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Post-operative impaired vocal cord mobility related to cardiovascular surgery

A study to the characteristics of cardiovascular surgery induced
impairment of the vocal cords mobility

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ABSTRACT

Background: injury to the recurrent laryngeal nerve during cardio-thoracic surgery is a well described phenomenon with an incidence of 1-2%, but is overlooked as a complication during admission. It may lead to an impaired mobility of the vocal cords and cause physical complaints like hoarseness, dyspnoea or aspiration and have a negative influence on the patient's quality of life.

Aim: the present study investigates impaired vocal cord mobility as a complication after cardiovascular surgery among 23 patients in a large non-academic hospital in the Netherlands. The study aims at determining whether there are any significant relationships between otorhinolaryngology data of the vocal cord impairment, general risk-factors and surgical characteristics of cardiovascular surgery.

Results: no significant relationships have been found. However, certain variables in the dataset did occur significantly more often than others.

Conclusions: general risk-factors or characteristics of cardiovascular surgery were not found to be statistically related to uni-/ bilaterality, side and severity of mobility impairment, position of the impaired vocal cord, and spontaneous recovery in this study. However, analysis of the dataset shows that impaired vocal cord mobility after cardiovascular surgery occurs significantly more frequently unilaterally than bilaterally, and significantly more frequently in patients who underwent open thorax surgery than in those who underwent a minimal invasive surgical procedure. Further research is required to determine potential risk-factors for a post-operative impaired vocal cord mobility.

Keywords: impaired vocal cord mobility, cardiovascular surgery, post-operative.

1. INTRODUCTION

1.1. Impaired vocal cord mobility and cardiac-thoracic surgery

Impaired vocal cord mobility is a commonly known disorder in the field of speech and language therapy because of the hoarseness it causes. Trauma to the motor component of the vocal cords, known to be the recurrent laryngeal nerve, may be inflicted in many different ways. One of the possible causes for injury to the recurrent laryngeal nerve is cardiac-thoracic surgery.

Unfortunately, vocal cord impairment after surgical intervention in the chest is often overlooked as a cause of post-operative respiratory insufficiency or hoarseness, and laryngeal examination is rarely clinically performed on post-operative patients (Hamdan, Moukarbel, Farhat, & Obeid, 2002; Shafei, El-Kholy, Azmy, Ebrahim, & Al-Ebrahim, 1996). Physical recovery is the primary goal after surgery, but vocal cord immobility can decrease a patient's quality of life (Tomoda et al., 2008). Literature on thyroid surgery points out dysphonia, hoarseness, dyspnea, ineffective cough, glottal obstruction and aspiration as a result of reduced vocal cord motion (Tomoda et al., 2008; Kundra et al., 2010). Cardiac-thoracic literature takes injury to the recurrent laryngeal nerve seriously in account during surgery, but nonetheless attributes the complication to non-surgical mechanisms like tracheal intubation. Dysphonia is thereby not addressed as a complication due to post-operative impaired mobility of the vocal cords (Dimarakis & Protopapous, 2004; Hamdan et al., 2002).

The true incidence of impaired vocal cord mobility after cardiac-thoracic surgery is hard to establish. First, a routine post-operative laryngeal examinations is lacking in most institutes. Second, there often is uncertainty about the exact cause of the nerve trauma. Studies have reported an incidence between 1-2%, primarily on patients with open-heart surgery. In some cases the nature of the cardiac procedure remained undisclosed. Cardiac-thoracic surgery in general did not seem to damage the recurrent

laryngeal nerve irreversibly, except for a few cases. (Dimarakis & Protopapus 2004; Hamdan et al., 2002; Shafei et al., 1996).

