Glasgow Prognostic Score Class 2 Predicts Prolonged Intensive Care Unit Stay in Patients Undergoing Pneumonectomy

Francesco Petrella, MD, Davide Radice, PhD, Monica Casiraghi, MD, Roberto Gasparri, MD, PhD, Alessandro Borri, MD, Juliana Guarize, MD, Domenico Galetta, MD, Marco Venturino, MD, and Lorenzo Spaggiari, MD, PhD

Departments of Thoracic Surgery, Biostatistics, and Anaesthesiology, European Institute of Oncology, Milan; and Department of Oncology and Hematology-Oncology—DIPO, University of Milan, Milan, Italy

Background. **The Glasgow prognostic score (GPS) is an inflammation-based score based on albuminemia and C-reactive protein concentration proved to be associated with cancer-specific survival in several neoplasms. The present study explored the immediate postoperative value of the GPS for patients undergoing pneumonectomy for lung cancer.**

Methods. **The value of the GPS preoperatively was studied in 250 patients undergoing pneumonectomy for non-small cell lung cancer (NSCLC). We analyzed overall postoperative complications, pulmonary and cardiac complications, 30-day postoperative death, reoperation for early complications, intensive care unit (ICU) length of stay and total length of hospital stay.**

Results. **Patients with a GPS of 0 and 1 had a mean ICU length of stay of 0.8 days, whereas patients with a GPS of 2 had a mean ICU stay of 5.0 days ($p = 0.004$). The postoperative mortality rate in patients with a GPS of 2 was much higher than in patients with a GPS of 1 and 2, although it was not statistically significant ($p = 0.083$).**

Conclusions. **A preoperative GPS of 2 effectively predicts a prolonged ICU stay in patients who undergo pneumonectomy for cancer. The score may be proposed as an easy-to-determine, economical, and fast preoperative tool to plan and optimize ICU admissions after elective pneumonectomy.**

(Ann Thorac Surg 2016;102:1898–904)

Although it is well known that cancer development has a genetic basis, there is increasing evidence that the host systemic inflammatory response, as evidenced by C-reactive protein, and nutritional status, as evidenced by serum albumin levels, have an important role in the progression of a variety of common solid tumors [1].

In 2003, Forrest and colleagues [2] first observed that a cumulative score based on C-reactive protein and albumin may have a prognostic value similar to that of more conventional measures in patients with inoperable non-small cell lung cancer (NSCLC) [2]. This score—subsequently termed the *Glasgow prognostic score* (GPS)—also had the advantage of being simple to measure, routinely available, and well standardized, thus being easier and faster to use than the conventional combination of cancer stage and performance status [3]. The prognostic value of stage and performance status in oncology patients may be hampered by the fact that they reflect the patient's status at a specific point in time, whereas the GPS reflects current nutritional status and also predicts continuing nutritional decline [4].

Since then, many studies have reported on the prognostic value of C-reactive protein and other markers of the systemic inflammatory response in patients with a wide variety of operable [5] and inoperable cancers [6], as well as in patients with cancer undergoing chemotherapy or radiotherapy, or both [7].

To date, however, no study has explored the prognostic value of the GPS on the acute postoperative course in patients undergoing major pulmonary resection for lung cancer.

Considering that the GPS reflects the systemic inflammatory state of the patient, as well as the nutritional status, we suppose that it may have a prognostic value in inoperable lung cancer but might also be predictive of acute postoperative outcomes in patients with resectable disease.

The aim of this study was therefore to examine the relationship between an inflammation-based prognostic score (GPS) and the 30-day postoperative course in patients undergoing pneumonectomy for NSCLC and validate the hypothesis that it may add useful information to optimize both clinical and management aspects in an elective setting.

Accepted for publication May 24, 2016.

Presented at the Joint Annual Meeting of the Association of Cardiothoracic Anaesthetists and the Society for Cardiothoracic Surgery in Great Britain and Ireland, Manchester, United Kingdom, March 25–27, 2015.

Address correspondence to Dr Petrella, Department of Thoracic Surgery, European Institute of Oncology - Via Ripamonti, 435, 20141 Milan, Italy; email: francesco.petrella@ieo.it.

Published by Elsevier
0003-4975/$36.00
http://dx.doi.org/10.1016/j.athoracsur.2016.05.111

Patients and Methods

Population

This was an observational retrospective study. Data were collected prospectively and entered into our institutional general thoracic database at the point of care and reviewed and double checked retrospectively. Two hundred fifty consecutive standard pneumonectomies performed for NSCLC over a 7-year period were analyzed.

Written informed consent to undergo the procedure and the use of clinical and imaging data for scientific or educational purposes, or both, was obtained from all patients before the operation.

