Original Article

# Torrington and Henderson and Epstein risk assessment scales: applicability and effectiveness in lung resection*

FABIANA STANZANI[1], MARIA ALENITA DE OLIVEIRA[2], VICENTE FORTE[3], SONIA MARIA FARESIN[2]

## ABSTRACT

**Objective:** To compare the incidences of pulmonary and cardiopulmonary postoperative complications estimated using, respectively, the scoring systems devised by Torrington and Henderson and by Epstein in a populational sample undergoing lung resection for the treatment of lung cancer. **Methods:** Prospective data from patients submitted to resection of one or more pulmonary lobes were selected from the databases of two tertiary-care hospitals. The outcome measures were pulmonary complications, cardiac complications and mortality rates. Fisher's exact test was used to evaluate the concordance between the predicted and observed complications. **Results:** The Torrington and Henderson scoring system was applied to 50 patients, in which the risk was found to be mild in 12, moderate in 32, and high in 6. Although accurately identifying patients at high risk, the Torrington and Henderson scale underestimated the rate of postoperative cardiopulmonary complications in the mild and moderate risk categories ($p = 0.0003$ and $p = 0.0006$, respectively). The Epstein scoring system was applied to 38 patients, 4 of which were found to be at high risk, and 34 of which were found to be at mild risk. The Epstein scale also underestimated the risk in the patients (the majority) that were classified as being at mild risk ($p < 0.0001$) and yet, like the Torrington and Henderson scale, accurately identified those at high risk. **Conclusion:** Neither of the two scoring systems analyzed were found to be appropriate for predicting the risk of pulmonary and cardiopulmonary complications in most cases.

**Keywords:** Postoperative complications; Preoperative care; Thoracic surgical procedures/mortality; Lung neoplasms/surgery; Pneumonectomy; Respiratory function tests; Risk factors; Risk assessment

* Study conducted in the Pulmonology Department of the Universidade Federal de São Paulo (UNIFESP, Federal University of São Paulo), São Paulo, (SP), Brazil.
1. Doctoral student of Pulmonology at the Universidade Federal de São Paulo (UNIFESP, Federal University of São Paulo), São Paulo, (SP), Brazil.
2. Doctor of Medicine at the Universidade Federal de São Paulo (UNIFESP, Federal University of São Paulo), São Paulo, (SP), Brazil.
3. Head of the Thoracic Surgery Department of the Universidade Federal de São Paulo (UNIFESP, Federal University of São Paulo), São Paulo, (SP), Brazil.
Correspondence to: Fabiana Stanzani. Disciplina de Pneumologia - Unifesp - EPM. Rua Botucatu, 740, Vila Clementino - São Paulo, SP. CEP: 04023-062. Phone.: 55 11 5084-1268. E-mail: fabiana.stanzani@uol.com.br
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## INTRODUCTION

Surgical risk is the sum of all abnormalities that can occur in all organic systems and in their interactions.[1]

Risk assessment scoring systems for preoperative evaluation have been used in order to estimate the chance that patients have of developing postoperative complications. The first description of a risk assessment scoring system, which basically estimated mortality, was published in the 1940.[2]

Due to the increased complexity of and demand for specific procedures, as well as the need to reduce hospital costs related to prolonged hospital stays caused by postoperative complications, other scoring systems have since been published.[3]

The scoring system devised by Torrington and Henderson[4] was validated for use in our milieu in 2000.[5] The final conclusion was that, by using this scoring system, we would be able to estimate the probability of the incidence of pulmonary complications and mortality, classifying patients as being at low, moderate or high risk.

Lung resection is the treatment of choice for malignant tumors and may provide a cure in the early stages of the disease. In the field of pulmonology, the evaluation of patients suffering from malignant tumors is more complex. The incidence of complications and mortality is higher in lung resection than in other surgical procedures. Therefore, a precise risk assessment scoring system would be of great value in such cases.

