Original Article

Major morbidity after video-assisted thoracic surgery lung resections: a comparison between the European Society of Thoracic Surgeons definition and the Thoracic Morbidity and Mortality system

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Background: The thoracic morbidity and mortality (TM&M) classification system univocally encodes the postoperative adverse events by their management complexity. This study aims to compare the distribution of the severity of complications according to the TM&M system versus the distribution according to the classification proposed by European Society of Thoracic Surgeons (ESTS) Database in a population of patients submitted to video assisted thoracoscopic surgery (VATS) lung resection.

Methods: A total of 227 consecutive patients submitted to VATS lobectomy for lung cancer were analyzed. Any complication developed postoperatively was graded from I to V according to the TM&M system, reflecting the increasing severity of its management. We verified the distribution of the different grades of complications and analyzed their frequency among those defined as "major cardiopulmonary complications" by the ESTS Database.

Results: Following the ESTS definitions, 20 were the major cardiopulmonary complications [atrial fibrillation (AF): 10, 50%; adult respiratory distress syndrome (ARDS): 1, 5%; pulmonary embolism: 2, 10%; mechanical ventilation >24 h: 1, 5%; pneumonia: 3, 15%; myocardial infarct: 1, 5%; atelectasis requiring bronchoscopy: 2, 10%] of which 9 (45%) were reclassified as minor complications (grade II) by the TM&M classification system. According to the TM&M system, 10/34 (29.4%) of all complications were considered minor (grade I or II) while 21/34 (71.4%) as major (IIIa: 8, 23.5%; IIIb: 4, 11.7%; IVa: 8, 23.5%; IVb: 1, 2.9%; V: 3, 8.8%). Other 14 surgical complications occurred and were classified as major complications according to the TM&M system.

Conclusions: The distribution of postoperative complications differs between the two classification systems. The TM&M grading system questions the traditional classification of major complications following VATS lung resection and may be used as an additional endpoint for outcome analyses.

Keywords: High-risk patients; video assisted thoracoscopic surgery (VATS) lobectomy; lung cancer; complications

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Introduction

Complication rates following video assisted thoracoscopic surgery (VATS) lobectomy for lung cancer range between 6% and 34.2% and the mortality rate ranges between 0.6% and 1.3% (1-3). To date, there is no standardization for their classification. Postoperative complications are directly related to treatment effectiveness, prognosis, hospitalization costs and patients' quality of life. The objective of this study was to verify whether those complications, traditionally classified as major cardiopulmonary complications according to the European Society of Thoracic Surgeons (ESTS) definition (4) and used as such in outcome analyses, were also classified as major according to the thoracic morbidity and mortality (TM&M) grading system (5,6).

Materials and methods

We retrospectively retrieved clinical and surgical information of 227 consecutive patients submitted to VATS lobectomies for lung cancer in our Institution, in the period comprised between August 2012 and October 2014. Patients' baseline and surgical characteristics are shown in *Table 1*. Within this cohort, the analysis was performed on those patients who faced at least one postoperative complication.

Board qualified thoracic surgeon performed all the procedures through a 2-3 ports VATS access. As a rule, all patients were extubated in the operating room and were transferred to a high dependency unit (HDU) where they spent the first night after the operation and from which were then moved to a dedicated thoracic ward bed. Inoperability criteria were a predicted postoperative forced expiratory volume in one second (ppo-FEV_1) and predicted postoperative carbon monoxide lung diffusion capacity (ppo-DLCO) <30% in association with a VO_{2max} <10 mL/kg/min, according to existing guidelines (7).

All patients were managed according to standardized pathways of care, including as early as possible mobilization, chest physiotherapy and rehabilitation, and venous thromboembolism (VTE) prophylaxis.

Pain control was achieved with a combination of a paravertebral catheter and intravenous patient controlled analgesia, with the aim of maintaining the numeric pain score consistently below 4 in a visual analogic scale (VAS).

In 18 cases the VATS procedure was converted into an open one due to complications that arose during the intervention (e.g., bleeding, major air leak) or for safety reasons (e.g., difficult dissection of vessels/fissure due to big lymph nodes or tumor), and were not excluded from the study according to the intention to treat model of the analysis.

