Gastroesophageal Reflux and Tracheobronchial Contamination After Cardiac Surgery: Should a Nasogastric Tube Be Routine?

Glenn N. Russell, FRCA*, Pierre C. Ip Yam, FRCA†, Jane Tran, B Tech†, Paul Innes, FRCA†, Steven D. Thomas, FRCA†, Peter D. Berry, FRCA†, Mark A. Fox, FRCA*, Brian M. Fabri, FRCS*, Mark Jackson, BSc†, and W. Ian Weir, FRCS*

*Departments of Anaesthesia and Surgery, Cardiothoracic Centre-Liverpool NHS Trust, and †University Department of Anaesthesia, Royal Liverpool University Hospital, Liverpool, England

Nasogastric (NG) tubes are routinely used in patients undergoing cardiac surgery. This randomized study was designed to assess gastroesophageal reflux (GER) without a NG tube (control) compared with a NG tube managed either by gravity drainage (gravity) or continuous low-grade suction (suction). Antimony pH probes were placed in the lower esophagus and trachea after induction of anesthesia in 51 patients, and pH was recorded every 5 s until the time of tracheal extubation. GER was defined as reversible decrease in esophageal pH to less than 4.0. No significant difference was found between groups in age, weight, gender, duration of postoperative ventilation, morphine use, or antiemetic use. All indicators of GER were seen more frequently in the gravity group compared with the two other groups (P < 0.001). One episode of sudden decrease in tracheal pH was observed in a patient in the gravity group, indicating tracheal aspiration, which was associated with delayed extubation and postoperative pneumonia. The absence of a NG tube is not associated with reflux, probably since the gastroesophageal sphincter remains competent. NG tubes are not routinely necessary for cardiac surgery in patients without risk factors for GER, and increase reflux risk if managed without low-grade suction.

(Anesth Analg 1996;83:228-32)

Approximately half of cardiac surgical centers in the United Kingdom use nasogastric (NG) tubes routinely in patients undergoing cardiac surgical operations (G. N. Russell, unpublished data). There are, however, differing opinions about the need for a NG drainage tube in this situation. Proponents suggest that gastric stasis associated with this type of surgery (1) may predispose the patient to gastroesophageal reflux (GER) and tracheal aspiration. Reducing gastric volume with a NG tube should reduce this risk. Opponents of NG tubes generally suggest that patient discomfort and complications such as epistaxis outweigh any specific advantages.

Two main types of NG tube are used in patients undergoing cardiac surgery. The first is a single-lumen tube that drains the stomach by acting to syphon gastric contents by a gravity effect. The second is a sump-type, dual-lumen tube to which low-grade suction can be applied without damaging the gastric mucosa.

With the advent of continuous pH monitoring, esophageal and tracheal pH can be recorded for up to 24 hours (2). This study was designed to establish the incidence of GER during cardiac surgery and the postoperative period without a NG tube and with a tube managed by either gravity drainage or low-grade suction.

Methods

After ethics committee approval and informed consent, 51 patients undergoing elective cardiac surgery were studied. Exclusion criteria were known hiatus hernia, a history of heartburn or acid reflux, previous gastric surgery, H2 receptor antagonist or omeprazole therapy, diabetes, and morbid obesity.

The anesthetic technique was standardized. After premedication with lorazepam 2–3 mg by mouth, anesthesia was induced with fentanyl 30 μg/kg, etomidate 0.2–0.3 mg/kg, and vecuronium 0.2 mg/kg. Anesthesia was maintained throughout with enflurane in

Accepted for publication April 10, 1996.

Address correspondence to Glenn N. Russell, FRCA, Department of Anaesthesia, Cardiothoracic Centre-Liverpool, Thomas Drive, Liverpool L14, England.
Figure 1. A tracheal pH probe was inserted through a hole pierced in the rubber diaphragm of a bronchoscopy type Portex catheter mount and protruded 2.5 cm beyond the end of the endotracheal tube.

All patients underwent hypothermic cardiopulmonary bypass and were cooled to a nasopharyngeal temperature of between 28 and 32°C. After cardiac surgery, the patients underwent a period of elective mechanical ventilation during which time they were sedated with bolus doses of morphine supplemented with a propofol infusion at 1–3 mg·kg⁻¹·h⁻¹. The total dose of morphine administered was recorded, as was the antiemetic requirement in the first 36 h after surgery.

