Frequency of aspirating gastric tubes for patients receiving enteral nutrition in the ICU: a randomised controlled trial

Teresa Williams, Gavin Leslie, Lauren Mills, Tim Leen, Hugh Davies, David Hendron, Geoff Dobb

Authors

Dr Teresa A Williams (Corresponding Author)

PhD, M Hlth Sci(Research), ICU Cert, RN

Research Assistant Professor and NH&MRC Clinical Research Postdoctoral Fellow,

Discipline of Emergency Medicine (M516)

School of Primary, Aboriginal and Rural Health Care (SPARHC), The University of Western Australia and

Research Fellow, ICU Royal Perth Hospital

Address: 35 Stirling Highway, Crawley, Western Australia 6009.

Tel: +61 439 907 616 | Fax: +61 8 9346 1665 | Email: Teresa.williams@uwa.edu.au

Professor Gavin D Leslie

PhD, PG Dip(Clin Nurs), BappSc, RN

Professor Critical Care Nursing (Joint Appointment Royal Perth Hospital)

Director Research & Development, School of Nursing & Midwifery, Curtin Health Innovation Research

Institute, Faculty Health Science, Curtin University

Kent Street Bentley, Western Australia, 6102

Tel | +61 8 9266 2070 Fax | +61 8 9266 2959 Email | g.leslie@curtin.edu.au

Ms Lauren Mills

BSc Nutrition & Dietetics, PG Dip Dietetics

Senior Dietician

Intensive Care Unit, Royal Perth Hospital,

Wellington Street, Perth, Western Australia, 6000

Tel | +61 8 9224 2601 Fax | +61 8 9224 1665 Email | lauren.mills@health.wa.gov.au

Mr Tim Leen

RN Bsc Nsg (Intensive Care)

Clinical Nurse Specialist

Intensive Care Unit, Royal Perth Hospital,

Wellington Street, Perth, Western Australia, 6000

Tel | +61 8 9224 2601 Fax | +61 8 9224 1665 Email | tim.leen@health.wa.gov.au

Dr Hugh Davies

RN PhD

Nurse Researcher/Clinical Nurse

Intensive Care Unit, Royal Perth Hospital,

Wellington Street, Perth, Western Australia, 6000

Tel | +61 8 9224 2601 Fax | +61 8 9224 1665 Email | hugh.davies@health.wa.gov.au

Dr David Hendron

MBBChBAO FCARCSI MRCP(UK) FJFICMI EDIC DIBICM PGDipClinEd

Senior Registrar,

Intensive Care Unit, Royal Perth Hospital,

Wellington Street, Perth, Western Australia, 6000

Tel | +61 8 9224 2601 Fax | +61 8 9224 1665 Email | dhendron1@gmail.com

Clinical Professor Geoff J Dobb

MBBS, FRCP (UK), FRCA, FANZCA, FCICM

Head of Department, Intensive Care Unit, Royal Perth Hospital, Perth, Western Australia.

School of Medicine and Pharmacology, The University of Western Australia,

Intensive Care Unit, Royal Perth Hospital,

Wellington Street, Perth, Western Australia, 6000

Tel | +61 8 9224 2603 Fax | +61 8 9224 1665 Email | geoffrey.dobb@health.wa.gov.au

Trial registration number ACTRN12610000243011

Abstract

Background

Enteral nutrition (EN) tolerance is often monitored by aspirating stomach contents by syringe at prescribed intervals. No studies have been conducted to assess the most appropriate time interval for aspirating gastric tubes. We compared gastric tube aspirations every four hours (usual care) to a variable regimen (up to every eight hours aspirations).

Methods

This randomized controlled trial (RCT) enrolled patients who stayed in ICU > 48 hours, had a gastric tube, and were likely to receive EN for 3+ days. Patients were randomized (computer-generated randomization) to either control (every four hours) or intervention group (variable regimen). The primary outcome was number of gastric tube aspirations per day from randomization until EN was ceased or up to two weeks post-randomization.

Results

Following Institutional Ethics Committee approval, 357 patients were recruited (control group n=179 and intervention group n=178). No differences were found in age, sex, worst APACHE II score or time to start of EN. In the intention to treat analysis, the intervention group had fewer tube aspirations per day (3.4 versus 5.4 in the control group, p<0.001). Vomiting/regurgitation was increased in the intervention group (2.1% versus 3.6%, p=0.02). There were no other differences in complications.

Conclusion

This is the first RCT to examine the frequency of gastric tube aspirations. The frequency of gastric tube aspirations was reduced in the variable regimen group with no increase in risk to the patient. Reducing frequency of aspirations saves nursing time, decreases risk of contamination of feeding circuit and minimises risk of body fluid exposure.

Clinical Relevancy Statement

Monitoring gastric residual volume (GRV) for patients receiving enteral nutrition is a common practice in the ICU but there is much variation in practice of the frequency of the removal of stomach contents. Aspirating stomach contents by syringe is the most common clinical practice but is time-consuming in a clinical environment where time is critical. Fewer tube aspirations are likely to improve the amount of enteral feed delivered and minimise breaking enteral feed circuit with the potential for contamination of the circuit and splash injuries. Until such time as this practice is no longer deemed necessary, reducing the frequency of performing this task is important.