Table 1 Characteristics of the patients included in the study

Variable	Mean
Age	67.8 (9.9)
Female gender, n [%]	121 [53]
Right side of operation, n [%]	141 [62]
Upper site of lobectomy, n [%]	153 [67]
CAD, n [%]	30 [13]
BMI (kg/m^2)	26.7 (4.8)
FEV_1%	87.3 (22.5)
DLCO (%)	71.3 (17.9)
PS	0.6 (0.7)
CCI	1.3 (1.5)

Results are expressed as means and standard deviations unless otherwise specified. CAD, coronary artery disease; BMI, body mass index; FEV_1%, forced expiratory volume in one second; DLCO, carbon monoxide lung diffusion capacity; PS, performance score; CCI, Charlson Comorbidity Index.

Definitions of complications

TM&M classification system

Seely and colleagues developed the TM&M system in 2010 (5,6), based on the Clavien-Dindo classification (8). Regardless the type of complication, this system proportionally grades each postsurgical complication in the I to V scale according to the complexity of its management. Grades I and II include minor complications requiring no therapy or pharmacologic intervention only. Grades III and IV are major complications that require surgical intervention or life support. Grade V complications result in patient death as illustrated in *Table 2*.

European Society of Thoracic Surgery (ESTS) definitions of major cardiopulmonary complications

The ESTS Database Committee definitions of major cardiopulmonary complications, as published in the ESTS Silver Book (4), include "pneumonia", "atelectasis requiring bronchoscopy", "adult respiratory distress syndrome (ARDS)", "mechanical ventilation >24 h", "pulmonary oedema", "pulmonary embolism", "myocardial infarct", "cardiac failure", "arrhythmia", "neurological complications (stroke)", "acute renal insufficiency" and "deep vein thrombosis (DVT)".

Table 2 Thoracic morbidity and mortality classification system

Classification system	Description
Minor complications	
Grade I	Adverse event which alters the standard postoperative course without requiring a specific treatment
Grade II	Pharmacologic treatment or minor intervention required
Major complications	
Grade IIIa	Surgical, radiologic, endoscopic treatment, or multi-therapy required without general anesthesia
Grade IIIb	Surgical, radiologic, endoscopic treatment, or multi-therapy required with general anesthesia
Grade IVa	Intensive care unit treatment for single organ dysfunction required
Grade IVb	Intensive care unit treatment for multiple organ dysfunction required
Mortality	
Grade V	Adverse event which leads to death

Table 3 Complications according to ESTS database in our cohort

Complications according to ESTS database	N
ARDS	1
Atrial arrhythmia	10
Atelectasis needing bronchoscopy	2
Pneumonia	3
Acute pulmonary embolism	2
Acute myocardial infarct	1
Mechanical ventilation >24 h	1
Total	20

ESTS, European Society of Thoracic Surgeons; ARDS, adult respiratory distress syndrome.

Design of the study

Firstly, all the identified postoperative complications of the cohort were classified according to the definitions proposed by the ESTS Database Committee. Subsequently, all the postoperative complications recorded were graded according to the TM&M classification system. In case a patient had multiple concurrent complications, only the most severe one was considered. A comparison of complications' severity distribution between the two groups was then performed.

The postoperative length of stay (LOS) was also analyzed. Descriptive statistics was utilized. Results are reported as means and standard deviation for numeric variables or frequency of occurrence for categorical variables. The statistical analysis was performed on STATA 12.0 statistical software (STATA Corp. College Station, TX).

Results

The total number of postoperative complications among the 227 patients included in this study was 34 (15%). Twenty patients (8.8% of the total population) were affected by major cardiopulmonary complications according to the ESTS definitions, such as: "atrial fibrillation (AF)": #10 (50%); "ARDS": #1 (5%); "pulmonary embolism:" #2 (10%); "mechanical ventilation >24 h": #1 (5%); "pneumonia": #3 (15%); "myocardial infarct": #1 (5%); "atelectasis requiring bronchoscopy": #2 (10%) (*Table 3*). This incidence accounts for 59% of the total complications recorded in this series.