Patients were randomly allocated to three groups: The control group did not have a NG tube placed. The gravity group had a single-lumen 14 Fr NG tube (Penning Health Care, Derby, England) inserted and managed by gravity drainage. The third group had a 14 Fr dual-lumen sump NG tube (Sherwood Medical, Petit Rechain, Belgium) inserted and managed by low-grade suction using an Ohmeda suction unit (Ohmeda, Windham, Surrey, United Kingdom). The unit applied a suction pressure of 75 mm Hg for approximately 1 min followed by a 30-s interval during which no suction pressure was applied. This intermittent cycling of suction pressure continued throughout the study. The nasogastric tubes were inserted after induction of anesthesia. The collection reservoir in both NG groups was always below the level of the patients' stomach.

After induction of anesthesia and muscle relaxation, fine esophageal and tracheal pH probes with antimony electrodes were inserted. Prior to insertion, the probes were calibrated to pH 1.0 and 7.0. The esophageal probe was inserted until a pH of less than 3.0 was detected, indicating gastric placement. It was then carefully withdrawn into the lower esophagus until a distinct change in pH was noted. The tracheal probe was inserted through a specially adapted catheter mount (Fig. 1) to protrude 2.5 cm beyond the tip of the endotracheal tube and lie in the main trachea. The probes and reference electrode were then connected to a Digitrapper MK (Synectics Medical Ltd., Middlesex, United Kingdom) device that recorded and stored pH values every 5 s for the duration of the operation and the period of ventilatory support. The technique has a quoted detection sensitivity of 0.1 pH units with a system drift over 100 h of < 0.1 units. The position of both probes was confirmed postoperatively in the intensive care unit by radiological assessment. An acceptable position for the esophageal probe was 5–10 cm above the diaphragm, with the tracheal probe in the main trachea.

All patients were supine during the period of sedation and mechanical ventilation (usually overnight) to facilitate hemodynamic stability. A high-volume, low-pressure endotracheal tube was used with the cuff inflated until an air leak was no longer audible. Five centimeters of positive end-expiratory pressure was used. During awakening, a maximum head-up tilt of 20° was used until endotracheal extubation and probe removal. After removal, the calibration of all probes was rechecked to exclude drift over the course of the measurement period. The data were transferred to an Amstrad personal computer using dedicated software (Synectics Liberty system and Eosophagram software). Hard copies of the resulting tracheal and esophageal pH traces were then obtained with a scale of 3 mm/min and analyzed manually with the investigator blinded to the study group allocation of the patients (Fig. 2). Tracheal and esophageal recordings were analyzed for number and duration of reflux episodes. A reversible decrease in pH to less than 4.0 for more than 1 min was used to define esophageal reflux. A return of the pH to > than 4 for 1 min or more was used to separate reflux episodes. The number of refluxes per hour of monitoring, the fractional (%) time of the esophageal pH was less than 4, and the number of refluxes more than 5 min in duration were compared.
Table 1. Demographic Data

<table>
<thead>
<tr>
<th></th>
<th>Control (n = 15)</th>
<th>Gravity (n = 17)</th>
<th>Suction (n = 16)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>62 (47-87)</td>
<td>63 (49-80)</td>
<td>63 (48-78)</td>
<td>0.83</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>167 (152-180)</td>
<td>173 (152-177)</td>
<td>165 (154-180)</td>
<td>0.31</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>75 (55-96)</td>
<td>75 (60-98)</td>
<td>71 (53-91)</td>
<td>0.55</td>
</tr>
<tr>
<td>Gender (male:female)</td>
<td>10:5</td>
<td>12:5</td>
<td>9:7</td>
<td>0.68</td>
</tr>
<tr>
<td>CPB time (min)</td>
<td>115 (60-166)</td>
<td>117 (60-270)</td>
<td>121 (62-165)</td>
<td>0.91</td>
</tr>
<tr>
<td>Duration of operation (min)</td>
<td>270 (180-420)</td>
<td>240 (150-360)</td>
<td>250 (135-420)</td>
<td>0.67</td>
</tr>
<tr>
<td>Duration of mechanical ventilation (h)</td>
<td>17 (12-20)</td>
<td>16.4 (8-19.5)</td>
<td>17.5 (8-19.5)</td>
<td>0.46</td>
</tr>
<tr>
<td>Length of stay in ICU (h)</td>
<td>18 (18-360)</td>
<td>36 (18-98)</td>
<td>18 (18-96)</td>
<td>0.56</td>
</tr>
<tr>
<td>Length of stay in hospital (days)</td>
<td>8 (6-21)</td>
<td>9 (6-17)</td>
<td>8 (7-16)</td>
<td>0.32</td>
</tr>
<tr>
<td>Total morphine (mg)</td>
<td>15 (5-45)</td>
<td>15 (0-30)</td>
<td>17.5 (0-25)</td>
<td>0.07</td>
</tr>
<tr>
<td>Metoclopramide requirement (mg) in first 36 h</td>
<td>0 (0-10)</td>
<td>0 (0-20)</td>
<td>0 (0-20)</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Values are median (95% confidence intervals).

