. In this era of evidence-based medicine, supporters of the NPO approach are coming under increasing pressure from midwife and maternal pressure groups to produce clinical data to back their policies. These groups expound the theoretical, metabolic, and psychological benefits of allowing a more liberal approach to eating and drinking during labor.

Death or significant morbidity from pulmonary aspiration is so rare that the use of randomized controlled trials to examine this outcome directly is impossible. Conversely, the subtle improvements that might result from allowing oral intake are confounded by the multitude of other factors that affect labor, and no convincing report of benefit has been published in the literature. The evidence that does exist is limited to the knowledge of the physiologic principles involved, studies using surrogate markers for outcome, observational data, and several anecdotal reports, all of which have their limitations. This article attempts to draw together the available evidence and provide some guidance for physicians who, increasingly, only can advise rather than dictate labor ward policy.

The decline in maternal mortality from pulmonary aspiration of gastric contents

In his 1946 landmark paper, Curtis Mendelson drew attention to the devastating consequences of gastric aspiration in pregnant women [2]. He audited 44,016 pregnancies, in which 66 women suffered pulmonary aspiration. In 45 of these cases the aspirated material was recorded: 40 mothers aspirated liquid and the remaining 5 aspirated solid food. Of significance, yet often overlooked, is the fact that only two mothers died. It was suggested that the cause of death was asphyxiation caused by aspiration of solid food. The women who did not asphyxiate but who went on to develop aspiration pneumonitis [suggested] survived. The term ”Mendelson's syndrome” became synonymous with the concept of pulmonary acid aspiration pneumonitis, and researchers have focused on

quantifying the volume and pH of solution required to be lethal in several animal models [3,4]. This preoccupation has driven the development of strategies to reduce gastric pH and volume, thereby causing investigators and clinicians to overlook the importance of the physical consistency of the oral intake.

In the decades after the publication of Mendelson's data, the series of triennial confidential reports on maternal death in the United Kingdom highlighted the initial importance and subsequent decline in the incidence of maternal death from aspiration of gastric contents (Fig. 1)[1]. These reports indisputably document a tremendous clinical success story, but the real cause to which this decline in maternal deaths can be attributed remains unproven. After Mendelson's paper and the early triennial reports, NPO policies were rapidly introduced. Several other clinical recommendations that changed anesthetic practice have been introduced since then, however, and may have obscured the importance of NPO policies (see Box 1).

Fig. 1. Maternal mortality from anesthesia (*white*) and pulmonary aspiration (*black*), 1952–1999. (*From* Department of Health. Reports on confidential enquiries into maternal deaths in England and Wales / United Kingdom 1952–1999. London: HMSO; 1957–2001; with permission.)

Box 1:

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Intubation and rapid sequence induction
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Antacids and H2 antagonists
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Increased use of regional anesthesia
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Increased training and education of obstetric anesthesiologists
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NPO policies

Tracheal intubation and the technique of rapid sequence induction with cricoid pressure were introduced in obstetric practice in the 1970s. Although it might seem

obvious that intubation is and remains mandatory to reduce the incidence of pulmonary aspiration, the rise in aspiration-related mortality in the three triennial reports from the United Kingdom between 1964 and 1972 (Fig. 1) resulted primarily from complications associated with failed or misplaced intubation. Failed intubation remains a prominent complication of general anesthesia in the pregnant population. Despite the recognition that anesthesiologists must achieve a high level of training before they are allowed to manage patients in labor, the incidence of failed intubation is still reported to be as high as 1:250 [5]. In such circumstances, increasing the chance of presenting an anesthesiologist with an unstarved patient by abandoning NPO policies may carry a heavy price.

The introduction of H2 antagonists was based on the work on animal models, subsequent to Mendelson's original paper [3,4]. It seems intuitive that reducing the acidity of residual gastric contents might reduce morbidity and mortality associated with aspiration pneumonitis, but this is difficult to prove clinically.

The increased use of regional techniques for cesarean section undoubtedly reduces the risk of pulmonary aspiration. Evidence suggests, however, that this does not explain the reduction documented in the United Kingdom series. In 1995, Brown and Russell published a survey of UK obstetric anesthetic practice [6]. The survey demonstrated that although the use of regional anesthesia had increased overall, so too had the number of emergency cesarean sections. There was no change in the absolute number of emergency cesarean sections performed under general anesthesia—the group identified as most at risk from pulmonary aspiration—but fewer of these women died as a result of aspiration. Although the increase in use of regional anesthesia may have prevented a rise in maternal deaths from aspiration, it fails to explain fully the remarkable fall documented in the United Kingdom [1].

