Pre-operative fasting—60 years on from Mendelson

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Mendelson's syndrome

2006 saw the 60th anniversary of the publication of New York obstetrician Curtis Lester Mendelson's classic paper, 'The aspiration of stomach contents into the lungs during obstetric anesthesia'.[1] Nitrous oxide and ether anaesthesia administered by face mask for operative delivery was complicated by aspiration in 66 women from 44 016 maternities (0.15%) between 1932 and 1945. The only two deaths were from airway obstruction by solid, undigested food in two of five women who aspirated solid material. In those who aspirated liquid, a syndrome of dyspnoea, cyanosis and tachycardia was observed. Recovery after 24–36 h was universal—in an era that predated respiratory intensive therapy by decades.

Mendelson went on to show that acid was responsible for this asthma-like syndrome. He instilled into the respiratory tracts of rabbits a variety of substances including 0.1N hydrochloric acid and vomitus (both untreated and neutralized) from pregnant women. He concluded that gastric retention of solid and liquid material is prolonged during labour, and that aspiration of vomitus into the lungs can occur while laryngeal reflexes are abolished. 'Respiratory failure secondary to aspiration pneumonitis during anaesthesia' became synonymous with Mendelson's syndrome, and its prevention a cornerstone of anaesthetic practice.

Gastric contents

Volume and pH

The volume and pH of gastric contents are a function of gastric secretion, oral intake and gastric emptying. Measurements after the direct instillation of acid into a Rhesus monkey's right main bronchus led to the statement in 1974 that patients were at risk of aspiration from the presence of 25 ml residual gastric volume (RGV) of pH < 2.5. In extrapolating this finding to the adult human, the assumption was made that the entire gastric contents would reach the tracheobronchial tree. However, in 50% of healthy, fasting patients the volume of gastric fluid is at least 25 ml, and median pH around 2 in most studies. Gastric volume and pH are 'surrogate end-points'—indirect measurements as opposed to factors directly influencing aspiration risk. The human stomach is a very distensible organ and can accommodate up to 1000 mL before intragastric pressure increases.

Reflux and regurgitation are gravitational (passive) processes. Reflux is the passage of gastric contents into the oesophagus, and implies that the lower oesophageal sphincter has been breached; regurgitation infers relaxation of the upper oesophageal sphincter and passage of gastrointestinal (GI) material into the pharynx.

Gastric emptying

About 100 yr before Mendelson's series, William Beaumont, an American military surgeon, treated a Canadian fur trapper for a gunshot wound to the stomach. Observation of a permanent gastric fistula (Fig. 1) allowed the distinction to be made between gastric emptying of liquids and solids. Beaumont wrote that 'water [and] ardent spirits . . . pass from the stomach soon after they have been received'. Gastric emptying of liquids is an exponential process—the rate of emptying at any time is proportional to the amount still in the stomach. The half-time for water is approximately 10 min; 95% of ingested clear liquid is emptied in 1 h. The pylorus retards passage of particles greater than 2 mm diameter. The rate of gastric emptying of solids is constant and starts 1 h after a meal. Fifty percent of a meal reaches the duodenum within 2 h.

Unlike RGV and pH, gastric emptying is a dynamic entity yet also a surrogate end-point in the determination of aspiration risk. The process can be measured by paracetamol absorption (paracetamol is absorbed by the duodenum, not the stomach), ultrasound, applied potential tomography and scintigraphy.

Key points

Residual gastric volume (RGV) and pH (two surrogate end-points of aspiration risk) are determined by oral intake, gastric secretion and gastric emptying. A 2 h fasting interval (*vs.* midnight) for fluids neither increases RGV nor decreases pH.

Gastric emptying of liquids is an exponential process. The half-time for water is about 10 min. It is wrong to regard the stomach as either 'empty' or 'full', and induction of anaesthesia 'safe' or 'unsafe'.

Current accepted fasting intervals for elective cases are 2 h for water and clear fluids, 4 h for breast milk, and 6 h for food (including milky drinks). 'Nil by mouth from midnight' has no place in modern perioperative practice.

Gastric emptying is impaired by trauma, labour and opioid analgesia. Fasting intervals assume limited importance compared with other aspects of the anaesthesia regimen (e.g. choice of airway management) in the prevention of aspiration.