Introduction

Enteral tubes are commonly used in the intensive care unit (ICU) for feeding patients, administration of medications and abdominal decompression. In the ICU, enteral feeding is the preferred method of nutrition support for patients unable to take oral diet or fluids. Risks associated with enteral feeding in the critically ill include gastric intolerance, pulmonary aspiration and pneumonia (ventilator associated pneumonia [VAP] and aspiration pneumonia in non-ventilated patients). While gastric intolerance and pulmonary aspiration are believed to contribute to the development of VAP, it has been reported that GRV and pulmonary aspiration may not increase the risk for VAP.[1] Nevertheless, monitoring of GRV and prevention of pulmonary aspiration are considered best practice and are surrogate activities for the clinical outcome of VAP.

The measuring of GRV by removal of the stomach contents (gastric aspirate) with a large syringe is the most common method of assessing GRV in the ICU, although this method has not been validated.[2] Other methods of measurement are being investigated but are not yet available for routine clinical use.[3] Gastric aspirates are usually returned to preserve gastric fluid and electrolytes unless considered excessive.[4] There is no consensus on the definition of 'excessive' gastric aspirate but volumes greater than 300-500 mls have been considered 'excessive'.[1]

Frequent tube aspiration consumes ICU nursing time and results in less nursing time being available for other tasks. Breaking the feeding circuit has the potential to introduce microorganisms and subsequent infection. Closed enteral feeding systems are commonly used in the ICU to minimise handling and contamination.[5] Reducing manipulation of the enteral feed set is also likely to reduce the risk of transmission of microorganisms. Matlow[6] found the hub of enteral feeding tubing was contaminated with organisms from health professionals. In addition, the upper respiratory and upper intestinal tract of patients are frequently colonised by intestinal flora that can colonise the intragastric part of the gastric tube, and migrate to and colonize the hub after gastric tube manipulation, as when checking the GRV. Furthermore, there is the potential for staff exposure to body fluids (splash injury). While standard precautions that include handwashing, gloving and protective eye wear are used to minimise the risk of splash injury when aspirating stomach contents and returning the gastric aspirate, reducing the frequency of this activity is likely to be the most effective harm reduction policy.[7]

Considering there is no consensus on how often gastric tubes should be aspirated it would be useful to establish a balance between frequency of aspiration to enable better use of nursing time whilst maintaining monitoring of feed absorption from the stomach and avoiding gastric

regurgitation. This study aimed to compare to every four hours gastric tube aspiration with a variable gastric tube aspiration regimen for patients in the ICU.

Materials and Methods

Design

A randomized controlled trial was used to test the hypothesis that a variable gastric tube aspiration regimen would reduce the frequency of gastric tube aspiration with no increase in the incidence of feed regurgitation or VAP (or pneumonia in non-ventilated patients). Patients were randomized (using computer generated randomization) to receive either to every four hours tube aspiration (standard practice) or a variable regimen of up to eight hourly gastric tube aspirations. The study was not blinded due to the nature of the intervention under consideration. Routine chest x-ray review procedures were maintained by unit medical staff and potential VAP cases were treated according to existing unit guidelines. Chest x-rays were reviewed for new infiltrates by an intensivist (author DH) who did not work in the ICU during the study, blinded to group allocation and independent of data collection and analysis. For the study assessment of VAP (or pneumonia in non-ventilated patients), an intensivist blinded to the patient's allocation reviewed the chest x-rays at the end of the study to ascertain whether the patient had developed a new infiltrate. The definition of VAP was adapted from the Centers for Disease Control and Prevention[8] and Wall[9] and is shown in Box 1.

Box 1 Definition of ventilator acquired pneumonia used in this study[12,13]

Body temperature >38.5°C OR body temperature < 35°C OR white cell count > 12,000/IL *OR* white cell count <3,000/IL

PLUS any two of

Change in sputum - purulent sputum, increased secretions, increased need for suctioning;

New or worsening dyspnoea, cough or tachypnoea;

Crackles or bronchial breath sounds

Worsening gas exchange- desaturation, increasing FiO_2, increased ventilation requirements

Isolation of pathogenic bacteria from endotracheal aspirate

PLUS

New radiographic infiltrate on one x-ray (two consecutive x-rays if underlying cardiopulmonary disease)

Ethical issues

The study was approved by the Institutional Ethics Committee (IEC). The study was regarded as very low-risk and the need for patient consent was waived.[10] Patient confidentiality was maintained. Personal identifiers were removed from the database after completion of data collection and before the data were analysed. Data were stored in a secure, password protected computer at the hospital. An independent safety monitoring committee of two independent clinicians was appointed to monitor the incidence of VAP (or pneumonia in non-ventilated patients) or consider any other serious adverse events but the committee's services were not required.

Participants and setting

The study was conducted in a 22-bed, adult, level III ICU[11] located in a metropolitan tertiary-referral teaching hospital. The ICU admits medical and surgical patients including cardiothoracic surgery and heart and lung transplants. All patients admitted to the ICU and who stayed in the ICU longer than 48 hours, with a gastric tube inserted, and were likely to receive enteral feeding for three or more days were eligible for recruitment. A minimum of three days of enteral feeding was

considered sufficient for patients to have gastric tube aspirations reduced to every eight hours. There were no exclusion criteria provided the patient met the inclusion criteria. Patients could be fed via a gastric tube or small bowel tube (if a gastric tube was also inserted) as the practice of monitoring feed residuals remained the same. Patient enrolment in the study finished once the patient was discharged from the ICU or after 14 days of enteral nutrition.

