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Cardiovascular Surgery

Vocal Cord Paralysis and Laryngeal Trauma in Cardiac Surgery

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Background: Cardiac surgery – associated iatrogenic laryngeal trauma is often overlooked. We investigated the risk factors of vocal cord paralysis in cardiac surgery.

Methods: Medical records were reviewed from 169 patients who underwent elective or emergency cardiac surgeries. Patients had transesophageal echocardiography (TEE) placed either under video fiberscopic image guidance (guided group) or blind placement (blind group). Routine postoperative otolaryngologist consultation with video laryngoscopic recording were performed.

Results: Vocal cord paralyses were found in 18 patients (10.7%; left-13, right-4, bilateral-1). The risk of vocal cord paralysis was associated with emergency operation [odds ratio, 97.5 (95% confidence interval [CI], 2.9 to 366), p = 0.01]. Use of fiberscope-guided TEE [odds ratio, 0.04 (95% CI 0.01 to 0.87), p = 0.04] can effectively reduce vocal cord injury.

Conclusions: Emergency cardiac surgery increased the risk of vocal cord paralysis. Fiberscope-guided TEE placement is recommended for all patients having cardiac surgery to decrease the risk of severe peri-operative laryngeal trauma.

Key Words: Emergency surgery • Outcomes • Risk factors • Transesophageal echocardiography

INTRODUCTION

Traumatic injuries of the larynx are diverse, uncommon, and potentially life-threatening conditions. Laryngeal trauma can be divided into 3 main categories: iatrogenic, blunt, and penetrating injuries. Iatrogenic laryngeal trauma may occur after endotracheal intubation, esophagectomy, surgery of the anterior cervical spine, thyroidectomy, and cardiac surgery. After cardiac surgery, the symptoms of hoarseness or dyspnea are often underestimated in importance orinitially incorrectly attributed to vocal cord edema or congestive heart failure. Statistically, the incidence increases markedly in cardiovascular surgery, with reported rates of 0.67% to 1.9% for cardiac surgery[1] and 8.6% to 32% for aortic surgery.[2]

Laryngeal trauma, especially vocal cord paralysis, can markedly affect a patient's quality of life, and bilateral vocal cord paralysis can cause life-threatening airway compromise. Fatal aspiration pneumonia caused by poor airway protection during the pharyngeal phase of swallowing is a grave consequence of unilateral vocal cord paralysis. Therefore, the early identification of vocal cord paralysis is important to initiate preventive measures.

Laryngeal trauma during cardiovascular surgery may be caused by endotracheal intubation, recurrent laryngeal nerve injury in its cervical or intrathoracic course,

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or thermal injury of the recurrent laryngeal nerve.[3] Although several risk factors have been proposed, there is currently no consensus about the factors that may lead to peri-operative laryngeal trauma.

The objectives of this study were to report the incidence and evaluate the risk factors of cardiac surgery-related laryngeal trauma, with the aim of improving airway care during surgery. In addition, we evaluated the possible protective effect of guided transesophageal echocardiography (TEE) placement during cardiovascular surgery.

MATERIAL AND METHODS

Patients

We retrospectively reviewed the medical records of 169 consecutive patients who underwent elective or emergency cardiac surgery (coronary artery bypass graft or valvular surgery) at Cathay General Hospital between January 2012 and July 2013. The Institutional Review Board of Cathay General Hospital approved the study.

Surgery

All of the patients underwent surgery under general anesthesia with endotracheal intubation in the supine position. In addition, a central venous catheter, Swan-Ganz catheter, and nasogastric tube were placed in each patient. A TEE transducer was placed in most patients, either under video fiberscopic image guidance (guided group) or blind placement (blind group) (Table 1).

Surgery was performed through a midline chest incision, sternotomy, and pericardiotomy. Cardiopulmonary bypass was established after cannulating the arterial and venous lines. The heart-lung machine was started and the body temperature decreased to 32 °C. The ascending aorta was clamped, and crystalloid cardioplegia solution was infused into the aortic root with antegrade perfusion intermittently every 15 to 20 minutes until the heart arrested. After completion of coronary vessel anastomoses or valve replacement, the body was rewarmed by the heart-lung machine. The aortic clamp was then released and heart beat resumed. The patients were weaned from cardiopulmonary bypass support, and the cannulation sites were repaired. After the absence of bleeding was confirmed, the sternum was repaired with wires. The wound was closed in layers.