1.2. Anatomic and surgical aspects related to the recurrent laryngeal nerve

The ipsilateral recurrent laryngeal nerve branches from the vagus nerve in the lower neck and lies in the tracheo-oesophageal groove. It innervates most of the larynx muscles, except the cricothyroid, and functions as the main motor for the vocal cords. The left recurrent branch passes under the arch of the aorta before ascending. The right recurrent branch loops around the right subclavian artery (Dimarakis & Protopapus, 2004; Nayler & Mackey, 2001). This non-symmetrical anatomy has surgical significance (Dimarakis & Protopapus, 2004). The left recurrent nerve is known to have a higher risk for injury because of its long intrathoracic segment compared to the much shorter right sided course (Hamdan et al., 2002). Although the vagus nerve is nearly always well identified and removed from the operative field during primary cardiac surgery, the recurrent laryngeal nerve remains at risk for trauma caused by e.g. self retained retractors in median sternotomy (Nayler & Mackey, 2001).

1.3. Mechanisms of nerve injury during cardiac-thoracic surgery.

Various mechanisms have been identified as a possible cause for post-operative vocal cord impairment. In the event of open heart surgery, longitudinal lateral strain may be put on both subclavian arteries through chest retractors, which may force an indirect injury to both recurrent nerves (Dimarakis & Protopapus, 2004). Other indirect strain trauma may be caused by the use of an inappropriately sized endotracheal tube cuff during intubation or an unnatural head and neck position during surgery. Direct trauma may be inflicted by traumatic endotracheal and/or nasogastric intubation and

direct manipulation and retraction of the heart during the procedure. Progress in prevention of nerve injury during surgery has been accomplished for hypothermic nerve trauma with the usage of saline slush in the last decade to cool the body temperature down during open heart surgery, instead of using ice in the pleural cavity. This with markedly less hypodermic nerve trauma as result (Hamdan et al., 2002).

1.4. Present study

Previous studies suggest that impaired vocal cord mobility after cardio-thoracic surgery is a commonly known post-operative complication, with various incidences between 1-2% (Dimarakis & Protopapou 2004; Hamdan et al., 2002; Shafei et al., 1996), generally is of a temporary nature (Hamdan et al., 2002; Shafei et al., 1996) and occurs more often on the left-, than on the right side (Dimarakis & Protopapou 2004; Hamdan et al., 2002). Nevertheless, there is little specific information in these studies about the surrounding, and perhaps explanatory factors. No differentiation has been made between factors like, amongst others, age, comorbidity, degree of the lesion or duration of surgery. Some factors have been named individually in particular previous studies, but they were never combined in order to find a possible relationship to impaired vocal cord mobility. Likewise, the duration of the vocal cord impairment has not been subject of any of the research discussed above. There seem to be commonly accepted factors related to post operative impaired vocal cord mobility that have not been researched in a broader context. Working on the speech and language therapy department of the participating hospital, impaired vocal cord mobility has always been a personal interest. Unfortunately there is little specific research which may serve as background information in therapy and council information towards affected patients. Especially in a large hospital (880 beds) that is specialized in cardio-thoracic surgery and where impaired vocal cord immobility as a post operative

complication of cardiovascular surgery is not thought to be uncommon, can such research may be of great value for both practitioners and patients. The present study therefore makes a start with investigating impaired vocal cord mobility as a complication after cardiovascular surgery among patients in a large non-academic hospital in the Netherlands and determines whether there are any significant relationships between the otorhinolaryngological data of the vocal cord impairment, general risk-factors, and surgical characteristics. It is hypothesized that the otorhinolaryngological data will especially correlate with surgical characteristics of the cardiovascular operation and perhaps generally known risk-factors.

2. METHOD

2.1 Participants

All adult patients that have been formally diagnosed in St. Antonius Hospital with impaired vocal cord mobility as a post-operative complication after cardiovascular surgery between January 2005 and May 2011, were included in the study. A total of 23 patients were found, consisting of 16 males and 7 females.

2.2. Material

The present study uses existing medical records from adult patients with clinically identified vocal cord impairment after cardiovascular surgery between January 2005 and May 2011. Patients that visited the otorhinolaryngology department in this period were automatically screened by a internal and reliable electronic system used in the hospital, that selected them all by their reported diagnose code. The patients that had been endoscopically diagnosed with impaired mobility of the vocal cords as a post-operative complication after cardiovascular surgery were included. No further criteria have been formulated and/or used. A total of 23 otorhinolaryngology patients have

been analysed in the study. Subsequently, their cardiovascular surgical reports have been closely examined using the patients individual electronic personal health records.