Study Procedure

Staff were informed of the study at staff meetings and by newsletter, flyers displayed on notice boards, the ICU 'communication book' and email. Formal education was given to staff, particularly the Clinical Nurse Specialists and Nurse Shift Coordinators who were responsible for screening patients for the study.

Patient recruitment: The Clinical Nurse Specialists and Nurse Shift Coordinators, who were experienced ICU nurses, liaised with intensivists and screened patients for their eligibility to be recruited into the study. Eligible patients were randomized by a Co-investigator (GDL) when the patients met the selection criteria using computer generated randomization to have their gastric tube aspirated either to every four hours or according to the variable aspiration regimen. The patient's allocation was concealed in sealed, opaque envelopes that were numbered sequentially and locked in a cupboard in a secure area until the patient was enrolled. In all other respects, patients were managed according to standard ICU practice.

Standard practice: A standardised feeding guideline was used for the management of enteral nutrition in the ICU. The guideline included guidance on insertion, placement verification, initiation of feeding, and management of GRV, feed delivery, medication administration and removal of enteral. Early enteral feeding was promoted in the ICU. Patients were reviewed by the

ICU dietitian each working day. Energy targets were based on energy estimation equations accounting for passive ventilation with injury factors dependent on injuries or illness type. Dietary formulas of different concentrations were used ranging from 1-2kcal/ml depending on fluid requirements but all were prescribed to ensure patients received adequate protein and energy requirements when the full volume of feed prescribed was delivered. We commenced feeding at 30ml/hour for four hours (usually until next aspirate) then increased to 60ml/hour for a further four hours then up to target volume. If concentrated feeds were used we commenced at 30ml/hour then increased to target volume. Patients were usually fed through a gastric tube (12 or 14 FG). Fine-bore, small bowel tubes were usually reserved for patients who did not tolerate gastric feeding. In this instance a gastric tube was also inserted for gastric decompression and aspiration. Intestinal tubes were flushed six-hourly with 30 mls of sterile water and never aspirated. The patients received continuous feeding via a volume-delivery pump (Kangaroo Control ™ Feeding Pump, Sherwood Medical Co) and a closed feeding circuit 24 hours a day. However, the circuit was broken when feed containers and the administration set had to be changed, when enteral medications were administered and for gastric aspiration. Gastric aspirates were returned if the volume was 300 mls or less, or for GRV exceeding 300 mls, the first 300 mls was returned to the stomach and the remainder discarded. While usual practice in our ICU is to as use 300 mls as the cut-off for return of aspirate to the patient, for this study we also added that if GRV was greater than the volume of the previous two hours feeding the feed was not returned but it is likely that some nurses continued usual practice. In either case avoiding interruptions to feeding was practiced.

Patients randomized to the control group received standard management. Gastric tubes were aspirated every four hours (the practice used currently in our ICU). Patients randomized to the intervention group received standard management except the frequency of gastric tube aspiration was reduced to every eight hours once feeding was established (reaching target feed volume and

maintaining this volume for greater than four hours *AND* the gastric residual volume is less than the feed volume administered for the previous two consecutive hours). If GRV were greater than the feed volume administered for the previous two hours, gastric tube aspirations were performed every four hours to monitor trends in GRV that may indicate gastrointestinal intolerance consistent with standard practice and prokinetics were considered. If feeding was stopped and resumed at a lower rate than prior to being stopped, the frequency of gastric tube aspirations reverted back to every four hours until the feeding target had been resumed.

Data collection: Recording of frequency of gastric tube aspiration started from the time of randomization. It was stopped when enteral nutrition was ceased, or if enteral feeding continued beyond 14 days, up to 14 days. Data on enteral nutrition were obtained from the ICU flow chart by the research nurse (Author HD). Signs and symptoms of VAP (as previously defined) or pneumonia in non-ventilated patients were obtained from the medical record, ICU flow charts, daily chest x-rays and laboratory results. The target nutrition goal, volume of feed prescribed, and actual feed delivered was collected by the ICU Dietician. Patient and cohort characteristics were abstracted from the ICU clinical database. Data on splash injury were obtained from the staff incident forms.

Outcome

The primary outcome was the number of gastric tube aspirations per number of feeding days from the time of randomization until study end. The mean feed days was calculated from the number of days on which feed was delivered in any volume or for any duration. Secondary outcomes included incidence of (1) vomiting or regurgitation, defined as the presence of feed in the mouth or flowing out of the mouth; (2) VAP or pneumonia in non-ventilated patients (up to 16 days after enteral feeding commenced), and (3) attainment of target feeding volume each day. A further

outcome was the incidence of splash injury. This was considered a tertiary outcome because it was subjective, relying on self-reporting.

