SWALLOWING DYSFUNCTION AFTER CARDIAC OPERATIONS

Associated adverse outcomes and risk factors including intraoperative transesophageal echocardiography

The frequency, importance to patient outcomes, and independent predictors of postoperative swallowing dysfunction documented by barium cineradiography were examined in 869 patients undergoing cardiac operations over a 12-month period. Swallowing dysfunction was diagnosed in 34 patients (4% incidence) and was associated with documented pulmonary aspiration in 90% of these patients, increased frequency of pneumonia ($p < 0.0001$), need for tracheostomy ($p = 0.0002$), length of stay in the intensive care unit ($p = 0.0001$), and duration of hospitalization after the operation ($p = 0.0001$). Independent predictors of postoperative swallowing dysfunction determined by multivariate logistic regression included age ($p < 0.001$), length of tracheal intubation after the operation ($p = 0.001$), and intraoperative use of transesophageal echocardiography ($p = 0.003$). Dysfunctional swallowing after cardiac operations, a serious complication significantly related to postoperative respiratory morbidity and extended length of hospitalization, is more common in older patients. An association between intraoperative use of transesophageal echocardiography and swallowing dysfunction was also observed in our patients. (J THORAC CARDIOVASC SURG 1995;110:517-22)

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Patients requiring cardiac operations are increasingly of advanced age and more likely to have complex cardiovascular and other diseases.¹⁻⁶ More frequent perioperative complications are thus to be expected.¹⁻⁷ During the past several years, we became aware of an apparent increase in the frequency of swallowing dysfunction after cardiac operations. Dysfunctional swallowing, by increasing the risk of pulmonary aspiration, is a potentially serious postoperative complication. Although swallowing disorders have been characterized in association with other pathophysiologic processes, little information is available about the risk factors and

clinical importance of swallowing disorders after cardiac operations.⁸⁻¹⁴ The apparent increased frequency of postoperative swallowing dysfunction at our institution appeared to coincide with the introduction of intraoperative transesophageal echocardiography (TEE). Others have since suggested no relation between postoperative dysphagia and the use of TEE during cardiac operations.^{15,16} Thus, it was not clear whether this apparent clinical increase in the prevalence of postoperative swallowing dysfunction reflected changes in the demographics of patients having cardiac operations or was related to the intraoperative use of TEE. The purpose of this study, therefore, was to examine the frequency of and importance to patient outcome of swallowing disorders after cardiac operations and to identify possible risk factors for the development of this complication.

Methods

All procedures of this study were approved by our institution's human studies committee. The patient population consisted of all patients undergoing cardiac operations necessitating cardiopulmonary bypass at Barnes Hospital, Washington University School of Medicine, St. Louis, over a 12-month period from February 1992

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through January 1993. Patients received routine perioperative care including opioid-based anesthetics supplemented with volatile anesthetics and skeletal muscle relaxants. Cardiopulmonary bypass included the use of membrane oxygenators (Cobe, Inc. Denver, Colo.) and arterial line filtration. Systemic hypothermia (at least 28° C) was used during cardiopulmonary bypass except in 55 patients in whom systemic normothermia was maintained. The decision to use intraoperative TEE was at the discretion of the attending anesthesiologist and surgeon. Common indications for intraoperative TEE use included a history of valvulopathy or reduced ventricular function, operations to correct arrhythmias, and reoperations. The TEE probe, inserted after orotracheal intubation by an anesthesiologist experienced with probe placement, was left in place (including during cardiopulmonary bypass) until the completion of the operation.

After postoperative tracheal extubation, patients with dysphagia or coughing when drinking water were evaluated with barium swallow cineradiography. Patients, seated upright and facing to the side, were given barium-impregnated custard and the swallowing mechanism was evaluated with a fluoroscope as to the time of oral transport of the food bolus, sensorimotor function, pharyngeal peristalsis, and epiglottic closure. The presence of pulmonary aspiration was also noted. Swallowing evaluations were recorded on high-resolution videotape with single-frame, stop-motion capability. Recordings from each examination were reviewed by two observers with consensus required for diagnosis of swallowing dysfunction. The diagnosis of a swallowing disorder required the presence of an abnormality in at least one of the evaluated phases of swallowing.