After surgery, all patients were admitted to the intensive care unit. Mechanical ventilation was continued for a few days under the supervision of a cardiovascular surgeon. Endotracheal extubation was performed on the following day under the instructions of respiratory specialists. The patients who could not be weaned from the ventilator (during the admission) and those who died in the intensive care unit were excluded from this study.

Laryngeal and general examinations

Otolaryngologists performed laryngeal examinations in all of the patients who underwent cardiac surgery to investigate the incidence and risk factors of laryngeal trauma after cardiac surgery. Whether or not the patients had hoarseness or sore throat, video laryngoscopy was routinely performed. We recorded and classified the appearance of the vocal cords, mobility (vocal paresis defined as weak or abnormal movement; vocal paralysis defined as no movement at all), and the presence of a contact ulcer, granulation tissue, abrasion or laceration wounds, or submucosal hemorrhage.

The patients' demographic, characteristic, and clinical data including body mass index, nutritional status, urgency of surgery (emergency or elective), duration of endotracheal intubation, type of surgery, cardiopulmonary bypass time, intraoperative body temperature, and the use of the left internal mammary artery were documented.

Statistical analysis

The incidence and risk of laryngeal trauma were calculated. Group comparisons were performed using the chi-square test and *t* test. Multivariate regression analysis was used to evaluate risk factors. Statistical significance was defined as $p \leq 0.05$.

RESULTS

Of the 169 patients, 117 (69%) had coronary artery bypass grafts and 52 (31%) had valvular surgery. Their mean age was 63.7 years, and most of the patients were men who had elective surgery (Table 1). Most of the patients had preoperative hypertension (Table 1). The av-

erage cardiopulmonary bypass time was over 2 hours (Table 1). and the average ventilator time was 34.6 hours.

None of the patients had preoperative vocal cord dysfunction. The postoperative laryngoscopic findings including vocal cord paralysis (mostly left vocal cord) and vocal cord ulcers (mostly bilateral vocal cords) are shown in Table 2. Preoperative hypertension was less frequent (44% vs. 70%, p = 0.04) in the patients with vocal cord paralysis (Table 2). There were no significant differences in the frequency of vocal cord paralysis when the patients were stratified by sex, age, body mass index, urgency of surgery, or history of diabetes mellitus or renal failure (Table 1). In addition, there were no significant differences in surgical or postoperative factors including the use of the left internal mammary artery,

Table 1. Clinical characteristics of patients with and without vocal cord paralysis* (N = 169)

Characteristic	Vocal cord paralysis (%)		p ≤#
	No	Yes	
Sex			NS
Male	108 (71.5)	11 (61.1)	
Female	43 (28.5)	7 (38.9)	
Age (y)			NS
≤ 65	83 (55)	7 (38.9)	
> 65	68 (45)	11 (61.1)	
Body mass index (kg/m²)			NS
< 24	62 (41)	9 (50)	
≥ 24	89 (59)	9 (50)	
Urgency of surgery			NS
Elective	144 (95.4)	15 (83.3)	
Emergency	7 (4.6)	3 (16.7)	
Comorbidities			
Hypertension	105 (70)	7 (44)	.04
Diabetes mellitus	70 (46.7)	7 (43.8)	NS
Renal failure	11 (8)	1 (6.3)	NS
Previous stroke	13 (8.7)	2 (12.5)	NS
Chronic obstructive pulmonary disease	3 (2)	0 (0)	NS
Surgery or postoperative factors			
Left internal mammary artery	36 (23.8)	2 (11.8)	NS
Intraaortic balloon pump			
Preoperative	5 (4.2)	0 (0)	NS
Postoperative	13 (10.9)	0 (0)	NS
Ventilator > 7 d	7 (4.8)	0 (0)	NS
TEE with fiberscope guide	95 (62.9)	10 (58.8)	NS
Revision open surgery	4 (2.7)	0 (0)	NS
Atrial fibrillation			
Preoperative	15 (10)	3 (17.6)	NS
Postoperative	26 (17.4)	4 (23.5)	NS
Hypothermia (°C)			NS
< 32	67 (48.2)	7 (38.9)	
≥ 32	72 (51.8)	11 (61.1)	
Hemoglobin at intensive care unit admission (g/dL)			NS
< 11.2	60 (50.8)	4 (36.4)	
≥ 11.2	58 (49.2)	7 (63.6)	
Cardiopulmonary bypass time (min)	131.4 ± 47.3	117 ± 28.9	NS

* Data reported as number (%) or mean ± SD. # Chi-square or unpaired *t* test. NS, not significant (p > .05).
TEE, transesophageal echocardiography.

duration of ventilator use, or cardiopulmonary bypass time between the patients with or without vocal cord paralysis (Table 1). The 18 patients with vocal paralysis and 13 with vocal ulcers all experienced various degrees of perceived hoarseness, however no permanent vocal complications were noted in this cohort 6 months after surgery. Multivariate logistic regression showed that emergency operations and the use of fiberscope-guided TEE were significant predictors of vocal cord paralysis (Table 3).