The ideal would be to work with specific scoring systems for each type of procedure, and there are scoring systems specific to lung resection. However, we found that some of these systems are extremely difficult to use in everyday practice. The simplest of these scoring systems is that devised by Epstein.[6]

In order to compare the applicability of a general scoring system and a specific scoring system used for lung resection in our population, we resolved to carry out this study, the objective of which was to compare the incidences of pulmonary complications, cardiopulmonary complications (CPC) and mortality, as estimated using the scoring systems devised by Torrington and Henderson[4] and by Epstein,[6] to those observed during the postoperative period.

## METHODS

Data from patients submitted to major lung resection (the resection of one or more pulmonary lobes) were selected from the database of two institutions: the Hospital São Paulo and the Hospital São Joaquim - Beneficência Portuguesa de São Paulo. All prospective data were obtained by the same clinical group from April 2001 to April 2004. The medical ethics research committee from both hospitals approved the study.

Inclusion criteria for the study were presenting malignant lung carcinoma, being older than 18 years of age, having been nominated for exclusive resection of the lung parenchyma of at least one lobe. Patients who were submitted to concomitant rib or diaphragm resection, or who died during the intraoperative period, were excluded from the study.

Data relating to age, gender, smoking history, current tobacco consumption, respiratory symptoms, cardiac symptoms and accompanying clinical diseases were collected from the medical records of each selected patient. Spirometry, blood gas analysis and electrocardiogram results were also collected.

The risk of postoperative pulmonary complications was calculated for each patient using the scoring system devised by Torrington and Henderson,[4] together with that devised by Epstein.[6] The Torrington and Henderson scoring system is based on scoring clinical and spirometric data, and the final sum allows us to classify patients within one of the three possible risk ranges (Figure 1).

The Epstein scoring system not only includes aspects related to the respiratory condition but also takes into consideration the cardiovascular condition of surgical candidates. Initially, respiratory and cardiac aspects are assessed separately and receive a score. Subsequently, the scores related to the cardiac condition are converted into another scoring category, ranging from 1 to 4. The sum of the score regarding the pulmonary condition (ranging from 0 to 6) and that of the cardiac condition define the final risk assessment score, which ranges from 1 to 10. Patients with a final score of 4 or higher are considered to be at high risk for CPCs (Figure 2).

Risk assessment scores were calculated without prior knowledge of the CPCs that developed postoperatively. These estimated scores for each patient were later compared to the incidences of postoperative CPCs.

Data from anesthesia and surgical records were collected. All patients underwent anesthesia that incorporated a combination of techniques. For

**Chart 1 -** Torrington Henderson scoring system

| Risk factor | | Score |
|---|---|---|
| Spirometry: 0 a 4 pontos | | |
| FVC < 50% of predicted | | 1 |
| $FEV_1$/FVC | 65 - 75% | 1 |
| | 50 - 65% | 2 |
| | < 50% | 3 |
| Age > 65 years | | 1 |
| Morbid obesity (BMI > 45) | | 1 |
| Surgical site | | |
| Thoracic or upper-abdominal | | 2 |
| Other | | 1 |
| Pulmonary history | | |
| Smoking within the past 2 months | | 1 |
| Respiratory symptoms | | 1 |

Quantification of risk for complications and mortality

| Score | Risk | Complications % | Mortality % |
|---|---|---|---|
| 0-3 | Low | 6,1 | 1,7 |
| 4-6 | Moderate | 23,3 | 6,3 |
| 7-12 | High | 35,0 | 11,7 |

FVC: forced vital capacity; $FEV_1$: forced expiratory volume in one second; BMI: body mass index

**Chart 2 -** Epstein scoring system

**Cardiac risk index**

| Variable | Score |
|---|---|
| CCI (jugular stasis, EF < 40%) | 11 |
| AMI within the past 6 months | 10 |
| More than 5 extrasystoles/minute | 7 |
| Rhythm different than sinus rhythm | 7 |
| Age > 70 years | 5 |
| Significant aortic stenosis | 3 |
| Poor clinical condition | 3 |

Score range: 3-47;

Scores:

| | |
|---|---|
| 1: 0 - 5 points | 3: 13-25 points |
| 2: 6 - 12 points | 4: > 25 points |