Data collection over the first 6 months of the study included completion of a questionnaire by the attending anesthesiologist on all patients ascertaining the use of TEE. During the remaining 6 months of the study, after methods of anesthesia data collection were improved, information about TEE use was obtained from the anesthesia records. Patient characteristics and perioperative data were collected from the medical record often after patient discharge from the hospital. This information included patient age, history of myocardial infarction, hypertension, diabetes mellitus, cerebrovascular accident, chronic obstructive pulmonary disease, renal insufficiency (plasma creatinine concentration $>122 \mu\text{mol/L}$ or requirement for dialysis, or both), and intubation at the time of the operation. Left ventricular function, as evaluated with contrast ventriculography at the time of cardiac catheterization or with preoperative transthoracic echocardiography, was also recorded. Left ventricular function was considered within normal limits, moderately reduced, and severely reduced for left ventricular ejection fractions of more than 50%, 35% to 50%, and less than 35%, respectively. Perioperative information evaluated included the duration of cardiopulmonary bypass and aortic crossclamping, the presence of low cardiac output state after the operation (cardiac index $<2.0 \text{ L/min per square meter}$ for >8 hours), the use of intraaortic balloon pumping for reduced left ventricular function, the development of a new cerebrovascular accident (new major neurologic deficit detected by physical examination), renal

insufficiency (plasma creatinine concentration $>122 \mu\text{mol/L}$), liver dysfunction (necessitating any two of the following: plasma alkaline phosphatase $\geq 156 \text{ IU/L}$, plasma total bilirubin $\geq 27 \mu\text{mol/L}$, plasma albumin $\leq 30 \text{ gm/L}$, and plasma aspartate aminotransferase $\geq 67 \text{ IU/L}$), use of parenteral nutrition, and the development of sepsis (defined as fever, reduced systemic vascular resistance, white blood cell count $>12 \times 10^3/\text{mm}^3$, and positive blood or urine culture of bacteria not believed to be a contaminant). The duration of orotracheal intubation was also determined and defined as the time until initial tracheal extubation for patients requiring reintubation. In addition to the development of swallowing dysfunction, postoperative outcomes evaluated included postoperative pneumonia (new and persistent roentgenographic infiltrate accompanied by fever, leukocytosis, or purulent tracheal aspirate), the need for tracheostomy, and the length of stay in the intensive care unit (ICU), and total postoperative hospital admission.

Patients were categorized on the basis of the presence or absence of a swallowing disorder as defined earlier. Because the presence of a tracheostomy may be associated with dysfunctional swallowing, data were analyzed both with and without patients having a tracheostomy.⁸⁻¹¹ One patient had left vocal cord paresis after repair of a descending thoracic aortic aneurysm. Because of the possibility of injury to the left recurrent laryngeal nerve, data from this patient were omitted from analysis.

Categorical data were evaluated with χ^2 testing or Fisher's exact test as appropriate, and continuous variables were compared with Student's *t* test by means of SAS software (PC version 6.0.4, SAS Institute, Cary, N.C.). Stepwise multivariate logistic regression analysis was performed with the following variables considered in the model: age, prior myocardial infarction, preoperative left ventricular function, diabetes mellitus, history of chronic obstructive lung disease, hypertension, perioperative renal dysfunction, prior and new postoperative stroke, postoperative low cardiac output state, postoperative use of an intraaortic balloon pump, cardiopulmonary bypass and aortic crossclamp times, intraoperative use of TEE, duration of tracheal intubation after the operation, and the need for tracheostomy. Data are reported as mean $\pm$ standard error of the mean. Differences were considered to be significant at $p \leq 0.05$.

Results

Patient demographics and other characteristics are shown in Table I. Swallowing dysfunction was demonstrated by postoperative radiography in 34 (4%) of 869 patients. Results of barium swallow cineradiography showed reduced oral preparatory phase in 22% of patients, impaired swallowing reflex in 67%, incomplete epiglottic closure in 48%, and decreased pharyngeal peristalsis in 56% of patients. Pulmonary aspiration was documented in 90% of patients without tracheostomy, with the aspiration silent or unaccompanied by cough reflex in 22% of these patients. No differences were ob-

Table I. Demographic and perioperative characteristics for patients with and without postoperative swallowing dysfunction

	Swallowing dysfunction (n=34)	No swallowing dysfunction (n=835)	p Value
Age* (yr)	71.0 ± 2.0	63.0 ± 0.4	0.0001
Male/female	20/14	537/296	NS
Medical history			
Myocardial infarction	13 (38%)	404 (48%)	NS
Left ventricular function			
Normal	17 (50%)	516 (62%)	NS
Moderately reduced	6 (18%)	195 (23%)	NS
Severely reduced	5 (15%)	105 (13%)	NS
Hypertension	15 (44%)	475 (57%)	NS
Diabetes mellitus	8 (24%)	210 (25%)	NS
CVA	5 (15%)	71 (9%)	NS
COPD	4 (12%)	64 (8%)	NS
Renal dysfunction	4 (12%)	72 (9%)	NS
Cardiopulmonary bypass time* (min)	148.0 ± 10.4	134.3 ± 2.1	NS
Aortic crossclamp time* (min)	63.1 ± 5.3	60.0 ± 1.3	NS
Low cardiac output state	5 (15%)	47 (6%)	0.047
Intraaortic balloon pump after operation	5 (15%)	45 (5%)	0.02
Postoperative stroke	2 (6%)	15 (2%)	NS
Tracheal intubation (days)	5.2 ± 1.7	2.1 ± 0.2	0.0006
Perioperative use of TEE	23 (68%)	404 (48%)	0.001
CABG	21 (62%)	621 (75%)	NS
CABG/valvular procedure	3 (9%)	40 (5%)	NS
Arrhythmia surgery	2 (6%)	47 (6%)	NS
Valvular surgery	1 (3%)	35 (4%)	NS
Other	7 (21%)	90 (11%)	NS