Statistical analysis

Patient and cohort characteristics were described as mean and standard deviation (SD) or median and interquartile range (IQR) as appropriate. Age, sex, severity of illness and diagnosis were compared between the control and intervention group. Severity of illness was estimated with the worst in first 24 hour Acute Physiology and Chronic Health Evaluation (APACHE) II score.[12] The physiological component of the APACHE II score, the Acute Physiology Score (APS), was also examined. Diagnosis (APACHE III diagnostic groups[13]) was re-grouped into sepsis on admission to ICU (including pneumonia), trauma and other diagnoses. Differences in continuous variables were compared using the Student's *t*-test and categorical variables using Chi square. Linear regression was used to examine the number of aspirations per day after adjusting for potential confounders: age, sex, APS, diagnostic group and group (control or intervention) entered simultaneously into the model. The volume of feed received was compared to the prescribed volume for the control and intervention groups. The ICU dietician reviewed all patients in ICU during the working week and prescribed the feed type and volume in liaison with medical staff. The type and volume of feed prescribed was based on the required amount of protein, other nutrients and caloric requirements of the patient, calculated using the Ireton-Jones[14] equation. ICU flow charts and incident report forms were examined for the number of splash injuries. All analyses were performed on an intention-to-treat basis. For missing data, the number of available observations was reported. No assumptions were made about the missing data. Data Analysis was undertaken using IBM SPSS version 19.0 (IBM; Chicago, IL) was used to analyse the data. Results were considered statistically significant if the 'p' value was <0.05.

Assuming a type I error probability for a two-sided test of 0.05, 80% power, a SD of 1.0, and a reduction in the mean frequency of gastric tube aspirations per 24 hours of 30%, we estimated a sample size of 176 patients per group, i.e. 352 in total. We planned to recruit 360 patients to allow for attrition.

Results

Cohort characteristics

There were 1,992 patients admitted to the ICU during the enrolment period 13th October 2010 to 16th December 2011 of whom, 360 were randomized (Figure 1). Two patients were randomized twice and the patients were analyzed in the original allocation group; the control group for both. One randomisation envelope (intervention group) was opened but not used because the patient was discharged and four patients were not fed after randomization but were included in the study (intention to treat analysis). Randomization occurred any time from ICU admission after assessment that the patient was likely to receive enteral nutrition for three or more days by the Clinical Nurse Specialists and Nurse Shift Coordinators. Three hundred and fifty seven patients were included in the study: 179 patients in the control group and 178 patients in the intervention group. The groups were well matched for age (p = 0.27), sex (p = 0.70), worst in first 24 hour APACHE II scores (p = 0.67) but there were fewer patients admitted with sepsis in the control group (p = 0.05) (Table 1). Vasopressors were administered to 72% of patients in the control group and 78% in the intervention group during the study. The proportion of patients receiving mechanical ventilation was 98% in both groups. Patients received similar amounts of sedation between groups (93% control group versus 92% intervention group) and 3% of patients in the control group and 2% in the intervention group received analgesia only. Nineteen patients in each

13

group received neuromuscular blocker during the study. Two patients had readmissions to ICU during the study: one patient 5½ months and the other 11 months after their index ICU admission.

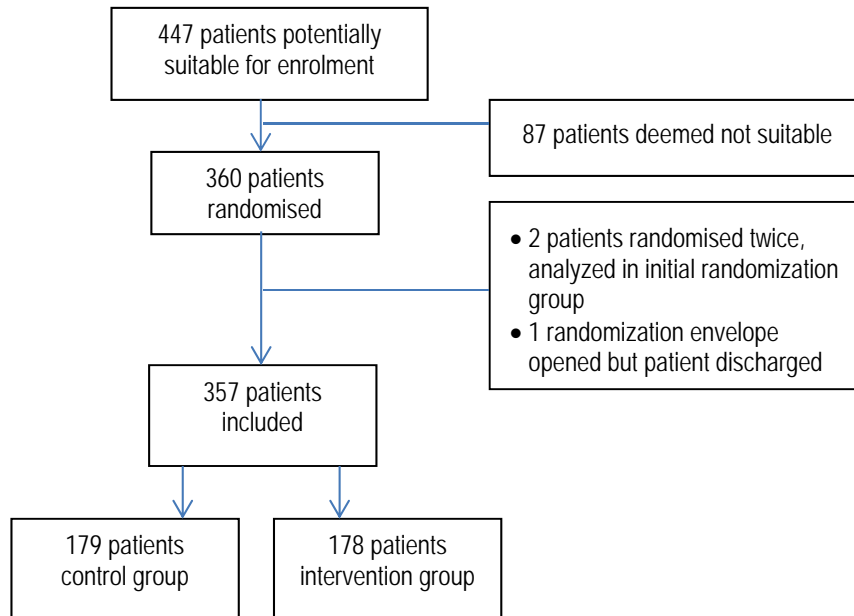Figure 1 Flow chart of patient recruitment

```
┌─────────────────────────┐
│  447 patients potentially│
│   suitable for enrolment │
└─────────────────────────┘
            │
            │         ┌─────────────────────────────┐
            ├────────▶│ 87 patients deemed not suitable│
            ▼         └─────────────────────────────┘
┌─────────────────────────┐
│  360 patients            │
│   randomised             │
└─────────────────────────┘
            │         ┌─────────────────────────────────────┐
            │         │ • 2 patients randomised twice,       │
            ├────────▶│   analyzed in initial randomization  │
            │         │   group                              │
            │         │ • 1 randomization envelope           │
            │         │   opened but patient discharged      │
            ▼         └─────────────────────────────────────┘
┌─────────────────────────┐
│  357 patients            │
│   included               │
└─────────────────────────┘
        │            │
        ▼            ▼
┌──────────────┐ ┌──────────────────┐
│ 179 patients │ │ 178 patients     │
│ control group│ │ intervention group│
└──────────────┘ └──────────────────┘
```