Pulmonary risk index

| Variable | Score |
|---|---|
| Obesity (BMI > 27 kg/m2) | 1 |
| Smoking within the preceding 8 weeks | 1 |
| Productive cough within the preceding 5 days | 1 |
| Diffuse wheezing or crackles within the preceding 5 days | 1 |
| dias do procedimento | |
| $FEV_1$/FVC < 70% | 1 |
| $PaCO_2$ > 45 mmHg | 1 |

Score range: 0-6 points

**Quantification of risk for cardiopulmonary complications according to the Epstein et al. scale**

| Score | Risk | Complication % |
|---|---|---|
| 1 - 3 | Low | 11 |
| 4 - 10 | High | 73 |

CCI: congestive cardiac insufficiency; EF: (left ventricle) ejection fraction calculated through echocardiography; AMI: acute myocardial infarction; BMI: body mass index; $FEV_1$: forced expiratory volume in one second; FVC: forced vital capacity; $PaCO_2$: arterial carbon dioxide tension

opioid administration, peridural catheters were left in place until the fifth postoperative day. The same surgical team performed the procedure in both hospitals.

Pulmonary complications evaluated in this study were pneumonia, tracheobronchitis, acute respiratory insufficiency, requiring mechanical ventilation for more than 48 hours after surgery, atelectasis and bronchospasm. For comparison, the cardiac complications assessed were those defined by Epstein[6] (Chart 1).

Fisher's exact test was used to evaluate the concordance between the complications estimated by each of the scoring systems and those observed.

## RESULTS

Data from 54 patients were compatible with inclusion criteria, but 4 of those were later excluded: 1 due to intraoperative mortality, 1 presenting advanced local tumors and 2 whose histological analysis of the resected tissue revealed an inflammatory process. The final sample, therefore, comprised 50 patients.

Patient ages ranged from 33 to 77 years, with a mean of 60.4 ± 12 years and a median of 59 years. Of these patients, 29 (58%) were male and 21 (42%) were female. Ten (20%) patients continued smoking 24 hours prior to the surgical procedure and 27 (54%) had quit smoking for more than 8 weeks prior to hospitalization. Of the 50 patients, 41 (82%) presented respiratory symptoms in the preoperative evaluation, and 6 (12%) presented cardiac symptoms. However, none presented clinically demonstrable left cardiac insufficiency or had suffered acute myocardial infarction in the preceding 6 months. Six patients (12%) suffered from diabetes and 21 (42%) presented systemic arterial hypertension. Eleven (22%) of the patients had

**Chart 3 -** Definition of postoperative pulmonary and cardiac complications

| Complication | Definition |
|---|---|
| Pneumonia | Chest X-ray revealing recent pulmonary infiltrate accompanied by purulent tracheobronchial secretion; hyperthermia higher than 38.3°C Leukocytosis greater than 25% of preoperative values |
| Tracheobronchitis | Normal chest X-ray; greater color shift or purulent aspect to tracheobronchial secretion |
| ARI | Acutely deficient gas exchange with the need for ventilatory support for treatment |
| Invasive MV | Invasive mechanical ventilation for longer than 48 hours required to treat ARI |
| Atelectasis | Abnormal chest X-ray and acute respiratory symptoms |
| Bronchospasm | Acute respiratory symptoms concomitant with sibilance upon auscultation requiring therapeutic intervention |
| Re-intubation | A second orotracheal intubation required due to ARI |
| AMI | ECG changes consistent with ischemia and increased enzyme levels; unstable angina; angina at rest with no change in enzyme levels |
| LHI | Rales on auscultation and radiologic signs suggesting congestion or clinical response with diuretics |
| Arrhythmia | Tachyarrhythmia or bradyarrhythmia requiring treatment |
| PTE | Suggestive clinical profile, together with confirmatory imaging |

ARI: acute respiratory insufficiency; MV: mechanical ventilation; AMI: acute myocardial infarction; ECG: electrocardiogram; LHI: left heart insufficiency; PTE: pulmonary thromboembolism

previously been submitted to chemotherapy.

Lobectomy was performed in 30 cases, bilobectomy in 7, pneumonectomy in 8, and extended lobectomy (in which one or more segments were removed) in 5. More extensive lung parenchyma resection than that initially planned was necessary in 16 cases (32%) due to tumor invasion. This procedure was designated extended resection. Bronchoplasty was required in 10 cases (20%).