CVA, Cerebral vascular accident; COPD, chronic obstructive pulmonary disease; CABG, coronary artery bypass grafting; Arrhythmia surgery, ventricular tachycardia surgery, Wolff-Parkinson-White surgery, or the maze procedure for atrial fibrillation; Valvular surgery, aortic valve replacement, mitral valve replacement or repair; Other, heart transplant, adult congenital heart procedures, cardiac tumor, ascending or descending aortic aneurysm repair; NS, not significant.

*Mean ± standard error of the mean.

served with regard to preoperative medical history, including history of cerebrovascular accident, between patients with and without postoperative swallowing dysfunction. Furthermore, no differences were detected between patient groups with regard to duration of cardiopulmonary bypass, aortic cross-clamping, or the frequency of major new neurologic complications. After the operation, patients with dysfunctional swallowing were significantly more likely to have low cardiac output ($p = 0.047$) and to require insertion of an intraaortic balloon pump than were patients without swallowing dysfunction ($p = 0.02$).

The adverse pulmonary outcomes associated with

Table II. Postoperative pulmonary outcomes, duration of ICU stay, and hospitalization in patients with and without postoperative swallowing dysfunction

	Swallowing dysfunction	No swallowing dysfunction	p Value
Tracheostomy	6 (18%)	19 (2%)	0.0002
Pneumonia	14 (41%)	64 (8%)	<0.0001
ICU admission* (days)	15.1 ± 3.1	4.4 ± 0.2	0.0001
Postoperative hospitalization (days)*	33.4 ± 4.4	12.3 ± 0.4	0.0001

*Mean ± standard error of the mean.

Table III. Independent predictors of swallowing dysfunction after cardiac operations

	p Value
Age	<0.001
Duration of tracheal intubation	0.001
TEE used during operation	0.003

Patients with tracheostomy were removed from analysis.

postoperative swallowing dysfunction are listed in Table II. Six patients with swallowing dysfunction underwent tracheostomy because of prolonged mechanical ventilation ($p = 0.0002$ versus patients without swallowing dysfunction). Patients with postoperative swallowing dysfunction and no tracheostomy were extubated on postoperative day 5.2 ± 1.7 , compared with day 2.1 ± 0.2 in patients without swallowing dysfunction ($p = 0.0006$). Nine patients with swallowing dysfunction and no tracheostomy complained of hoarseness after tracheal extubation. Patients with postoperative swallowing dysfunction were significantly more likely to have pneumonia ($p \leq 0.0001$). Also, the length of stay in the ICU after the operation ($p = 0.0001$) and total hospitalization after the operation ($p = 0.0001$) were significantly longer in patients with postoperative swallowing dysfunction. Two (6%) patients with swallowing dysfunction died before hospital discharge and 73 (9%) patients without postoperative swallowing dysfunction ($p =$ no significant difference).

The results of multivariate logistic regression analysis to identify independent predictors of swallowing dysfunction are shown in Table III. Independent predictors of documented dysfunctional swallowing after cardiac operations were age ($p < 0.001$), length of tracheal intubation after the operation ($p = 0.001$), and intraoperative use of TEE

($p = 0.003$, odds ratio = 4.68, 95% confidence intervals 1.76 to 12.43).

Discussion

Activation of the swallowing reflex involves coordination of multiple physiologic events to ensure passage of food and liquid to the digestive system while protecting the lungs from aspiration. Impaired swallowing can result from dysfunction at any level of the swallowing reflex, including injury to oropharyngeal, laryngeal, and esophageal receptors important in initiating or providing feedback about swallowing, muscular weakness or injury, anatomic defects resulting from surgical resections (e.g., neck surgery), motor nerve dysfunction, and diffuse or localized central nervous system injury.^{8, 12-14, 17-22} In the current study we have used barium roentgenography to identify swallowing dysfunction in 4% of patients after cardiac operations. Independent predictors of postoperative swallowing dysfunction were age, duration of tracheal intubation, and intraoperative use of TEE. Moreover, the seriousness of this postoperative complication was demonstrated by the significant association between swallowing dysfunction and postoperative pneumonia, tracheostomy, and increased length of stay after the operation in the ICU and on the nursing ward.