Table 1 Comparison of cohort characteristics for control and intervention groups

Characteristic	Control group (n=179)	Intervention group (n=178)	p-value
Median age (IQR)	54 (37-69)	51 (36-65)	0.27
Males (%)	70%	68%	0.70
Mean APACHE II score (SD)	23.1 (7.7)	23.4 (7.8)	0.67
Acute Physiology Score (SD)	19.9 (6.4)	20.0 (6.9)	0.89
Diagnosis			0.05
Number of patients admitted with Sepsis (%)	76 (42%)	(91) 51%	
Number of patients admitted with Trauma (%)	61 (34%)	(40) 23%	
Number of patients admitted with Other diagnosis (%)	42 (24%)	47 (26%)	
Median time to randomization (IQR)	26 (13-56) hours	32 (16-60) hours	0.64
Mean feed days after randomization (up to 14 days) (IQR)	6.8 (5.1) days	6.2 (4.4) days	0.22
Mean number of interruptions to enteral feeding (SD)	3.5 (3.4)	3.1 (3.2)	0.21
Median number of hours feed interrupted (IQR)	21 (6-42)	14 (2-42)	0.28

IQR - Interquartile Range

APACHE II score - Worst Acute Physiology and Chronic Health Evaluation (APACHE) II score in first 24 hours

SD – Standard Deviation

n - number

Enteral feeding characteristics

The mean time to commencement of EN after admission to ICU was similar, 7 (IQR 3-16) hours for the control group and 7 (IQR 3-14) hours for the intervention group, p=0.97. Likewise, time from admission to randomization was not different between groups: 26 (IQR 13-56) hours for the control group and 32 (IQR 16-60) hours for the intervention group, p=0.64). Patients received enteral nutrition for mean 6.8 days in the control group compared to 6.2 days in the intervention group after randomization (up to 14 days) but this was not statistically significant. Fifteen patients (8%) in each group received enteral nutrition for three days or less. Eight patients (4.5%) in the control group and ten (5.6%) patients in the intervention group received parenteral nutrition at some time after enrolment into the study and enteral feeding had commenced (p=0.62).

Patient outcomes

There was a significant reduction in the mean number of gastric tube aspirations per day, 5.4 for the control group and 3.4 for the intervention group (p=<0001), as shown in Table 2. The only variables independently associated with number of aspirations per day in the linear regression model were the Acute Physiology Score (F = 2.2, p < 0.001) and allocation group (F = 49.7, p < 0.001), but not age, sex or diagnostic group. The mean number of interruptions (3.5 for the control group and 3.1 for the intervention group, p=0.21) and the median time feeding was interrupted (21 [IQR 6-42] hours for the control group and 14 [IQR 2-35] hours for the intervention group) were similar between groups (p=0.28). Vomiting and regurgitation in the control group was almost half to that of the intervention group (2.1% versus 3.6%, p=0.02) but interruptions to enteral feeding due to vomiting/regurgitation were similar (1.5% versus 2.1%, p=0.24). Four patients in the control group and two patients in the intervention group were changed to intestinal feeding. No splash injuries were reported during the study.

Table 2. Patient outcomes

Outcome	Control group (n=179)	Intervention group (n=178)	p-value
Mean number of tube aspirations per enteral feeding days	5.4 (1.3)	3.4 (1.3)	< 0.001
Proportion (%) of patients with Ventilator Associated Pneumonia	14.1	13.2	0.81
Vomiting/regurgitation	2.1%	3.6%	0.02
Interruptions to enteral feeding due to vomiting	1.5%	2.1%	0.24
Median ICU length of stay	9 (5-15)	9 (6-14)	0.57
Median hospital length of stay	25 (13-41)	23 (12-38)	0.19
Intensive care unit survival	86%	82%	0.24
Hospital survival	81%	78%	0.36

Incidence of VAP

The incidence of VAP and pneumonia in non-ventilated patients was 14.1% for the control group and 13.2% for the intervention group (p = 0.81). The proportion of chest x-rays that were inconclusive was similar between groups, 1.8% in the control group and 1.1% in the intervention group (p=0.63). The results were consistent with interim analyses at enrolment of 120 (p=0.43) and 240 patients (p=0.78). The patients admitted with pneumonia (19 patients in the control group and 16 in the intervention group, p=0.48) all received mechanical ventilation during the study period and were not diagnosed with VAP.

Nutritional intake

Diet data were missing for one patient. Excluding the days patients received some parenteral nutrition or diet on that day, 48% of patient days received 80% or more of their prescribed feeding volume in the control group and 50% in the intervention group (p=0.39). Similar results were

found for patient days that received three or more days of enteral nutrition from the start of enteral feeding.