The 'top 3' risk factors for aspiration are emergency surgery, light anaesthesia/unexpected response to stimulation and upper/lower gastrointestinal pathology.

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doi:10.1093/bjaceaccp/mkl048
Continuing Education in Anaesthesia, Critical Care & Pain | Volume 6 Number 6 2006

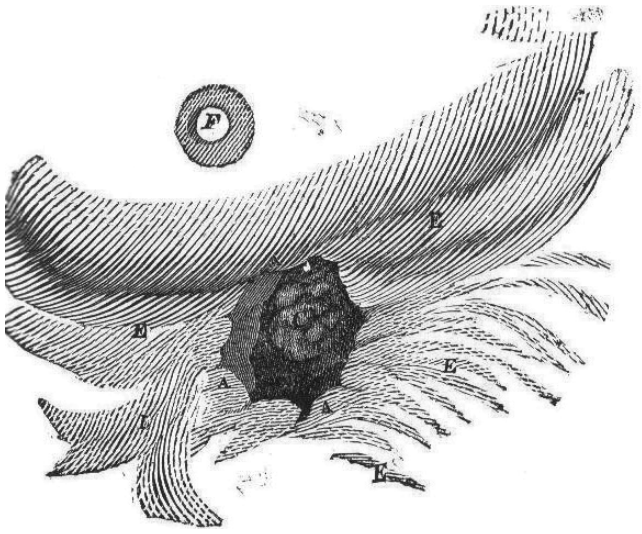

Fig. 1 Gastrocutaneous fistula following gunshot wound, described by Dr William Beaumont (1785–1853). 'F' is the nipple. *Source*: Scanned by Professor J. R. Maltby from Beaumont W. Experiments and Observations on the Gastric Juice and the Physiology of Digestion. Plattsburgh: Allen, 1833.

Risk factors for aspiration pneumonitis

The top 10 predisposing factors in 133 cases of aspiration (from a total of 5000 anaesthetic incidents) in the Australian Anaesthetic Incident Monitoring Study (AIMS)[2] are listed in Table 1. In patients with these risk factors, rapid sequence induction (RSI) is strongly indicated; duration of preoperative fasting has limited (if any) bearing upon anaesthetic management.

Obesity

In obese patients, RGV at induction of anaesthesia is not increased by ingestion of 300 ml fluid 2 h previously. Studies of gastric emptying have not shown a delay. It is the association with other pathology (e.g. hiatus hernia) that warrants particular caution with position and airway management.

Patient position for induction

Before the widespread adoption of cricoid pressure, a head-up position was commonplace. The risk of (passive) reflux and regurgitation will be decreased, although if (active) vomiting propels gastric contents to the pharynx, there will be more chance of material entering the tracheobronchial tree. Snow and Nunn reported no instances of aspiration in over 600 high-risk cases (which included 480 Caesarean sections) induced with a 40° head-up tilt. In patients anaesthetized supine, six cases of inhalation of gastric contents were cited.[3] Returning patients to supine as soon as the airway is secured will minimize the duration of possible cerebral hypoperfusion in patients with cerebrovascular disease.

Table 1 Top 10 factors predisposing to vomiting/regurgitation and aspiration [from Ref (2)]

1	Non-elective surgical procedure
2	Light anaesthesia/unexpected response to stimulation
3	Acute or chronic, upper or lower GI pathology
4	Obesity
5	Opioid medication
6	Neurological disease, impaired conscious level, or sedation
7	Lithotomy position
8	Difficult intubation/airway
9	Gastrointestinal reflux
10	Hiatus hernia

Airway device

The appropriateness of the laryngeal mask airway (LMA) in various situations has been debated. It is unknown whether the ProSeal™ device (which isolates respiratory from GI tracts) truly enhances protection. Anaesthesia with an LMA compared with tracheal tube allows a lighter plane of anaesthesia but with increased risk of coughing/vomiting in response to surgical stimulation.[4] In pursuit of avoidance of aspiration, arguably more weight should be attached to the potential risk associated with a supraglottic airway than whether or not the patient has been fasted for an arbitrary period.