The postoperative diagnosis of swallowing dysfunction was based in part on the subjective presence of dysphagia objectively documented with barium radiography. Although no patient complained of preoperative dysphagia or had clinical evidence of pulmonary aspiration, the possibility of preoperative subclinical swallowing dysfunction in some patients cannot be excluded. It is equally possible that subclinical swallowing dysfunction was undetected in some patients after the operation. We are confident, however, that the most clinically severe forms of swallowing dysfunction, those that are associated with adverse patient outcomes, were detected by the methods used in this study.

Because of the relationship between swallowing dysfunction and tracheostomy, patients with tracheostomies were omitted from analysis.⁸⁻¹¹ Swallowing disorders have also been reported to follow extended endotracheal intubation.^{8, 10, 11} Thus, our results confirmed the relationship between duration of intubation and postoperative swallowing dysfunction. Because of the relation between advanced age and increased risk of complications after cardiac operations, the significant relationship between age and dysfunctional swallowing after cardiac opera-

tions is not surprising.¹⁻⁷ Also, the risk of neurologic complications after cardiac operations in elderly patients is disproportionately higher than the risk of other complications.⁷ Although there were no differences in the frequency of new, major neurologic complications in the current study in patients with and without postoperative swallowing dysfunction, we cannot exclude the possibility that more detailed neurologic examinations might have revealed neurologic deficits, having swallowing dysfunction as a component, between the patient groups.

Intraoperative use of TEE provides useful diagnostic and monitoring information during cardiac operations that can influence surgical decision making.²³⁻²⁸ Because of these benefits and the mentioned changes in the demographics of patients having cardiac operations, which include increasing numbers of individuals who are older and have more associated preexisting morbidity, the use of intraoperative TEE will most likely increase. Although TEE is believed to impose little risk of complications, the association between intraoperative TEE use and postoperative swallowing dysfunction identified in the current study cannot be disregarded.^{15, 16, 29-32} Prior investigations that have reported no relationship between TEE use and dysphagia after cardiac operations have limitations including potential bias of retrospective chart reviews or small numbers of patients.^{15, 16} The frequency of intraoperative TEE use in these prior reports also is either unknown or was less than the frequency used in our cohort (17% of patients compared with 60% in the current study).

A confounding factor in evaluating the relationship between TEE and dysfunctional swallowing is that severely ill patients may both be more likely to have intraoperative TEE and also be at higher risk for prolonged endotracheal intubation. Although no differences in patient demographics between patient groups were detected (see Table I), additional factors identified by others as being associated with perioperative morbidity and not examined in this study could have been present.^{2, 33} The more frequent use of TEE, the increased frequency of low cardiac output states after surgery, and the increased need for insertion of intraaortic balloon pumps in patients with, compared with patients without, swallowing dysfunction (Table I) support the hypothesis that patients in whom this complication developed were more severely ill.

Although intraoperative use of TEE in the current study was a risk factor for the development of

postoperative swallowing dysfunction, these results suggest only an association and not a cause and effect relationship. In fact, dysfunctional swallowing occurred in 11 patients even in the absence of intraoperative TEE use. Also, swallowing dysfunction occurred in only a minority of patients having intraoperative TEE use (7% of patients excluding those patient with tracheostomy), which suggests that the combination of advanced age, duration of endotracheal intubation, and TEE use are important determinants of postoperative swallowing dysfunction and not TEE use alone. Nonetheless, when patient age and duration of tracheal intubation were controlled for with the use of multivariate logistic regression analysis, intraoperative TEE use remained an independent predictor of postoperative swallowing dysfunction. Perhaps anesthesia-induced reduction in pharyngeal patency, especially in the presence of systemic hypothermia and the nonphysiologic conditions of cardiopulmonary bypass, could result in injury to pharyngeal structures or innervation by the relatively rigid TEE probe.^{34, 35} Finally, although our results do not establish a causal relationship between intraoperative TEE use and postoperative swallowing dysfunction, even if such a relationship were present, the benefits of TEE during cardiac operations may still dictate the use of this device. Perhaps it could be used more selectively in elderly patients or only intermittently for diagnostic purposes and not continuously for monitoring purposes.

In conclusion, we observed dysfunctional swallowing in 4% of patients after cardiac operations. The presence of postoperative swallowing dysfunction was significantly associated with postoperative pneumonia, need for tracheostomy, and increased length of hospital admission in the ICU and on the postoperative nursing ward. Multivariate logistic regression analysis demonstrated that age, duration of intubation after the operation, and intraoperative use of TEE are independent predictors of postoperative swallowing dysfunction.

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