Discussion

This is the first study to use a randomized controlled trial to examine different time intervals to remove stomach contents (aspirate) from an enteral tube in ICU patients. A to every 4 hours aspiration schedule that was routinely used in the study hospital's ICU was compared to a variable regimen. Patients expected to be fed enterally longer than three days were recruited to provide sufficient time for patients to receive their target feeding volume. This time frame was informed by Mentec[16] who found among 153 critically ill patients that the median time of development of high GRV was two days. As hypothesised, the frequency of gastric tube aspiration was significantly lower in the intervention group. However, the incidence of regurgitation/ vomiting was significantly higher in the intervention group but the incidence of VAP was similar. The study was powered to show a difference in the number of aspirations and may not have had sufficient power to show a difference in the incidence of VAP. However, there is little evidence to support a correlation between GRVs and the incidence of regurgitation and aspiration.[1,17]

No study has previously compared different timings of gastric-tube aspiration. The frequency of checking GRV varies with no clear consensus or evidence for this routine nursing activity.[4,18-20] Gastric aspiration regimens include four to 12-hourly [21-23]; to every four hours on the first day of feeding and then to every eight hours [24]; three to every four hours when EN was commenced then checked daily once full volume and tolerance is established [20,25,26]; six-hourly on the first day, to every 8 hours on the second day and daily after the third day if EN tolerated [27]; and daily alone.[28] The risk of pulmonary aspiration during continuous EN has been reported as greatest during the

first few hours of administration.[26] Monitoring GRV more closely during the early phase of feeding and then less frequently once feeding is established is likely to reduce the risk.[24]

Although there are no established guidelines indicating how often enteral tubes should be aspirated, most institutions follow some type of protocol. Frequent tube aspiration consumes nursing time and results in less nursing time being available for other tasks. There is the potential for exposure to body fluids (splash injury) although there were none reported during our study. Reducing the frequency of this activity is likely to contribute to an effective harm reduction policy.[7]

The accuracy of the amount of GRV aspirated from enteral tubes is questionable. Variation in technique size of the syringes used to aspirate tubes, method of feeding, tube size, openings of the gastric tube, adherence of the tip of the feeding tube to the gastric mucosa and patient position may alter the GRV aspirated.[29-33] This randomized controlled trial was a pragmatic study with no attempt to control enteral feeding practice, with the exception of frequency of aspirating enteral tubes. A Nursing Practice Standard[34] guided enteral feeding tube practice within the ICU and was used for both the control and intervention groups.

Methods that are reliable, sensitive, harmless, feasible, and inexpensive are needed as an alternative to aspirating stomach contents by syringe to assess gastric emptying.[3] Scintigraphy, considered the gold standard of measuring gastric emptying,[3] uses a gamma scintillation camera to observe gastric emptying after administration of a test meal labeled with isotope markers but it is unsuitable for repetitive monitoring in the critically ill. Electric impedance tomography is a noninvasive technique measuring impedance changes in the stomach when food is given usually as a meal or bolus but is not particularly useful in monitoring the GRV in ICU patients who are fed

continuously.[35] The paracetamol absorption test[28, 36 37-40] requires standardisation and validation for routine use in the critically ill.[3,41] Breath testing can be used to evaluate gastric emptying at the bedside, with the advantage of avoiding radiation exposure,[42,4344] but it is labour intensive and requires normal function of the duodenum, liver, and lungs that may influence the accuracy in the ICU.[3] The use of breath tests as a routine bedside test to monitor GRV has not been established. Ultrasound is a noninvasive method using cross-sectional scans of a defined portion of the stomach to calculate the cross-sectional area and the gastric volume. Its use has not been validated in critically ill patients, and standardization is lacking even for healthy subjects.[3] Refractometry and the derived mathematical equations measure formula concentration, GRV, and formula volume.[29] The use of refractometry for the regular assessment of enteral nutrition in the critically ill is promising; however, standardisation and validation of this method are needed.[3] While some of these methods to monitor GRV are promising further research is needed leaving the current routine practice of intermittent aspiration as the most common approach to gastric emptying assessment.

The necessity of checking gastric residual volume at all has been questioned. The stomach does not empty continuously and having some GRV stimulates contractions to facilitate gastric emptying.[45] It is unknown what the volume should be for individual patients and an elevated GRV may simply be a physiologic occurrence. Spain (1999) demonstrated that 80% of critically ill patients who experienced an elevated GRV never had a second episode, despite feeding being continued after the first episode.[46] In a recent multicentre French randomized controlled trial, patients in the intervention group did not have their GRV checked. Their EN delivery was adjusted only when patients experienced vomiting or regurgitation. Although almost twice as much vomiting was experienced by the intervention group, the occurrence of VAP was similar between

the control and intervention groups and the intervention group received more of their target nutrition.[47] Further research is needed before routine GRV monitoring is stopped.

Limitations

This was a single centred study but patient characteristics are similar to ICUs in metropolitan tertiary-referral hospitals in Australia. The trial could not be blinded so there is the possibility of bias although the clinical nurse specialists monitored adherence to the protocol regularly and did not find any evidence for this. Age, sex and severity of illness (APACHE II score) were evenly distributed between the control and intervention groups but there were more patients with sepsis in the control group and this may have influenced the results. However, diagnosis was not an independent predictor of the number of aspirations in multivariate linear regression models.

Any pattern of increased VAP was monitored during the study period and reported to a safety monitoring committee comprised of two independent intensivists but no patterns were observed. Chest x-rays were reviewed for new infiltrates at the end of the study by an intensivist blinded to group allocation. An independent radiologist had been employed to conduct this review during the study but work commitments in the busy radiology department prevented this. The review of chest x-rays found no difference in the incidence of VAP.