Twenty-three (46%) of the patients presented some type of CPC. Of these, 19 developed complications that were exclusively pulmonary, 3 developed cardiac complications only, and 1 developed both. The pulmonary complication rate was 42% (21/50). Of the 38 cases of CPC observed, 34 (86.7%) were pulmonary. Of these, 8 (16%) patients presented tracheobronchitis, 6 (12%) presented pneumonia, 6 (12%) presented bronchospasm, 5 (10%) presented atelectasis, and 4 (8%) presented acute respiratory insufficiency; 3 (6%) patients were submitted to orotracheal intubation, and 2 (4%) required mechanical ventilation for more than 48 hours. No patients presented coronary events, left cardiac insufficiency or pulmonary thromboembolism during the postoperative period. Four patients (8%) presented supraventricular tachyarrhythmia and were submitted to pharmacotherapy. One patient (2%) died.

According to the Torrington and Henderson scoring system, 12 patients (24%) were considered to be at low risk, 32 (64%) were considered to be at moderate risk, and 6 (12%) were considered to be at high risk. When we compared the rates of

TABLE 1

**Comparison between the postoperative pulmonary complications predicted with the Torrington and Henderson scoring system and those observed in the study**

| | % Without Complications | | % With Complications | | |
|---|---|---|---|---|---|
| Risk | Expected | Observed | Expected | Observed | *p* |
| Low | 94 | 75.0 (*n* = 9) | 6 | 25.0 (*n* = 3) | 0.0003 |
| Moderate | 77 | 53.1 (*n* = 17) | 23 | 46.9 (*n* = 15) | 0.0006 |
| High | 65 | 66.6 (*n* = 4) | 35 | 33.3 (*n* = 2) | 0.881 |

*n*: absolute number of patients

pulmonary complication expected for each risk category to those compiled in the study, we determined that there was no statistically significant difference between the estimated and observed incidence of complications in the high-risk category. However, there was a statistically significant difference between the estimated and observed incidence of complications for the other two risk categories, that is, there was a greater number of pulmonary complications than those estimated by using that scoring system (Table 1).

The Epstein scoring system was applied to 38 patients, among which the risk of developing CPCs was found to be high in 4 (10.5%) and low in 34 (89.5%). The CPC rate in the group considered to be at low risk was statistically different than that estimated, whereas, in the group found to be at high risk, there was no difference between the estimated and observed incidence of CPC (Table 2).

## DISCUSSION

The mean incidence of postoperative pulmonary complications observed in our population sample was 42%, which is higher than the approximately 30% found in other studies.[1,3] This difference is probably due to the current trend in the literature to limit the definition of postoperative pulmonary complications to only those that are potentially life-threatening, including pneumonia, acute respiratory insufficiency or mechanical ventilation for more than 48 hours. If only these pulmonary complications were considered in our study, the rate would be 24% (n = 12). However, we believe that any pulmonary complications should be considered significant since there is a frequent interrelation between them. In general, patients who develop acute respiratory insufficiency are those who were initially diagnosed with tracheobronchitis or atelectasis. This correlation was verified in 100% of the cases in our study.

Busch *et al.*[7] described the incidences of mortality and pulmonary complications after 106 resection procedures used to treat malignant tumors. The authors included bronchospasm requiring intravenous medication and atelectasis requiring bronchoscopy in their definition of postoperative complications. They found a mortality rate of 6% and a rate of complications of 39%, similar to those found in our study.

After lung resection, cardiac complications are as frequent and as serious as pulmonary complications. The most prevalent cardiac complication is cardiac arrhythmia, especially atrial fibrillation, and the most severe is acute myocardial infarction.[8] In the present study, there was an 8% incidence of cardiac complications, all of which were atrial fibrillation. In other studies, the incidence of supraventricular arrhythmia ranged from 8% to 40% after pneumonectomy and from 7% to 8.5% after lobectomy.[8]

The mortality rate in our study was 2%, which is concordant with that found in other studies.[3,9] In our study, the patient who died had been submitted to neoadjuvant chemotherapy, presenting a Karnofsky index score of 70 points. This patient required a more extensive surgical procedure than that previously proposed and, during the postoperative period, presented bronchopleural fistula, empyema and septic shock. The risk for this patient had been found to be moderate in accordance with the Torrington Henderson scoring system and low according to the Epstein scoring system.