According to the TM&M system, 10 patients had minor complications (grades I and II), while 24 patients (11% of the total population) developed major complications, including 3 deaths (grade V). This group of major complications represents 71% of all complications (*Table 4*).

Nine postoperative complications considered as major according to the ESTS DB classification were reclassified as minor complications (grade II) by the TM&M system. They represent 45% of all major cardiopulmonary complications, which were recoded as minor by the TM&M system. These patients' characteristics, including the in-hospital median LOS, are evidenced in *Table 5*.

A total of 14 other complications, including surgical ones, occurred. Thirteen were considered as major complications and one minor according to the TM&M system.

Of the 18 VATS lobectomies converted to an open procedure, three patients faced postoperative complications and were classified as such by the TM&M classification: 1 minor complication (grade II), 1 major complication (grade IVb) and 1 death (grade V).

Table 4 Distribution of complications according to the TM&M classification system

TM&M grade	TM&M definition/treatment performed	Distribution of complications according to TM&M grading (n=34)
I	Adverse event which alters the standard postoperative course without requiring a specific treatment	0
II	Pharmacologic treatment or minor intervention required	10
IIIa	Surgical, radiologic, endoscopic treatment, or multi-therapy required without general anesthesia	8
IIIb	Surgical, radiologic, endoscopic treatment, or multi-therapy required with general anesthesia	4
IVa	Intensive care unit treatment for single organ dysfunction required	8
IVb	Intensive care unit treatment for multiple organ dysfunction required	1
V	Adverse event which leads to death	3

TM&M, the thoracic morbidity and mortality.

Table 5 Characteristics of patients reclassified by the TM&M scoring system

Age (years)	Gender	Type of intervention	Post-op complication	Lenght of stay (days)	Outcome at discharge
63	F	RUL	AF	18	Alive
67	M	RLL	HAP	15	Alive
71	F	RUL	AF	4	Alive
66	M	RUL	AF	6	Alive
76	M	LUL	AF	5	Alive
59	M	LLL	AF	16	Alive
84	F	RLL	AFl	8	Alive
82	F	LLL	AF	8	Alive
73	M	RLL	AF	10	Alive

TM&M, the thoracic morbidity and mortality; RUL, right upper lobectomy; RLL, right lower lobectomy; LUL, left upper lobectomy; LLL, left lower lobectomy; AF, atrial fibrillation; HAP, hospital acquired pneumonia; AFl, atrial flutter.

The analysis of the postoperative LOS between the two groups evidenced a 12-day difference in the LOS between the patients who remained classified in the ESTS major complication group after the TM&M recoding and the patients reclassified in the minor complication group according to it (21.6 *vs.* 9.6 days; Mann Whitney Test P=0.08).

Discussion

Clinical background and rationale for the study

Postoperative complications are often used as primary endpoint for outcome analyses. In fact, as they are directly related to prognosis and treatment efficacy, at the same time they may be utilized as indirect indicators of the quality of surgical treatment given to the patient, hospitalization cost and patients' quality of life following surgery (9,10). In a time in which minimally invasive surgical procedures (VATS) are increasingly adopted worldwide, along with the aim of decreasing patients' hospitalization, an appropriate, accurate and standardized measurement and monitoring of adverse events following surgery becomes of utmost importance.

It is of evidence that VATS lung resections for lung cancer reduces overall postoperative complications, acute and chronic pain and loss of pulmonary function when compared to standard open technique (11). For this reason, the American College of Chest Physicians (ACCP) recommends VATS lobectomy as the procedure of choice for clinical stage I non-small cell lung carcinoma (12).

Perioperative complications and mortality in patients submitted to VATS lobectomy for lung cancer is low, yet not negligible (1-3).

The ESTS classification system identified a series of frequent and potentially life threatening complications while TM&M classification system does not discriminate between the types of complication occurred, but weighs each complication through a grading system that takes into account the effort required to treat them.

Main findings

Through this study we aimed to evaluate potential inconsistencies between the coding of postsurgical complications following minimally-invasive lung resections for cancer according to the ESTS definitions and the TM&M classification.