DISCUSSION

The results of this study showed that emergency surgery was a significant predictors of vocal cord trauma during cardiac surgery. However, we found that fiberscope-guided TEE placement may reduce the risk of laryngeal trauma.

Previous studies have proposed 8 possible mechanisms of vocal cord dysfunction: (1) central venous catheterization; (2) traction on the esophagus; (3) direct vocal cord damage or paralysis from traumatic endotracheal intubation; (4) trauma caused by compression of the recurrent laryngeal nerve or its anterior branch at the tracheoesophageal groove by an inappropriately sized endotracheal tube cuff; (5) faulty nasogastric tube insertion; (6) median sternotomy and/or sternal traction pulling laterally on both subclavian arteries; (7) direct manipulation and retraction of the heart during open heart procedures; or (8) hypothermic injury with ice slush.[4] In this study, we observed that the use of the left internal mammary artery (which is adjacent to the left recurrent laryngeal nerve) and the total time of ventilator use (which may affect the duration of recurrent laryngeal nerve compression) had no effect on the development of vocal cord trauma. In addition, we did not find associations between the duration of intubation, type of endotracheal tube, and size of endotracheal tube and the incidence of vocal fold mobility and degree of laryngeal injury.[13] It has been suggested that the highest frequency of vocal cord paralysis after cardiac surgery may occur after aortic surgery. However, we did

Table 2. Types of laryngeal trauma (N = 169)

Type of laryngeal trauma	Number (%)
Vocal cord paralysis (N = 18)	
Right	4 (22)
Left	13 (72)
Bilateral	1 (6)
Vocal cord ulcer (N = 13)	
Right	2 (15)
Left	1 (8)
Bilateral	10 (77)

Table 3. Vocal cord paralysis outcomes predictor*

Variable	Odds ratio	95% confidence interval	p ≤#
Male sex	0.21	0.03 to 1.9	0.16
Age > 65 y	5.38	0.7 to 42.1	0.10
Body mass index ≥ 24 kg/m²	1.46	0.14 to 14.7	0.74
Emergency	97.5	2.9 to 366	0.01
Previous stroke	0.81	0.04 to 15.1	0.88
Diabetes mellitus	6.1	0.5 to 36.1	0.15
Hypertension	0.13	0.02 to 1.9	0.14
Renal failure	5.46	0.29 to 95.1	0.28
Left internal mammary artery	0.67	0.09 to 20.3	0.79
TEE with fiberscope guide	0.04	0.01 to 0.87	0.04
Atrial fibrillation			
Preoperative	1.93	0.09 to 41.6	0.67
Postoperative	0.49	0.01 to 17.8	0.70
Ventilator > 3 d	0.56	0.05 to 5.6	0.62
Hypothermia ≥ 32 °C	1.23	0.13 to 11.6	0.85
Hemoglobin ≥ 11.2 g/dL at intensive care unit admission	2.98	0.52 to 21.9	0.28
Cardiopulmonary bypass time (min)	0.99	0.97 to 1.02	0.76

* Multivariate logistic regression. TEE, transesophageal echocardiography.

not include patients undergoing aortic surgery in this study due to the small number of cases at our institute.

With regards to voice quality after surgery for a thoracic aortic aneurysm, it has been reported that 32% of patients may have postoperative hoarseness caused by vocal cord paralysis,[2] including 23% with mild hoarseness.[5] In other studies after cardiovascular surgery, up to 23% of patients have been reported to develop unilateral vocal fold paralysis.[6,7] In addition, vocal cord paralysis after cardiac surgery has been reported to occur more frequently on the left than right side because of the long intrathoracic segment of the left recurrent laryngeal nerve.[4] In the present study, we observed that some patients had a hoarse voice after cardiac surgery, but only a portion of these patients had vocal cord paralysis. In addition, the incidence of postoperative vocal cord paralysis was nearly 11% in our hospital, with left side predominance similar to previously published data (Table 2).[6,7] The incidence of vocal paralysis in this study was higher than data reported for non-aortic surgery, however the frequency was markedly reduced after the routine use of a fiberscope in airway maneuvers (Table 3).