Standard pneumonectomy was defined as the intrapericardial or extrapericardial removal of the entire lung associated with radical mediastinal lymph node dissection without any resection of mediastinal, chest wall, or diaphragmatic structures [8]. Patients who underwent induction chemotherapy were enrolled in the present study.

Patient Selection and Management

Operability was determined by standard clinical and radiographic procedures (whole-body computed tomography), nuclear imaging (whole-body fluorodeoxynucleotide positron emission tomography), and staging procedures, including endobronchial ultrasonographic bronchoscopy and transbronchial needle aspiration, video mediastinoscopy, and mediastinotomy, as appropriate.

Preoperative respiratory function was assessed routinely by blood gas analysis, spirometry, and lung perfusion scanning to identify the functionally prevalent lung. Patients were always admitted the day before the surgical procedure unless they required preoperative management of medical comorbidities, which was exceedingly uncommon.

Comorbidities were stratified according to an adapted Charlson comorbidity index [9], with a mean score of 4 (range, 2–6); they included a history of myocardial infarction, peripheral disease, cerebrovascular disease, diabetes (without end-organ damage), mild and moderate liver disease, and moderate kidney disease.

Amoxicillin and clavulanic acid were administered for the first 5 postoperative days in nonallergic patients, with the first dose administered before the skin incision [10]. Intraoperative fluid administration was on the order of 5 to 7 mL/kg/h crystalloid infusion, not exceeding a total of 1,500 mL in all cases. Ventilation was managed by a protective ventilation strategy (tidal volume $\leq$6 mL/kg, driving pressure <20 cm H_2O above the positive and negative expiratory pressure, permissive hypercapnia, and the preferential use of pressure-limited ventilation modes) [8].

Thromboprophylaxis was maintained with sequential compression devices, early ambulation, and low-molecular-weight heparin delivered subcutaneously (4,000 IU/d enoxaparin sodium). Postoperative analgesia was achieved in conjunction with anesthesiologists using a combination of epidural analgesia (when technically feasible and not contraindicated), patient-controlled analgesia, and oral and parenteral adjuncts as needed to improve pulmonary and physical therapy.

Patients were instructed preoperatively regarding incentive spirometry. Postoperatively they received 2 assisted sessions of chest physiotherapy daily starting on the first postoperative day and were asked to repeat the physiotherapy program 6 times during the day until discharge. Therapeutic bronchoscopy was instituted early based on clinical findings and correlation with daily chest films. The thoracostomy tube (a standard 32F thoracic drainage tube) was usually removed on the third postoperative day, except in the case of early complications such as bleeding, chylothorax, or suspected early bronchopleural fistula.

Postoperative Complications

Postoperative death was defined as 30-day mortality or longer if mortality occurred during hospitalization. Complications were classified according to the Thoracic Morbidity and Mortality classification system [11] as minor (grade I and II) and major (grade IIIa, grade IIIb; grade IVa, grade IVb; grade V).

In-Hospital and ICU Length of Stay

In-hospital length of stay was defined as the time spent in the hospital from the day of operation (operative day 0) to discharge. ICU length of stay was defined as the time spent in the ICU from the day of admission to discharge to the ward.

Glasgow Prognostic Score

The GPS was constructed as previously described [2]. Patients with both elevated C-reactive protein (>10 mg/L^{-1}) and hypoalbuminemia (<35 g/L^{-1}) were allocated to a GPS of 2; patients in whom only 1 of these biochemical abnormalities was present were allocated to a GPS of 1; patients in whom neither of these abnormalities was present were allocated to a GPS of 0. Blood samples were collected the day before the planned operations.

Statistical Methods

Patient characteristics and clinical outcomes or complications were summarized either by counts and percent or mean, median, minimum, and maximum for categorical and continuous variables, respectively. Complications and 30-day postoperative mortality were cross-tabulated against the GPS (0, 1, 2) and tested for association with the Cochran-Armitage test for trend. Counts, mean, median, minimum, and maximum of ICU stay and in-hospital stay were also computed and tested for association with the GPS using the Kruskal-Wallis test. The risk of postoperative complications and the risk of an ICU stay of at least 1 day or longer were estimated by univariate and multivariable logistic regression models using the GPS as a predictor and tabulated as odds ratios (ORs) alongside their 95% confidence intervals (CIs). All tests were 2-sided and considered significant at the 5% level. All analyses were conducted using SAS, version 9.3 (SAS Institute, Cary, NC).

Results

Population

From January 2004 to December 2011, 250 patients underwent pneumonectomy for NSCLC, 199 (79.6%) of whom were men. The overall mean age was 63.9 years (range, 36–85 years; SD, 9.1 years). There were 105 right pneumonectomies (42%) and 145 left pneumonectomies (58%). Mean body mass index (BMI) was 25.9 (range, 16.3–44.5; SD, 4.4). Twenty-six patients were never-smokers (10.4%) and 224 were active or former smokers (89.6%) at the time of diagnosis. One hundred twenty-three patients (49.2%) received induction treatment, whereas 127 patients (51.8%) did not.