Table 2. Incidence of Gastroesophageal Reflux in Three Study Groups

<table>
<thead>
<tr>
<th>Index of reflux</th>
<th>Control</th>
<th>Gravity</th>
<th>Suction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of refluxes</td>
<td>0 (0-1)</td>
<td>1 (0-6)</td>
<td>0 (0-5)</td>
</tr>
<tr>
<td>No. refluxes &gt; 0</td>
<td>0 (0-0)</td>
<td>1 (0-5)</td>
<td>0 (0-0)</td>
</tr>
<tr>
<td>5 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total time (min) &lt;4.0 pH</td>
<td>0 (0-1.9)</td>
<td>10 (0-147)</td>
<td>0 (0-5)</td>
</tr>
<tr>
<td>% Time pH &lt; 4.0</td>
<td>0 (0-0.05)</td>
<td>0.98 (0.12-7)</td>
<td>0 (0-0.44)</td>
</tr>
<tr>
<td>Refluxes/hour</td>
<td>0 (0-0.6)</td>
<td>0.06 (0-0.4)</td>
<td>0 (0-0.76)</td>
</tr>
</tbody>
</table>

Values are median (95% confidence intervals).

All data were tested for normality of distribution. Due to significant skewness in some of the data (predominantly confined to event variables such as the total number of refluxes), all descriptive data are presented as median values with 95% confidence intervals. Differences in demographic and nonevent data between groups were sought using a Wilcoxon rank sum test. Any differences were corrected for prior to assessment of the true effect of NG tube type using multivariate analysis of variance. The pairwise comparisons of Bonferroni and Tukey were then applied to identify the origin of differences. Throughout, P values ≤ 0.05 were considered significant.

Results

Three patients were excluded from the study. In two, the esophageal probe could not be correctly positioned in the lower esophagus, and in the third, the tracheal probe was accidentally removed on return to the intensive care unit.

Table 1 displays the demographic data. There were no significant differences in any of the demographic or length of stay variables.

The results of all indicators of GER are summarized in Table 2. Despite the significantly increased incidence and duration of GER in the gravity group, only one patient demonstrated a decrease in tracheal pH (Fig. 2) suggesting tracheal aspiration. This was directly preceded by an episode of GER. The patient developed marked bronchospasm and hypoxemia, resulting in delayed endotracheal extubation for 24 h. Discharge from intensive care was also delayed until the fourth postoperative day.

Discussion

Patients excluded from the study were those with a high risk of GER, such as those with diabetes, known hiatus hernia, and morbid obesity. In addition, a history of heartburn or acid reflux is strongly predictive of GER as shown by pH studies (3,4). We feel that these patients should, as a matter of routine, receive continuous NG drainage with a sump tube. The purpose of our study was to examine the routine use of NG tubes in patients without GER risk factors—a group that constitutes the majority of patients presenting for cardiac surgery.

While there have been a number of other techniques used to assess GER (5,6), continuous esophageal pH recording as used in this study is the only method that allows monitoring over prolonged periods. The definition of GER applied in this study, and in particular the use of pH 4 to define an episode, is standard in most studies of reflux (7,8). There is, however, little agreement as to the importance of gastric pH and the potential for lung injury. Aspiration pneumonia has been described after neutralization of gastric contents to a pH as high as 3.5 (9), and aspiration of gastric contents containing fine particulate matter at pH 5.9
causes hypoxemia, hypercarbia, and pneumonitis in dogs (10). The use of pH 4 is therefore in keeping with the precedent and has relevance to the potential for lung injury should tracheal aspiration occur.