2.3. *Design for data collection*

Independent variables were formed prior of the data collection. Table 1 shows an overview of the factors that have been filtered from the electronic personal health records of every participant. All retrieved data has been treated anonymously. Three major groups were formed for general, otorhinolaryngological and surgical characteristics, consisting specific parameters which have been analysed on the study population. The general parameters were based on generally known personal risk factors for surgical complications such as increasing age and the presence of comorbidity as smoking, diabetes mellitus, chronic lung diseases (*e.g.* COPD) and obesity. The otorhinolaryngology parameters have been chosen to match with widely used terms and available data within the hospital’s otorhinolaryngology (endoscopic) examination reports. The surgical parameters were selected by using general terms found in surgical reports and patient information resources.

Main category	Subcategories
General parameters	Age Sex Presence of comorbidity
Otorhinolaryngology parameters	Uni,- bilaterally impaired Side of impairment Gradation of impairment Position of impaired vocal cord(s) Recovery of vocal cord mobility
Surgical parameters	Type of surgery Operation procedure Duration of surgical procedure

Table 1: overview of investigated parameters and variables in present study

2.4. Statistical analysis

The present study hypothesizes that the research variables are interdependent and that there is a significant relationship between post-operative impaired mobility of the vocal cords and one or more of the considered parameters. The null hypothesis on the contrary holds that there is not enough evidence for any plausible relationship. The collected data was analysed within a 2x2 cross table, as showed in table 2. To compare two unpaired independent variables, the non-parametric Fisher's exact test has been performed two-sided in SPSS 17.0 for every combination of two variables between the general parameter and otorhinolaryngology parameter, and between the surgical parameter and the otorhinolaryngology parameter

	Variable	Label of value	
		1	2
General	Age	< 65 years	≥ 65 years
	Sex	Male	Female
	Presence of comorbidity	Yes	No
Otorhinolaryngology	Uni,- bilaterally impaired	Unilateral	Bilateral
	Side of impairment	Left	Right
	Gradation of impairment	Partial paresis	Full paralysis
	Position of impaired vocal cord(s)	(Para)mediate	Intermediary
	Recovery of vocal cord mobility	Yes	No
Surgical	Type of surgery	Heart surgery	Carotid surgery
	Operation procedure	Minimal invasive	Open thorax
	Duration of surgical procedure	< 5 hours	≥ 5 hours

Table 2: overview of independent variables and their label values used in 2x2 parametric analysis conducted in present study

Additional analysis of the independent variables has been conducted by way of a second Fisher's exact test to analyze whether some value labels in the dataset occurred significantly more frequently than others. The null hypothesis implied that the frequency distribution of the variables is equal to a theoretical distribution of 1/1, so that every value label was 50% present within the variable itself. All variables were analysed because of indistinct indications in the literature about possible frequency distributions.

3. RESULTS

The analysis of the data does not indicate any significant relationship between post-operative impaired vocal cord mobility and the independent variables conducted in this study. All p-values measured by the Fisher's exact tests exceeded the level of alpha (0.05) as shown in table 3. The null hypotheses is therefore accepted, no plausible relationship could be proven.

		Otorhinolaryngology				
		Uni,- bilateral	Side	Gradation	Position	Recovery
General	Age	1.00	1.00	1.00	.174	1.00
	Sex	1.00	.124	.621	1.00	.245
	Presence of comorbidity	1.00	.369	.369	1.00	.588
Surgical	Type of surgery	.478	1.00	.640	.350	1.00
	Operation procedure	1.00	1.00	1.00	1.00	1.00
	Duration of surgery	.435	.660	.660	1.00	.576

Table 3: p-values Fisher's exact test of every independent variable combination between the general-, and surgical parameters and the otorhinolaryngology parameters.