Elective anaesthesia—fasting guidelines

Logic dictates that there are three mechanisms whereby fluid ingestion in healthy, elective patients might increase aspiration risk: increase in RGV, decrease in pH and decrease in oesophageal sphincter tone. There is no evidence that any of these is a consequence of unrestricted oral fluid intake until 2 h pre-induction. Many comparisons of fasting intervals have found that RGV is, if anything, decreased by shorter fasting intervals. The dogma of 'nil by mouth from midnight' has proved hard to dispel.[5] The Royal College of Nursing (RCN) consulted widely and published detailed multidisciplinary guidelines in 2005 (Table 2). Key recommendations concur with the American Society of Anesthesiologists' Task Force guidelines published in 1999 (web links at the end of the article) and current Scandinavian policies.[6] The '2 and 6 rule' for adults means 2 h for water and clear fluids (defined as fluids through which newsprint might be read) and 6 h for food. The effect of chewing gum on RGV and pH is uncertain, but the ban on chewing gum on the day of surgery should at least eliminate the threat to the airway if a retained bolus of gum were to become dislodged. The guidelines point out that patients should be encouraged to take fluids as close as possible to 2 h before operation.

Pharmacological strategies for prevention of postoperative nausea and vomiting should be complemented by optimal

Table 2 Royal College of Nursing recommendations for preoperative fasting (see web link). Grades of recommendations: A = at least one meta-analysis, systematic review or randomized controlled trial; B = body of evidence applicable to the target population, demonstrating consistency of results D = non-analytic evidence (case reports, case series), expert opinion/consensus

Grade	Recommendation
A	Water and other clear fluids (through which newsprint can be read), clear tea and black coffee up to 2 h before induction of anaesthesia for elective surgery are safe and improve patient well-being
B	Tea and coffee with milk are acceptable up to 6 h before induction of anaesthesia
D	Minimum preoperative fasting time of 6 h recommended for food (solids and milk)
D	Breast milk may be given up to 4 h before induction; formula or cows' milk up to 6 h before induction
B	Chewing gum should not be permitted on the day of surgery
D	Sweets (including lollipops) are solid food. Minimum preoperative fasting time of 6 h recommended

preoperative hydration, which is of proven benefit. Medication should not be withheld on account of preoperative fasting – up to 150 ml water is sanctioned in Scandinavia to help ingestion of tablets. There is insufficient evidence to support routine prescription of antacids, gastric prokinetic agents and H_2-receptor antagonists/proton pump inhibitors.

Babies and children

The '2-4-6 rule' for children denotes intervals of 2 h for fluids, 4 h for breast milk and 6 h for formula milk/solids. Sweets and lollipops are regarded as solid food (Table 2). Regurgitation is extremely common in the first 6 months of life because of higher resting intragastric pressure (relatively small size of the stomach and encroachment of other abdominal organs) and relaxation of the gastro-oesophageal sphincter. The risk of regurgitation is exacerbated during inhalational induction. Negative intrapleural pressure secondary to airway obstruction will be transmitted to the oesophageal lumen and increase the intragastric-oesophageal pressure gradient.

Unlike adults, children exhibit irritability after prolonged fasting. Therefore, restricted fasting times confer the additional benefit of smoother induction of anaesthesia. Whereas paediatric ward nurses typically strive to establish the timing of a child's operation and offer a drink if permissible, the same advocacy does not tend to exist for delayed elderly patients, whose physiological reserve is rather less.

Ophthalmic surgery, local anaesthesia and sedation

Despite the proximity of the central nervous system (CNS) to the site of injection of a local anaesthetic (LA), the risk of CNS toxicity/loss of consciousness is deemed by a majority of ophthalmologists insufficient to mandate fasting before either topical or needle (e.g. sub-Tenon's) ophthalmic blocks. Surprisingly, a third of ophthalmologists responding to a survey were prepared to administer sedation to non-fasting patients. In other clinical areas with less well-defined care pathways, relaxation of fasting regimens have been slower to change. Patients for minor orthopaedic procedures under LA on lists shared with major cases still commonly fast all day, despite much less risk of systemic toxicity. Studies of gastric contents after different fasting times at upper GI gastroscopy have shown that fluid restriction beyond 2 h should be the exception, not the rule.[7]

Guideline implementation

No complications of liberalized fasting guidelines (compared with 'nil by mouth from midnight') have been reported. A recent editorial has pointed out that organizational issues conspire against changes in practice.[8] The Peri-operative Implementation Study Evaluation (PoISE) project has set out to compare the effectiveness of different means of dissemination of the RCN guidelines.