Conclusion

The frequency of gastric tube aspirations reduced in the variable regimen group with no increase in risk to patients using VAP as the measure of risk. The proportion of patients who regurgitated or vomited feed almost doubled (although this was a small proportion overall) which might be considered a risk factor for further complications. The reduced frequency of aspirations saves

nursing time, decreases risk of contamination of EN circuit and minimises risk of body fluid exposure, however this was not sustained due to the increased exposure to regurgitated enteral feed. On the basis of this study introducing a variable regimen of gastric aspiration will reduce the number of tube aspirations but ultimately doesn't assist in meeting feed volume targets and should be considered carefully given the likelihood of increased vomiting and regurgitation. Further research is needed to determine if delaying the introduction of the variable regimen may limit the incidence of vomiting and regurgitation. The absolute value for reducing or ceasing feeding also remains to be established, as does the necessity for measurement of GRV and the most appropriate technique for measurement in the clinical setting.

References

1.   McClave SA, Lukan JK, Stefater JA, et al. Poor validity of residual volumes as a marker for risk of aspiration in critically ill patients. Crit Care Med. 2005;33:324-30.

2.   Chapman M, Fraser R, Kluger M, Buist M, De Nichilo D. Erythromycin improves gastric emptying in critically ill patients intolerant of nasogastric feeding. Crit Care Med. 2000;28:2334-7.

3.   Moreira TV, McQuiggan M. Methods for the assessment of gastric emptying in critically ill, enterally fed adults. Nutr Clin Pract. 2009;24:261-73.

4.   Cataldi-Betcher EL, Seltzer MH, Slocum BA, Jones KW. Complications occurring during enteral nutrition support: a prospective study. JPEN J Parenter Enteral Nutr. 1983;7:546-52.

5.   Vanek V. Closed versus open enteral delivery systems: a quality improvement study. Nutr Clin Pract. 2000;15:234-43.

6.   Matlow A, Jacobson M, Wray R, et al. Enteral tube hub as a reservoir for transmissible enteric bacteria. Am J Infect Control. 2006;34:131-3.

7.   Pellowe CM, Pratt RJ, Harper P, et al. Evidence-based guidelines for preventing healthcare-associated infections in primary and community care in England. J Hosp Infect. 2003;55 Suppl 2:S2-127.

8.   Centers for Disease Control and Prevention. The National Healthcare Safety Network (NHSN) manual: patient safety component protocol (2007). Available at:

http://www.cdc.gov/ncidod/dhqp/pdf/nhsn/NHSN_Manual_Patient_Safety_Protocol052407.pdf.

Accessed April 2009

9.   Wall RJ, Ely EW, Talbot TR, et al. Evidence-based algorithms for diagnosing and treating ventilator-associated pneumonia. J Hosp Med. 2008;3:409-22.

10.   National Health and Medical Research Council (2007). National Statement on Ethical Conduct in Research Involving Humans. Available from

http://www7.health.gov.au/nhmrc/publications/_files/e35.pdf. Accessed May 2011.

11.   College of Intensive Care of Australia and New Zealand (2010). IC-1. Minimum standards for intensive care units. Available from http://www.cicm.org.au/cmsfiles/IC-1%20Minimum%20Standards%20for%20Intensive%20Care%20Units.pdf. Accessed Oct 2011.

12.   Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. Crit Care Med. 1985;13:818-29.

13.   Knaus WA, Wagner DP, Draper EA, et al. The APACHE III prognostic system. Risk prediction of hospital mortality for critically ill hospitalized adults. Chest. 1991;100:1619-36.

14.   Ireton-Jones C, Turner WJ, Liepa G, Baxter C. Equations for the estimation of energy expenditures in patients with burns with special reference to ventilatory status. J Burn Care Rehabil. 1992;13:330-3.

15.   Harris J, Benedict F. A biometric study on basal metabolism in men.Washington, DC: Carnegie Institute of Washington; 1919. Public N° 279. Available from

http://archive.org/details/biometricstudyof00harruoft Accessed Dec 2012.

16.   Mentec H, Dupont H, Bocchetti M, Cani P, Ponche F, Bleichner G. Upper digestive intolerance during enteral nutrition in critically ill patients: frequency, risk factors, and complications. Crit Care Med. 2001;29:1955-61.

17.   McClave SA, Snider HL, Lowen CC, et al. Use of residual volume as a marker for enteral feeding intolerance: prospective blinded comparison with physical examination and radiographic findings. JPEN J Parenter Enteral Nutr. 1992;16:99-105.

18.   Arrowsmith H. Nursing management of patients receiving a nasogastric feed. Br J Nurs. 1993;2:1053-8.

19.   Bowers S. Tubes: a nurse's guide to enteral feeding devices. MEDSURG Nursing. 1996;5:313-24.

20.   Goodwin RS. Prevention of aspiration pneumonia: a research-based protocol. Dimens Crit Care Nurs. 1996;15:58-71.

21.   Edwards SJ, Metheny NA. Measurement of gastric residual volume: state of the science. Medsurg Nurs. 2000;9:125-8.

22.   Metheny N. Minimizing respiratory complications of nasoenteric tube feedings: state of the science. Heart Lung. 1993;22:213-23.