The use of TEE is traditionally considered to be a potential confounding factor for laryngeal trauma, especially in female patients with a narrow larynx.[8,9] However, we did not find a gender difference in patients using TEE. Rather, regression analysis showed that fiberscope-guided TEE remarkably reduced the likelihood of laryngeal trauma (vocal paralysis). Therefore, we recommend using this technique routinely since the equipment is usually available in the operating room and it usually takes minutes to complete.

Most vocal cord paralysis after cardiac surgery has been reported to recover spontaneously in 8 to 10 months.[11] In the present study, none of our patients had permanent vocal paralysis, suggesting that the injuries may have been caused by compression rather than direct dissection.

In this study, the incidence and risk of postoperative vocal cord paralysis were higher in the patients who underwent emergency operations. This may have been due to rapid intubation, manipulation, and poorer patient condition. Recurrent laryngeal nerve and laryngeal mucosal injury may be caused by the presence of an endotracheal tube and may lead to vocal cord insufficiency.

The incidence and risk of vocal cord ulcers have been associated with male sex, prolonged ventilator time, and preoperative renal failure.[10-12] The larger endotracheal tube required for men and longer duration of direct compression on the vocal cord may increase the risk of mucosal trauma on the vocal cord. However, we did not find such an association in our patients.

CONCLUSIONS

In summary, the present study showed that laryngeal trauma after cardiac surgery, especially vocal cord paralysis, is not rare. Emergency surgery increased the risk of vocal paralysis, and fiberscope-guided TEE may reduce the risk of iatrogenic vocal paralysis.

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CONFLICTS OF INTEREST

No author has conflicts of interest.

REFERENCES

1. Dimarakis I, Protopapas AD. Vocal cord palsy as a complication of adult cardiac surgery: surgical correlations and analysis. *Eur J Cardiothorac Surg* 2004;26:773-5.
2. Ishimoto S, Ito K, Toyama M, et al. Vocal cord paralysis after surgery for thoracic aortic aneurysm. *Chest* 2002;121:1911-5.
3. Neema PK, Sinha PK, Varma PK, Rathod RC. Vocal cord dysfunction in two patients after mitral valve replacement: consequences and mechanism. *J Cardiothorac Vasc Anesth* 2005;19:83-5.
4. Hamdan AL, Moukarbel RV, Farhat F, Obeid M. Vocal cord paralysis after open-heart surgery. *Eur J Cardiothorac Surg* 2002;21: 671-4.
5. Inada T, Fujise K, Shingu K. Hoarseness after cardiac surgery. *J Cardiovasc Surg (Torino)* 1998;39:455-9.
6. Joo D, Duarte VM, Ghadiali MT, Chhetri DK. Recovery of vocal fold paralysis after cardiovascular surgery. *Laryngoscope* 2009;119: 1435-8.
7. Itagaki T, Kikura M, Sato S. Incidence and risk factors of postoperative vocal cord paralysis in 987 patients after cardiovascular surgery. *Ann Thorac Surg* 2007;83:2147-52.

8. Kawahito S, Kitahata H, Kimura H, et al. Recurrent laryngeal nerve palsy after cardiovascular surgery: relationship to the placement of a transesophageal echocardiographic probe. *J Cardiothorac Vasc Anesth* 1999;13:528-31.
9. Sakai T, Terao Y, Miyata S, et al. Postoperative recurrent laryngeal nerve palsy following a transesophageal echocardiography. *Masui* 1999;48:656-7.
10. Ohta N, Kuratani T, Hagihira S, et al. Vocal cord paralysis after aortic arch surgery: predictors and clinical outcome. *J Vasc Surg* 2006;43:721-8.
11. Tewari P, Aggarwal SK. Combined left-sided recurrent laryngeal and phrenic nerve palsy after coronary artery operation. *Ann Thorac Surg* 1996;61:1721-2.
12. Yuan SM. Hoarseness subsequent to cardiovascular surgery, intervention, maneuver and endotracheal intubation: the so-called iatrogenic Ortner's (cardiovocal) syndrome. *Cardiol J* 2012;19:560-6.
13. Colton House J, Noordzij JP, Murgia B, Langmore S. Laryngeal injury from prolonged intubation: a prospective analysis of contributing factors. *Laryngoscope* 2011;121:596-600.