The application of continuous pH recording to assess tracheal aspiration is more recent and has been facilitated by the availability of probes less than 1.5 mm in diameter (2). In contrast to studies of esophageal pH, there are few studies defining the normal tracheal pH. In 1990, McLoughlin et al. (11) reported the mean tracheal pH to be 5.71 ± 0.29. These authors, however, used as a local anesthetic 4% lidocaine, which has a pH of 4.9. A subsequent study (12) under general anesthesia found a mean tracheal pH of 7.0 (range 6.5–7.4), which is more in keeping with the values seen in our study.

Factors promoting GER are gastric stasis and incompetence of the gastroesophageal sphincter. The use of relatively large-dose opioids during cardiac surgery and the postoperative period of mechanical ventilation may promote gastric stasis (13) and reduce lower esophageal sphincter (LES) tone (14), thus promoting GER. Despite these factors, reflux was rare in the control group. Although there are no studies of LES barrier pressure in this clinical situation, it would appear adequate to prevent reflux of stomach content, even in the presence of the opioid dose used in this study.

In marked contrast to the control group, reflux was common in the gravity group. Nagler et al. (15) demonstrated that a NG tube placed across the LES may render it incompetent, thus promoting reflux. In their study, acid reflux was not seen when the tube remained above the sphincter—a situation analogous to the control group in this study. Vinnik and Kern (16) similarly noted GER in the presence of a NG tube, despite elevation of the head by 15–20°. Consistent with this, Arms et al. (17) noted aspiration to occur more frequently in patients with NG tubes after general surgery and suggested the cause to be passive regurgitation of stomach contents around the tube.

The sump NG tube used in the suction group would also render the LES incompetent. However, a sump tube may be more efficient in reducing gastric volume (18) compared with a single-lumen tube and accordingly has been used to assess residual gastric volumes in studies concerned with gastric aspiration (19,20). The application of low-grade suction to this tube should also facilitate gastric emptying. Although the LES may also have been rendered incompetent in the suction group, the incidence of reflux was probably reduced by the action of more complete gastric emptying.

In the long term, GER is associated with esophagitis and stricture formation. However, during the perioperative period, the main concern is the potential for pulmonary complications. Three mechanisms have been proposed. First, reflux of acidic material may stimulate esophageal mucosal receptors and induce a vagally mediated reflex bronchoconstriction. This reflex has been demonstrated in acid perfusion studies of the esophagus and is most likely to occur in patients with asthma or bronchial hyperreactivity (21). Second, microaspiration of gastric contents into the upper airway may cause bronchospasm and mucosal edema (6). Third, gross contamination of the lungs may occur. Although the presence of a cuffed endotracheal tube does not guarantee protection of the airway (22), gross contamination of the lungs is unlikely and microaspiration is the most likely cause of lung injury seen in the patient from the gravity group described previously.

Prior to this study, we could find no data on the incidence of GER in our study population, making power prediction difficult. We performed data analysis after 51 patients had been recruited. Our results indicate a significantly greater incidence of reflux with gravity drainage and, in one patient, a clear relationship with tracheal aspiration. We therefore felt it unreasonable to recruit additional patients for this group and terminated the study. However, with reference to the suction and control groups, the study commands approximately 30% power to detect a difference of one reflux at the 5% level of significance with the number of patients studied. The similarity of outcome data such as length of stay in this study is related to the multiple factors that influence postoperative morbidity, not simply to the use of NG drainage. A much larger study would be required to isolate the contribution of all the individual factors, including NG drainage technique, relevant to outcome.

Our results suggest that GER is uncommon in patients without risk factors for GER undergoing cardiac surgery and postoperative mechanical ventilation, despite use of a moderate-dose opioid anesthetic technique. If NG drainage is indicated for reasons other than reflux, a sump-type tube should be used and managed by low-grade suction. This study demonstrates that the insertion of a single-lumen NG tube managed by conventional gravity drainage may promote GER, thereby exposing the patient to the risk of microaspiration and consequent postoperative pulmonary complications.

We are grateful to Ohmeda (UK) Ltd. for the loan of the low-grade suction unit.

References