It is wrong to view fasting times as thresholds above or below which the stomach is 'empty' or 'full', and anaesthesia 'safe' or 'unsafe'. Given that the rate of production of saliva and upper GI secretions can amount to 2 ml min^{-1}, postponement of patients on accounts of sips of fluid is hard to justify. Anaesthetists are better placed than ward nurses to appreciate the minimum durations of various operations on a list. They are in a position to liaise between the surgical team and ward staff and sanction (ideally by written prescription) administration of drinks for patients whose operations are many hours ahead.

Emergency anaesthesia

It has been emphasized that a constellation of factors influences the totality of perioperative risk facing emergency patients.[9] The familiarity of theatre practitioners from different subspecialties covering unfamiliar procedures out-of-hours is an important factor. Fasting is unlikely to render an emergency patient 'fasted and elective'. Imposition of a delay to await gastric emptying should be weighed against the risk of a patient losing the services of a daytime subspecialty theatre team.

Anaesthetists were surveyed as to management of a hypothetical child with a forearm fracture sustained at various intervals after eating. Although both pain and opioid analgesia delay gastric emptying, there was lack of consensus as to the necessity for RSI. 'Rolling' emergency trauma lists typically comprise a heterogeneous group of patients, many of whom do not have risk factors for gastric stasis (e.g. wound washouts in patients not receiving opioid analgesia). It falls within the remit of anaesthetists to discriminate between patients with low or high likelihood of impaired gastric emptying and prescribe oral or i.v. fluids, respectively.

Obstetrics

It is a common misconception that pregnancy *per se* delays gastric emptying. In a crossover study of non-labouring

pregnant women at term, 300 ml of ingested water emptied faster than 50 ml. However, labour and opioid analgesia undoubtedly cause gastric stasis. The women in Mendelson's series underwent emergency GA without tracheal intubation.

Labour

Functional labour demands adequate hydration and a high calorie intake. Light diet is acceptable for labouring women at low risk of operative delivery. Women allowed a low-residue diet in labour had larger RGVs after giving birth compared with those given only water. A compromise appears to be glucose-containing isotonic drinks that prevent dehydration and ketosis without increasing gastric volume.[10] The effect of epidural fentanyl on gastric emptying seems to be dose dependent. Obstetric indications for epidural analgesia (e.g. twin pregnancy or pre-eclampsia) that carry a significant risk of operative intervention dictate restriction of oral intake to water, and prescription of regular oral ranitidine.

Caesarean section

The small risk of aspiration in the event of loss of consciousness secondary to unintentionally high regional block or vasovagal/Bezold–Jarisch reflex may be greater than that in the course of tracheal intubation for planned GA. There is evidence that a regimen of unrestricted sips of water appears to be safe for women awaiting elective Caesarean section under regional block or GA.[11] This policy has been adopted in a number of UK obstetric units.

Preoperative nutrition

The metabolic implication of carbohydrate (CHO) administration is that preservation of normal endogenous release of insulin (an anabolic hormone) should prevent the catabolic response to fasting. A Swedish group has compared administration of a 400 ml flavoured iso-osmolar CHO drink (containing 200 kcal) with the same volume of placebo 2 h before anaesthesia in patients undergoing laparoscopic cholecystectomy or colorectal surgery.[12] RGV and pH were similar between the groups; there were no instances of aspiration. Patients who received the CHO drink experienced less hunger, thirst and anxiety (thought to be diminished by elimination of hunger by energy substrate). Plasma glucose and serum insulin concentrations were both increased in the CHO group.

Conclusion

Mendelson's landmark paper showed that solid gastric contents can kill by asphyxiation if non-fasting labouring women are anaesthetized without airway protection. It was proven that gastric acid was responsible for the respiratory syndrome that follows liquid aspiration.

The spectre of life-threatening aspiration pneumonitis has underpinned reluctance to modernize unnecessarily restrictive preoperative fasting regimens for healthy, elective patients. Evidence accrued over the past 20 yr supports a 2 h fasting time for clear fluids.

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Web links

Royal College of Nursing 2005. Perioperative fasting in adults and children. http://www.rcn.org.uk/publications/pdf/guidelines/perioperative_fasting_adults_children_full.pdf

Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures: a report by the American Society of Anesthesiologists task force on preoperative fasting. www.asahq.org/publicationsAndServices/NPO.pdf

Please see multiple choice questions 1–3.