Nearly 60% of the complications occurred in our cohort of patients submitted to VATS lobectomy for lung cancers were classified as major cardiopulmonary complications according to the ESTS definitions, which are the ones most commonly used as outcome indicators for quality of care evaluation. In our series these were mostly represented by atrial arrhythmias. Although potentially cause of morbidity and mortality, 45% of them was reclassified as minor complications according to the TM&M classification, since required just a pharmacological treatment and had a minimal impact on patients postoperative course.

This finding confirms a previous comparative study performed in a population of patients operated by thoracotomy and showing that almost 62% of those complications defined as major by the ESTS definitions were reclassified as minor complications using the TM&M system (9).

The absolute incidence of major complications according to the TM&M system found in our study (11%) is also in line with the one previously reported after open lobectomies and using this classification system (9.3%) (9).

An interesting finding is the large discrepancy in the proportion of major complications found in the present study compared to the one published by Salati and colleagues (9) and including open lobectomies. They found that more than 70% of the complications occurring after open lobectomy were graded as minor complications using the TM&M system, while in our series almost 70% of complications were graded as major. This discrepancy may be explained by the lower absolute incidence of complications observed in our series (15% *vs.* 34%), which is consistent with the one observed in most of the publications after VATS lobectomy. In particular, several studies have shown a consistent reduction of AF after VATS compared to open lobectomies (13-15) and this may account for a lower proportion of minor complications after VATS.

Due to its nature, the ESTS major cardiopulmonary complication list does not account for the so called surgical morbidity (redo surgery, bleeding, bronco-pleural fistula, surgical emphysema etc.), as omitting the occurrence of a considerable set of complications relatively frequent in our specialty, thus being less accurate. In fact, in our study, 14 complications could not be assessed according to the ESTS classification, but were graded according to the TM&M.

More than half of the complications (55%) considered as major complications according to the ESTS were confirmed so in the TM&M system since they required a complex management.

Limitations

The major potential limitations of this study are its retrospective nature, and the analyses conducted on a small cohort of patients. Its retrospective nature may impact on the data collection affecting its accuracy, especially in identifying the pharmacological treatment used, particularly in those in the case of Grade I and II of the TM&M classification system. On the other hand, the short period of analysis ensured standardization of indication for surgery, treatment of complications and data collection.

The possible inter-observer discrepancy in the classification of the post-surgical complications is reduced due to a prior agreement between surgeons, working in the same centre, as described in the paper by Varela and colleagues (16).

Clinical implications

The classification of the most frequently occurring postoperative complications in thoracic surgery, like the one proposed by the ESTS, is important to standardize the type of treatment of the occurred adverse event, as well as serving the purpose of collecting data for statistical analysis. In particular, major cardiopulmonary complications are frequently selected as endpoint of outcome analyses. For instance, risk adjusted morbidity is one of the parameter compounding the Composite Performance Score used for evaluating the institutional quality of care during the

European accreditation process (17,18). Therefore, it appears of critical importance to find a standardized system capable of reliably grade the complications, overcoming one of the most important limitations when dealing with morbidity analysis. The use of TM&M in this regard may be complementary to the traditional classification, or even replace it, if future analyses will confirm its inter-observer stability.

One critical aspect that would warrant further investigation is the correlation between the TM&M grade of complication and other parameters associated with quality of care, such as the postoperative LOS. In fact, we found a 12-day LOS difference between patients who remained classified in the ESTS major complication group after the TM&M recoding and the patients reclassified in the minor complication group according to it.

Finally, a more aggressive attitude toward management of complications (reflected in a higher TM&M grade) would not necessarily mean a poor practice and may in fact lead to a better outcome (reduced failure to rescue).

Conclusions

Postoperative complications are an indicator of quality of care and an important primary endpoint in outcome analysis. The distribution of postoperative major complications between the two classification systems differs. The TM&M system questions the traditional classification of major cardiopulmonary complications following VATS lobectomy, which is currently used for risk-modeling and quality of care analyses. In fact, only 55% of the traditionally defined major cardiopulmonary complications were classified as major by the TM&M grading system due to the complexity of their management. In this regards the TM&M scoring system should be used as an additional instrument for risk-modeling. Only those complications graded greater than II should be selected as endpoints for any future outcome analysis.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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