The attention brought to focus on maternal mortality by Mendelson's paper and the subsequent reports and the high-profile nature of maternal mortality have resulted in improved training for obstetric anesthesiologists. Undoubtedly this has improved obstetric anesthetic care and reduced maternal morbidity and mortality, but this is something that cannot be proved.

In summary, many changes have, in varying degrees, led to a welcome reduction in the incidence of maternal mortality from aspiration. In this context it is impossible to prove or refute the importance of NPO policies.

Gastrointestinal anatomy and physiology in pregnancy

Several changes that occur during pregnancy and labor may increase the risk of pulmonary aspiration should general anesthesia be required. Broadly these changes can be divided into anatomic changes that increase the incidence of failed

or difficult intubation and physiologic changes that increase the likelihood of gastroesophageal reflux and subsequent aspiration.

The anatomic changes that complicate intubation in pregnancy have been well described. Laboring women tend to have full dentition, raised body mass index, and enlarged breasts. All these factors can make application of cricoid pressure and laryngoscopy difficult. Incorrectly applied cricoid pressure and the tendency of fluid to collect in the soft tissues of the oropharynx in late pregnancy may further obscure the view of the larynx. The increase in maternal oxygen demand and the reduction in pulmonary functional residual capacity result in early desaturation even after assiduous preoxygenation, and they add to the psychological pressure of the emergency obstetric situation, which increases the chances of a failed intubation.

Symptomatic gastroesophageal reflux occurs in up to 80% of pregnant women by term, and studies that used lower esophageal pH monitoring demonstrated significant reflux, even in women without symptoms [7,8]. The tendency to reflux lies in the difference between lower esophageal sphincter pressure and intragastric pressure, the so-called “barrier pressure.” Intragastric pressure steadily rises during the course of pregnancy as a result of the increasing size of the gravid uterus. At the same time, lower esophageal sphincter tone declines as a result of the high circulating progesterone levels, which results in an overall decrease in barrier pressure and an increasing tendency to reflux as pregnancy progresses. Anesthetic agents, particularly induction agents and opioids, relax the upper esophageal sphincter and may allow reflux into the pharynx and subsequent aspiration of gastric contents—a particular hazard for women in whom the protection provided by the lower esophageal sphincter is deficient.

The influence of pregnancy and labor on the rate of gastric emptying has been a subject of much investigation and debate. Techniques used to measure gastric emptying in pregnancy and labor have included radiographic studies [9,10], dye dilution [11], real time ultrasound [12], gastric impedance [13], and acetaminophen absorption [14–19]. Although labor may have a varying effect on the rate of gastric emptying, all studies seem to concur that pregnancy alone has none.

Measuring gastric emptying in labor is technically and ethically challenging. Currently a reasonable body of evidence, using several different techniques, indicates that active labor delays the rate of gastric emptying [10,11,16,17]. The most acceptable and widely reported technique for measuring gastric emptying in labor is the acetaminophen absorption technique. Acetaminophen is not absorbed until it leaves the stomach, whereupon it is rapidly taken up in the small intestine [20]. The rate of rise in plasma acetaminophen levels is directly related to the rate of gastric emptying. In particular, the maximum plasma acetaminophen level, the

time taken to achieve maximum concentration, and the area under the concentration versus time curve are calculated. Although simple, the technique has its limitations. Subjects must be starved and the test only correlates with the rate of gastric emptying of liquids. Solids and semi-solids behave differently from liquids, do not correlate with acetaminophen absorption, and, as suggested by Mendelson [2], are probably more important as a cause of maternal mortality.

Acetaminophen studies show that whereas the rate of gastric emptying may be normal or increased in early labor, it is delayed in late labor [16,17]. The cause of this delay in gastric emptying in advanced labor is unclear. Pain delays gastric emptying [21], but even when labor pain is abolished with epidural techniques using local anesthesia alone, delay still occurs [16,17]. Parenteral opioids are known to exacerbate this delay in gastric emptying and increase residual gastric volume at the time of delivery [9,10,17,22]. The effect of neuraxial opioids on gastric emptying is less clear. Porter et al examined the effects of infusions of low dose epidural anesthetics in combination with fentanyl [18]. Up to a total dose of 100 É g fentanyl, gastric emptying was not delayed over and above the effect of labor itself. When the total dose exceeds 100 É g, however, or if given by bolus, epidural fentanyl seems to cause a significant delay in gastric emptying [14,18].