When we analyzed the results in Table 1, we found out that the Torrington Henderson scoring system allowed the appropriate stratification of patients at high risk of pulmonary complications, although its use resulted in an underestimation of the incidence of complications in patients at low

TABLE 2

**Comparison between the postoperative pulmonary complications predicted with the Epstein et al. scoring system and those observed in the study**

| | % Without Complications | | % With Complications | | |
|---|---|---|---|---|---|
| Risk | Expected | Observed | Expected | Observed | *p* |
| < 4 points | 89 | 58.8 (*n* = 20) | 11 | 41.2 (*n* = 14) | < 0.0001 |
| > 4 points | 27 | 25.0 (*n* = 1) | 73 | 75.0 (*n* = 3) | 0.872 |

*n*: absolute number of patients

and moderate risk categories. We must emphasize that most patients with tumors who are candidates for lung resection belong to the group of patients determined to be at moderate risk according to this system.

Considering the applicability of the Torrington Henderson scoring system, we observed that the surgical procedure performed (thoracic surgery) and the presence of chronic obstructive pulmonary disease, which frequently accompanies lung tumors, already added 3 points to the scores of patients (putting these patients at the upper limit of the low-risk category). More than 80% of the patients presented respiratory symptoms, common in this population, and thus received another point, placing them in the moderate risk category, which was predominant in our population sample.

The Torrington Henderson scoring system[4] was devised in order to determine which surgical patients were likely to be submitted to assisted respiratory physiotherapy with a physiotherapeutic team, and its main objective was to reduce hospital costs. The scores attributed to each of the variables were empirically determined and were not based on statistics. In addition, only fever and radiological alterations were considered postoperative complications. As previously mentioned, this scoring system was validated at the Hospital São Paulo.[5] However, in that study, only 70 patients (6% of the population sample) were submitted to lung resection, whereas the majority of patients were submitted to abdominal and peripheral procedures. This leads us to assume that those results better reflected what occurs after abdominal and peripheral procedures than what occurs after thoracic procedures. Therefore, the use of this scoring system resulted in an underestimation of the incidence of postoperative pulmonary complications.

A Brazilian prospective study,[10] carried out in order to identify variables related to the incidence of pulmonary complications after elective thoracic and upper-abdominal surgical procedures, used the same group of complications included in the present study. However, the authors only recorded the incidence of complications up to the third postoperative day. In that study, the Torrington and Henderson scoring system was applied to 297 patients. Fisher's exact test was used to evaluate the concordance between the incidence of pulmonary complications observed in each risk category and those found in the study by Faresin.[5] The statistical test showed statistical significance only for the moderate risk category ($p < 0.0001$), which was the group that comprised the greatest number of patients.

A similar phenomenon occurred with the Epstein scoring system. The scores of the majority of the patients ($n = 29$) were lower than 4 points, and these patients were considered to be at low risk. The use of this scoring system also resulted in an underestimated incidence of CPCs. Thirteen (37.1%) of the patients presented complications, whereas the estimated incidence of CPCs was 11% ($p < 0.0001$).

The Epstein scoring system[6] has the objective of identifying patients who are more likely to develop CPCs after thoracic surgery. Therefore, in theory, it would be a more appropriate system for assessing the risk of the patients evaluated in this study. In addition, it is a rather interesting system since it is based on clinical parameters and takes into account, albeit in a very simplistic way, the cardiac condition of such patients. It is noteworthy that this scoring system was devised based on the analysis of only 42 patients, and the extent of the surgical procedure was not specified in the original study.

Melendez and Carlon[11] published a study in which the Epstein scoring system was applied to 180 candidates for thoracotomy, 133 of which were submitted to extensive lung resection. In that study, patients with a score equal to or greater than 4 were considered to be at high risk for CPCs. In agreement with our findings, the authors reported that majority of the population presented scores lower than 4, and only 24.4% of the patients had a score higher than 4. Their final analysis demonstrated that the scoring system was inappropriate since it presented a low predictive power.