For analysis of the frequency distribution for individual variables, the boundaries for dismissal of equal distribution were determined by a second 2-sided Fisher's exact test. The considered thresholds were on the safe side to analyze the present distribution quite conservative, with less probability for a Type-I error (false-positives):

N=23 < 4 - > 19

Because of missing data in two of the variables, the thresholds for these variables were computed on a different sample size. For the variables *position of impaired vocal cord(s)* and *recovery of mobility* the thresholds respectively were:

N=20 < 4 - > 16

N=18 < 3 - > 15

The conducted boundaries computed by the Fisher's exact test showed significant difference for the variables unilateral and bilateral impairment of the vocal cord mobility and the operation procedure, as shown in table 4. The values found fell under and above the stated thresholds and were therefore statistically unevenly distributed. No statistical significance was found within the group of general parameters. Unilateral impaired vocal cord mobility was significantly more frequently observed than a bilateral impairment within the group of the otorhinolaryngology parameters. Finally, within the group of surgical parameters open thorax surgery occurred significantly more than minimal invasive operations. For the remaining variables the null hypothesis has been accepted because the distribution fell within the estimated range of equal distribution.

	Variable	N	Label of value	Frequency
General	Age	23	< 65 years	8
			≥ 65 years	15
	Sex	23	Male Female	16 7
	Comorbidity	23	Yes No	15 8
Otorhinolaryngology	Uni,- bilaterally impaired*	23	Unilateral Bilateral	22 1
	Side of impairment	23	Left Right	17 6
	Gradation of impairment	23	Partial pareses Full paralysis	6 17
	Position of impaired vocal cord(s)	20	(Para)mediate Intermediary	13 7
	Recovery of mobility	18	Yes No	4 14
Surgical	Type of surgery	23	Heart surgery Carotid surgery	11 12
	Operation procedure*	23	Minimal invasive Open thorax	2 21
	Duration of surgical procedure	23	< 5 hours ≥ 5 hours	13 10

Table 4: Frequency overview of every independent variable and their value labels.

** = statistical significantly frequency distribution (under/above 50%)*

4. DISCUSSION

The hypothesis of this study, that there would be statistical relationships between otolaryngological data and the conducted parameters, was not confirmed by its results. No significant relationship between any of the general-, and/or surgical variables and the presence of impaired vocal cord mobility as a post-operative complication could be established.

The research design of the present study encountered some limitations. It was not possible to compute the actual incidence of impaired vocal cord mobility as a postoperative complication of cardiovascular surgery, due to the lack of parametric data from the full population of patients undergoing cardiovascular surgery in the hospital. The screening and analysis of the full surgical population could therefore not be accomplished practically within the period of time. The true incidence is thought to be a object for future research.

Due to the relatively small dataset, this study lacked sensitivity and was only able to significantly detect coarse relationships. This limitation may well have influenced the statistical results and, in all, made the null hypothesis difficult to decline. The presence of light and refined relationships between the variables could not be derived from the present study population. The small size of the dataset may be attributed to the relatively short hospitalization time in the participating hospital, which is generally only 7 to 11 days before dismissal or transfer to another hospital¹. Some signs of vocal cord immobility, like hoarseness, are considered as regular and non-threatening post-operative symptoms for a cardiologist, due to *e.g.* fatigue and a decreased physical condition. A considerable amount of these patients show a reduced diaphragm function in speaking because of common dyspnoea, which may understandably reduce the vocal quality during phonation. Therefore patients with clinical impairment to the vocal cord mobility as a post-operative complication are not always referred to an otorhinolaryngologist during admission itself. Another explanation may be found in the geographical distribution of patients undergoing cardiovascular surgery. From the 23 patients that were selected in this study, 61% were from the province of Utrecht. The remaining 39% came from a range of four

¹ From the annual year report cardiac-thoracic surgery department of the St. Antonius hospital 2005 and 2006-2007.