Although simple, noninvasive, and able to visualize solid particles, real time ultrasound scanning has been shown to be unreliable in advanced pregnancy and labor because of displacement and distortion of the gastric signal [12]. Davison et al used a dye dilution technique to show that gastric emptying is delayed during labor [11]. As with acetaminophen, this technique almost certainly reflects emptying of liquids rather than solids. The definitive technique to examine the gastric emptying of solids or semisolids is the use of radiographic studies. Although such studies likely would be unacceptable currently, in 1950, La Salvia et al used barium meals to confirm that labor delays gastric emptying of solids and that this delay is exacerbated by administration of parenteral opioids [10].

The metabolic advantages of eating and drinking in labor

Labor is a highly demanding metabolic challenge for mother and fetus. Metzger showed that women in the third trimester of pregnancy exhibit a state of ”accelerated starvation” if denied food and drink [23]. This state results in the accelerated production of ketones—in particular É¿-hydroxybutyrate and acetoacetic acid—and the non-esterified fatty acids from which they are derived. These changes are compounded by the metabolic demands of labor and delivery, but have not been shown to bear any relationship to maternal or fetal acid base balance [24,25].

In the 1960s and 1970s, concern about the detrimental effects of maternal ketosis led to the administration of intravenous dextrose as a preventive measure.

Although initial reports were promising [25,26], it quickly became apparent that such strategies were detrimental and so the practice was abandoned. Mothers and babies became hyponatremic and fluid overloaded, and after delivery, babies exhibited rebound hypoglycemia, jaundice, and lactic acidosis, particularly when there had been fetal compromise [27–30].

The production of ketones is a useful physiologic adaptation to produce an alternate energy supply when glucose is lacking. For many years, it was believed that these substrates could not be used by vital organs in mother and fetus, particularly the brain of mother and fetus and the contracting uterus. This belief has been disproved and the question remains as to whether the production of ketones is detrimental to the progress and outcome of labor or is an appropriate physiologic response to provide energy.

In 1983, Lind suggested that “the problems of dehydration, hypoglycaemia and ketosis have probably been overstated” [31]. Subsequent to this statement, the introduction of active management of labor has meant that labors are shorter, the development of ketosis is less severe, and investigation into the possible detrimental effects of this metabolic state have become rare in obstetric literature [32].

The outcome of labor

Initial reports that examined the use of intravenous dextrose infusions not only claimed improvement in fetal parameters but also suggested that the progress and outcome of labor were enhanced [26]. The subsequent metabolic disadvantages of dextrose infusions for mother and baby have seen such strategies abandoned, but many researchers still believe that rehydration with isosmolar crystalloid infusions may be beneficial. Infusions of normal saline can improve markers of fetal well-being and reduce maternal ketosis, but there is no proof that this improves the outcome of labor [33]. Some evidence suggests that intravenous crystalloid volume loading may slow the progress of labor. Cheek et al reported that intravenous administration of a liter of normal saline transiently reduced uterine contractility, although this did not seem to increase the overall length of labor or produce any detrimental outcome [34].

In contrast, a recent randomized controlled trial of the effect of increased intravenous hydration during labor (Ringer's lactate solution, 125 mL versus 250 mL h-1) showed that the incidence of labor lasting more than 12 hours was statistically higher in the 125 mL h-1 group [35]. It was also suggested that the incidence of oxytocin use was less in the 250 mL h-1 group. Two hundred fifty mL h-1 is a large amount of fluid to give intravenously, even to a normal pregnant woman, and it may cause fluid overload in mother and baby. Although preventing dehydration is probably beneficial during labor, this may not be the correct route for

administration of fluids. In the healthy uncomplicated parturient, perhaps the oral route might be more logical.

The cornerstone of the midwifery-led thrust to promote eating as being beneficial for the progress and outcome of labor was a report from the North Central Bronx Maternity Hospital [36]. This municipal hospital in New York City serves one of the most disadvantaged populations in the United States. Historically, eating and drinking had been allowed and even encouraged in labor; however, Ludka reported a 6-month period during which an NPO policy was imposed. There is no documentation as to why such a sudden change in practice was introduced, but it was claimed that the new policy led to the following dramatic changes in labor outcomes:

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The use of chemicals to stimulate labor increased fivefold
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Instrumental deliveries increased by 35%
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Cesarean sections increased by 38%
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Successful vaginal births after previous cesarean section decreased by 37%
*

The need for intensive care for neonates increased by 69%
*

The unit had its first case of maternal aspiration

Taken at face value, these changes might be of great concern, but in reality they seem too astonishing to be entirely credible. Despite being presented as an abstract at a congress in The Hague in 1987 and being mentioned frequently in subsequent reviews [36,37], this report has never been published as a formal peer reviewed paper. Results are reported as percentages and background data are lacking. There are no demographic data, no information as to why the NPO policy was introduced, and no indication of whether any other parallel changes in obstetric management that could have affected or confounded the outcomes occurred at the same time. Although the data from North Bronx may look superficially compelling, it remains no more than an anecdotal report. Until it is

presented with all the background data in a peer reviewed journal, it is impossible to engage in a reasoned debate over the author's claims.