23.   Payne-James J. Retrograde (ascending) bacterial contamination of enteral diet administration systems. JPEN J Parenter Enteral Nutr. 1992; 16:369-73.

24.   Fellows LS, Miller EH, Frederickson M, Bly B, Felt P. Evidence-based practice for enteral feedings: aspiration prevention strategies, bedside detection, and practice change. Medsurg Nurs 2000;9:27-31.

25.   Jolliet P, Pichard C, Biolo G, et al. Enteral nutrition in intensive care patients: a practical approach. Working Group on Nutrition and Metabolism, ESICM. European Society of Intensive Care Medicine. Intensive Care Med. 1998;24:848-59.

26.   Kleibeuker JH, Boersma-van Ek W. Acute effects of continuous nasogastric tube feeding on gastric function: comparison of a polymeric and a nonpolymeric formula. JPEN J Parenter Enteral Nutr. 1991;15:80-4.

27.   Montejo JC, Minambres E, Bordeje L, et al. Gastric residual volume during enteral nutrition in ICU patients: the REGANE study. Intensive Care Med. 2010;36:1386-93.

28.   Soroksky A, Lorber J, Klinowski E, et al. A simplified approach to the management of gastric residual volumes in critically ill mechanically ventilated patients: a pilot prospective cohort study. Isr Med Assoc J. 2010;12:543-8.

29.   Chang W-K, McClave SA, Hsieh C-B, Chao Y-C. Gastric residual volume (GRV) and gastric contents measurement by refractometry. JPEN J Parenter Enteral Nutr. 2007;31:63-8.

30.   McClave SA, Sexton LK, Spain DA, et al. Enteral tube feeding in the intensive care unit: factors impeding adequate delivery. Crit Care Med. 1999;27:1252-6.

31.   Lukan J, McClave S, Stefater A, et al. Poor validity of residual volumes as a marker for aspiration. Am J Clin Nutr. 2002;75:417S-8S.

32.   Metheny N, Reed L, Worseck M, Clark J. How to aspirate fluid from small-bore feeding tubes. Am J Nurs. 1993;93:86-8.

33.   Metheny NA, Stewart J, Nuetzel G, Oliver D, Clouse RE. Effect of feeding-tube properties on residual volume measurements in tube-fed patients. JPEN J Parenter Enteral Nutr. 2005;29:192-7.

34.   Jacobsen A, Jenaway S, Jones D, Phillips F, Sims K, T. W. Nursing Practice Standard for the Management of Enteral Tubes and Enteral Feeding Administration. Perth: Royal Perth Hospital; 2009.

35.   Soulsby CT, Khela M, Yazaki E, Evans DF, Hennessy E, Powell-Tuck J. Measurements of gastric emptying during continuous nasogastric infusion of liquid feed: electric impedance tomography versus gamma scintigraphy. Clin Nutr. 2006;25:671-80.

36.   Walker DA, Nimmo WS. New non-invasive methods for measuring gastric emptying. Br J Anaesth. 1988;60:483-5.

37.   Goldhill DR, Whelpton R, Winyard JA, Wilkinson KA. Gastric emptying in patients the day after cardiac surgery. Anaesthesia. 1995;50:122-5.

38.   Tarling MM, Toner CC, Withington PS, Baxter MK, Whelpton R, Goldhill DR. A model of gastric emptying using paracetamol absorption in intensive care patients. Intensive Care Med. 1997;23:256-60.

39.   Cohen J, Aharon A, Singer P. The paracetamol absorption test: a useful addition to the enteral nutrition algorithm? Clin Nutr. 2000;19:233-6.

40.   Chapman MJ, Besanko LK, Burgstad CM, et al. Gastric emptying of a liquid nutrient meal in the critically ill: relationship between scintigraphic and carbon breath test measurement. Gut. 2011;60:1336-43.

41.   Willems M, Quartero AO, Numans ME. How useful is paracetamol absorption as a marker of gastric emptying? A systematic literature study. Dig Dis Sci. 2001;46:2256-62.

42.   Ritz MA, Fraser R, Edwards N, et al. Delayed gastric emptying in ventilated critically ill patients: measurement by 13 C-octanoic acid breath test. Crit Care Med. 2001;29:1744-9.

43.   Nguyen NQ, Ng MP, Chapman M, Fraser RJ, Holloway RH. The impact of admission diagnosis on gastric emptying in critically ill patients. Crit Care. 2007;11:R16.

44.   Kim DY, Myung SJ, Camilleri M. Novel testing of human gastric motor and sensory functions: rationale, methods, and potential applications in clinical practice. Am J Gastroenterol. 2000;95:3365-73.

45.   Rice TW. Gastric residual volume: End of an era. JAMA. 2013;309:283-4.

46.   Spain DA, McClave SA, Sexton LK, et al. Infusion protocol improves delivery of enteral tube feeding in the critical care unit. JPEN J Parenter Enteral Nutr. 1999;23:288-92.

47.   Reignier J, Mercier E, Le Gouge A, et al. Effect of not monitoring residual gastric volume on

risk of ventilator-associated pneumonia in adults receiving mechanical ventilation and early

enteral feeding: a randomized controlled trial. JAMA. 2013;309:249-56. doi:

10.1001/jama.2012.196377.