different provinces in the Netherlands, knowing to be Friesland (9%), Noord-Brabant (13%), Drenthe (4%) and Gelderland (13%). It may be assumed that patients with *e.g.* persisting dysphonia, and not living in the district of Utrecht, will rather consult an otolaryngologist close to their residence. Out of nine patients who did not come from the province of Utrecht, only one was already known by the examining otorhinolaryngologist in connection to a different medical complaint in the past. Three were referred to a different otorhinolaryngologist in a hospital closer to their hometown for a later check-up after their first (polyclinic) evaluation of the vocal cords in the participating hospital, so no further information about the recovery was registered in the participating hospital's system. The five remaining patients were examined during dismissal and afterwards dismissed to another hospital in their own region with expected spontaneous recovery of the impaired vocal cords. These patients are very likely to undergo further otorhinolaryngological examination and/or treatment in this other hospital, when spontaneous recovery of the vocal cords mobility fails. It is therefore very plausible that a substantial amount of the patients with impaired vocal cord mobility after cardiovascular surgery in the participating hospital will visit a (general) practitioner closer to their residence, in the event the reduced vocal function persists for a certain time after hospital dismissal or for a during admission recommended check-up in a later stage. Some patients are not registered at the otorhinolaryngologist department of the participating hospital with impaired vocal cord mobility and could therefore not be included in the present study through the applied method of data collection.

In the analysis itself the number of original formulated value labels was restricted in order to comply with the requirements for a multinomial Chi-square analysis with more than 20% of the cells having an expected cell count of less than 5. The amount of value labels within the different variables had therefore been cut down to fit a 2x2

crosstab, so a Fisher's exact test could be conducted on the data. This made the study less specific than was originally intended and prevented that possible risk factors for a post-operative impaired vocal cord mobility could be explored closer. On the other hand, a larger variety of value labels could make a possible relationship even more refined and, consequently, even harder to verify statistically, unless a more extensive dataset is used.

Although generalization on the basis of the statistical analysis was not possible, there was there no reason to suspect any specific bias in the dataset that would distinguish the dataset from the full population of patients with a post-operative impaired vocal cord mobility after cardiovascular surgery. It is therefore assumed that the research population was representative.

To conclude, there was no substantiated link found between possible risk factors for a impaired vocal cord mobility and the presence of this post-operative complication. This was against the expectation of the present study and the stated research hypothesis.

5. CONCLUSION

This study primarily aimed on vocal cord immobility as a complication after cardiovascular surgery. Possible relations between a range of general, otorhinolaryngological, and surgical parameters were researched. It was hypothesized that there would be a relationship between post-operative impaired vocal cord mobility and one or more of the considered parameters. The statistical analysis nevertheless does not demonstrate any significant relationship. The otorhinolaryngological variables; uni-/bilaterality, side and severity of mobility impairment, position of impaired vocal cords, and spontaneous recovery were not found to be related to any characteristics of cardiovascular surgery or general risk-

factors. The null hypothesis that stated that there is no relationship was therefore accepted.

Further analysis of the frequency distribution within the individual variables was performed to determine whether this distribution was significantly equal to the theoretical distribution of probability (50%). The results showed that impaired vocal cord mobility after cardiovascular surgery occurred significantly more frequently unilaterally than bilaterally, and significantly more frequently in patients who underwent open thorax surgery compared than in those who underwent a minimal invasive surgical procedure. Further research is required to determine potential risk-factors for a post-operative impaired vocal cord mobility.

6. RECOMMENDATIONS

Further research is necessary to determine whether any significant relationship exists between cardiovascular surgery and post-operative impaired vocal cord mobility. Future studies are recommended to be conducted on a larger number of patients for more specificity. A multinomial Chi-square can then be performed on different combinations of parameters and with a greater variety of variable labels. The use of surgical records of cardiovascular patients without this complication should be collected to investigate the true incidence. Consequently, regression analysis can clarify the understanding of impaired vocal cord mobility in the context of specific conditions and thereby possible risk-factors. This would have great value in pre-operative patient information, patient therapy, and council information towards affected patients.

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