Indirect evidence on eating and drinking in labor

A report in the British medical magazine *Hospital Doctor* in 1992 presented preliminary results from a pilot study at the Jubilee Hospital in Belfast of 44 low-risk women who were allocated randomly to two groups [38]. One group was allowed a light diet, the other sips of water only. Mothers who were allowed to eat needed less intervention and requested meperidine later in labor. Neonatal Apgar scores also were higher in the eating group. Unfortunately, full details of this pilot or the proposed large follow-up study have yet to be published.

In 1999, a group from St. Thomas' Hospital in London published the results of a prospective, randomized study that examined the effect of a light diet on the metabolic profile, the outcome of labor, and the risk of aspiration [39]. Women who presented at term in early, uncomplicated labor with a singleton fetus and cephalic presentation were stratified by parity and randomized to receive either a light, low-fat diet or water only. Any women who requested parenteral opioid (meperidine) analgesia were excluded because of the well-documented effect on gastric emptying [22]. Epidural analgesia using low-dose bupivacaine, 0.0625% to 0.1%, and fentanyl, 2 É g mL-1, was permitted.

Women in the eating group were allowed a low-residue diet (toast, cereal, crackers, low-fat cheese) and a range of drinks (water, juice, tea, coffee, cocoa) throughout labor. In general, women became increasingly disinterested in eating as labor progressed, the exception being women with epidural analgesia.

The development of ketosis in the two groups was compared by measuring plasma É¿-hydroxybutyrate, the principle ketone produced in labor, and non-esterified fatty acids, from which ketones are derived. Plasma glucose also was measured. The results demonstrated that the light diet prevented the rise in É¿-hydroxybutyrate and non-esterified fatty acids seen in the starved group during the first stage of labor (Table 1). Glucose levels were higher in the eating group. In contrast to the experience in North Bronx, there were no differences in the length or outcome of labor and, unlike the report from Belfast, there was no difference in neonatal Apgar scores.

Table 1. Plasma values of metabolites measured at the end of the first stage of labor

	Eating mean (SE)	Starved mean (SE)	Estimate of difference	95% confidence interval of difference	*P* value
É¿-hydroxybutyrate: mmol/L	0.020 (0.003)	0.058 (0.008)	0.038	0.021 – 0.055	0.000

Non-esterified fatty acids: mmol/L	0.85 (0.05)	1.20 (0.05)	0.35	0.22 – 0.48	0.000
Glucose: mmol/L	5.20 (0.14)	4.58 (0.15)	0.62	0.22 – 1.01	0.003

Estimates adjusted for baseline and confidence intervals use robust standard errors.

Data from Scrutton MJL, Metcalfe GA, Lowy C, et al. Eating in labour. Anaesthesia 1999;54:329–34.

No mother required general anesthesia, so the risk of aspiration was avoided. To estimate the potential risk, however, residual gastric volume was assessed within 1 hour of delivery using real time ultrasound to measure the cross-sectional area of the gastric antrum (Table 2)[39]. The results suggested that mothers in the eating group had significantly larger residual gastric volumes at the time of delivery. This theory was supported by the fact that mothers in the eating group who vomited after delivery vomited significantly larger volumes than women in the starved group (Table 2). The vomit contained a considerable amount of solid and semi-solid residue.

Table 2. Gastric antral cross-sectional area and incidence and volume of vomiting

	Eating	Starved	Estimate of difference	95% confidence interval	*P* value
Gastric antral X-sectional area: cm2 mean (SD)	6.35 (1.98)	4.50 (1.64)	1.85	0.81–2.88[a]	0.001
Number vomiting (%)	17 (38)	8 (19)	19%	0.8–38%	0.046[b]
Volume vomited: mL mean (SE) (of those vomiting)	309 (173)	104 (83)	205	99–311*	0.001

Data from Scrutton MJL, Melcalfe GA, Lowy C, et al. Eating in labour. Anaesthesia 1999;54:329–34.