Ferguson and Durkin devised a scoring system to estimate the incidence of postoperative complications after lung resection, dubbing it EVAD.[12] This system was later validated and compared to that by Epstein and to the Physiological and Operative Severity Score for enUmeration of Mortality and Morbidity (POSSUM),[13] another risk assessment scoring system that can be used to estimate the incidence of pulmonary complications. In that comparative study, the authors analyzed eight categories of complications (including pulmonary, cardiovascular, cardiopulmonary and infectious), as well as mortality. The EVAD scoring system presented a

considerable advantage over the other two systems because it is simple and includes only 3 variables: age, predicted percentage of lung diffusing capacity for carbon monoxide and predicted percentage of forced expiratory volume in one second. The comparison of the three systems led to the conclusions that: none were able to predict mortality; only the Epstein and EVAD scales were able to determine pulmonary and cardiopulmonary risks; cardiovascular complications were only estimated accurately using the EVAD and POSSUM scales, whereas infectious complications were only evaluated accurately using the POSSUM scale. Therefore, each scoring system has clear limitations when applied to the same population sample.[12]

Currently, the feasibility algorithm for resection of pulmonary tumors includes two variables that have proven predictive of postoperative complications: the stair-climbing test and the predicted postoperative lung diffusing capacity for carbon monoxide. Unfortunately, there is no surgical risk assessment scoring system that includes both variables in order to determine their predictive value when accompanied by other clinical variables. We believe that such a scale would be extremely useful, since the stair-climbing test could help better evaluate the cardiopulmonary interaction.[14] The advantage of evaluating lung diffusing capacity for carbon monoxide would result in a more precise evaluation of gas exchange, in comparison with the isolated determination of the forced expiratory volume in one second.[15]

Another aspect worth mentioning is that the highest morbidity and mortality rates were found after pneumonectomy, especially after right pneumonectomy, which has inspired studies whose primary aim is to identify preoperative variables that are predictive of these complications.[16-17]

The results of present study raise two questions. First, what is the behavior of risk assessment scoring systems used for various procedures when applied to a population submitted to a specific procedure? Second, how do risk assessment scoring systems behave in specific procedures used to treat specific diseases?

In addressing the first question, it must be remembered that scoring systems are, undoubtedly, useful and necessary in order to identify patients at high risk of developing complications or dying. However, they also need to be useful for predicting surgical risk for the majority of a population. Therefore, the population to which the scoring system will be applied needs to be taken into consideration. Thoracic procedures are complex and present relevant variables that are not assessed by scoring systems devised for general procedures. The extent of the lung parenchyma resection, the use of preoperative chemotherapy, chest wall or diaphragm resection and the need for bronchoplasty are relevant aspects in such procedures. This may partially explain why, using the Torrington and Henderson scoring system, we were unable to accurately estimate the surgical risk for the majority of our population sample.

Our second question is more intriguing. Tumors inflict a certain degree of chronic inflammation on the organism, which may have local or systemic effects, and whose clinical expression would be difficult to measure. Tumor staging, nutritional state and muscle involvement in the extremities might be other potential markers of postoperative complications in this subpopulation.

Our study presented some limitations, principal among which is the small number of patients. This occurred because we attempted to evaluate extensive lung resections exclusively, since this is the ideal treatment in the early stages of non-small cell lung cancer, and we excluded patients submitted to resection of other thoracic structures such as of costal arches and diaphragm, which might present a higher incidence of complications. However, this affected the analysis of a greater number of variables that might have helped to predict postoperative complications in the majority of this population sample.

All of the data discussed to date underscore the need to develop and test new scoring systems aimed at candidates for lung parenchyma resection of varying extent. Ideally, this scoring system would comprise few variables and favor clinical aspects, dispensing with the need to perform complex mathematical calculations in order to determine the risk score.

In conclusion, this study allowed us conclude that, for this population sample (candidates for extensive lung resection for the treatment of lung cancer), the Torrington and Henderson and Epstein scoring systems were only appropriate for estimating the incidence of CPCs in patients at high risk, which represented the minority of our population.

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