[a] Confidence intervals calculated using robust standard errors.

[b] É‘2 test.

In summary, this study showed that allowing a light diet reduced the development of ketosis without providing any benefit to the progress or outcome of labor for mother or baby. At the same time, residual gastric volume around the time of delivery was significantly higher in the eating group. This would almost certainly have increased the risk of aspiration had general anesthesia been unexpectedly required. Despite the reports from North Bronx and Belfast, power calculations show that the study was too small to show any effect on the outcome of labor. A follow-up study currently underway at St. Thomas' Hospital involves a much larger number of women to try to address the question of labor outcomes directly.

If oral intake is to be permitted, what might be the alternatives to solid food? Semi-solids seem to behave like solids in the stomach [40], the rate at which they empty being dependent on volume [41], pH [42], fat content, temperature, and osmotic pressure of the meal. Foods in this category (eg, yogurt and yogurt drinks) are not as safe as has been suggested previously [43]. Fluids generally empty more quickly and clear isotonic fluids seem to be the most rapidly absorbed medium for the administration of oral calories. A similar strategy is used by endurance athletes—a group to whom laboring women are often compared. Endurance athletes need to take in fluid and calories to optimize their performance. Isotonic oral sport drinks provide an effective means of achieving this goal despite the fact that isotonicity limits the caloric load. The ideal characteristics for rapid absorption with minimal gastric residue are listed in Box 2[44,45].

Box 2:

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Liquid
*

Isotonic
*

Normothermic (37°C)
*

pH 7.4
*

Low residue

Surprisingly, a recent Dutch study of 201 nulliparous women who were randomized to consume either a carbohydrate or a noncarbohydrate drink showed that the incidence of cesarean section was statistically higher in the carbohydrate group [46]. Unfortunately, the numbers were small and there was a greater use of meperidine in the carbohydrate group, which might have confounded the outcome. In another publication, the same group reported that 70% of mothers allowed access to oral intake during labor chose to consume water only [47].

Investigators from St. Thomas' Hospital repeated their original study, comparing a group allowed isotonic sport drinks in labor with a group allowed water only [48].

Despite the caloric limitation of the isotonic fluids, it was shown that these drinks prevented the rise in É¿-hydroxybutyrate and non-esterified fatty acids seen in the starved group. Again, there was no change in any outcome of labor, but in contrast to the light diet allowed in the original study, there was no increase in residual gastric volume in the isotonic sport drink group. Although this approach may not provide the whole answer, it does at least provide a way of preventing ketosis that might be acceptable to most anesthesiologists.

Summary

Maternal death from pulmonary aspiration of gastric contents has virtually disappeared in the United Kingdom. The one case documented in the most recent triennial report was a woman with multiorgan failure in intensive care and is probably not relevant to the current debate [1]. Although not so well documented, other Western countries seem to be experiencing the same decline in maternal death from this cause. At the same time, the burden of proof is falling increasingly on obstetric anesthesiologists as obstetricians and midwives demand that NPO policies should be rejected, unless anesthesiologists can prove that they are necessary. Without any proof of benefit, many midwives actively encourage eating in women who do not really want to eat.

A hospital manager who wants to divert money to other areas of health care might make the same argument about employing less experienced—and therefore cheaper—anesthesiologists or nurse anesthetists on the labor floor. Although no self-respecting obstetric anesthesiologist would accept such a situation, there is still no randomized controlled trial that proves that experienced anesthesiologists reduce maternal mortality. Similarly it is difficult for a mother to comprehend the negligible risk of pulmonary aspiration during labor while her care providers insist that it would be more dangerous for her to cross a busy road! Against a background of conflicting advice from midwives and medical practitioners, the mother is likely to eat if she feels so inclined.

Pulmonary aspiration is a rare complication, so even if a light diet in labor became acceptable, it is likely that it would take many years for a subsequent increase in maternal mortality to become apparent. It would be disappointing if mistakes made by a previous generation had to be relearned in the twenty-first century. Increasingly, media-controlled pressure groups dictate health fashions, and the physicians frequently can only stand on the sidelines and advise. Most obstetric anesthesiologists agree that a rigid NPO policy in labor is no longer appropriate and that at least water or ice chips should be allowed. Current evidence suggests that solids and semi-solids should be avoided once a woman is in active labor or requests analgesia. The appropriate advice is to allow a carefully audited introduction of isotonic drinks. These drinks seem to be an effective medium for providing calories while minimizing any increase in gastric volume, and such a

policy would be unlikely to reverse the reduction in aspiration that has been achieved over the past 50 years.

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