Table 1. Characteristics of the Study Population

Categorical Variables	N (%)
Side	
Right	145 (58.0)
Left	105 (42.0)
Sex	
Male	199 (79.6)
Female	51 (21.4)
Smoking status	
Never	26 (10.4)
Active or former smoker	224 (89.6)
Induction treatments	
Yes	123 (49.2)
No	127 (51.8)
GPS	
0	137 (54.8)
1	92 (36.8)
2	21 (8.4)
Complications	
Cardiac	61 (24.4)
Pulmonary	39 (15.6)
Any	116 (46.4)
30-day mortality	14 (5.6)
Early reoperation	24 (9.6)
Continuous Variables	**Mean ± SD (median)**
Age, y	63.9 ± 9.1 (65.3)
Preoperative BMI	26.1 ± 4.4 (25.9)
Preoperative albumin	4.1 ± 0.4 (4.1)
Preoperative PCR	22.5 ± 29.3 (8.0)
Hospital stay, d	7.9 ± 5.2 (7.0)
ICU stay, d	1.2 ± 4.6 (0.0)
FEV_1	2.3 ± 0.7 (2.3)
FEV_1 (%)	83.4 ± 20.5 (81.7)
DLCO (%)	85.2 ± 25.2 (81.7)
V/Q	37.4 ± 11.5 (39.0)
ppoFEV_1	50.8 ± 11.1 (49.1)
ppoDLCO	52.8 ± 19.6 (50.3)

BMI = body mass index; DLCO = diffusing capacity of lung for carbon monoxide; FEV_1 = forced expiratory volume in the first second of expiration; GPS = Glasgow prognostic score; ICU = intensive care unit; PCR = polymerase chain reaction; ppo = predicted post operative; V/Q = ventilation/perfusion.

Morbidity, Mortality, Length of Stay, and GPS

The mean preoperative albumin level was 4.1 g/L^{-1} (range, 2.4–5.2 g/L^{-1}; SD, 4.1 g/L^{-1}), and the mean preoperative C-reactive protein level was 8 mg/L^{-1} (range, 0–138.4 mg/L^{-1}; SD, 29.3 mg/L^{-1}). One hundred thirty-seven patients were scored as GPS 0; 92 patients were scored as GPS 1; and 21 patients were scored as GPS 2. Thirty-day mortality was 5.6% (14 of 250 patients), and the reoperation rate for early complications was 9.6% (24 of 250 patients). One hundred sixteen patients experienced any type of complication (overall complication rate, 46.4%), 61 patients had cardiac complications (24.4%), and 39 patients had pulmonary complications (15.6%) (Table 1). According to the Thoracic Morbidity and Mortality classification system, 63 patients (25.2%) had minor complications (grade I or grade II), 39 patients (15.6%) had major complications (grade III or grade IV), and 14 patients (5.6) had grade V complications. One hundred patients were admitted to the ICU (40%), and among them, 29 were admitted or readmitted urgently (29%). Nine of 29 patients (31.0%) who ended up urgently in the ICU died; however, failure to rescue these patients in the ICU was not associated with GPS (p = 0.736) (Table 2).

The mean in-hospital stay was 7.9 days (range, 4–48 days; SD, 5.2 days) and the mean ICU stay was 1.2 days (range, 0–44 days; SD, 4.6 days) (Table 1). Thirty-nine percent of patients had an ICU stay of 1 to 9 days, and only 5 (2%) had an ICU stay longer than 19 days (data not shown). The mean ICU stay for patients with a GPS of 2 was 5.0 days, which was significantly longer than in patients with GPS of 1 and 0 (p = 0.012) (Table 3). The postoperative mortality OR for patients with a GPS of 2 was 3.10, which was much higher than in patients with a GPS of 0 and 1, although it was not statistically significant (p = 0.083) (Table 4).

All other postoperative variables were not directly related to the preoperative GPS. Predictors of a significantly increased risk of an ICU stay of 1 day or longer in univariate analysis were age (OR, 1.09; $p < 0.001$), male sex (OR, 2.10; $p = 0.032$), current smoker/ex-smoker status

Table 2. Frequency Distribution of 30-Day Complications and Side by Glasgow Prognostic Score

	Glasgow Prognostic Score			
	0	1	2	p Value
Complications, n (%)[a]				
Lung	18 (13.1)	15 (16.3)	6 (28.6)	0.100
Heart	35 (25.5)	21 (22.8)	6 (28.6)	0.958
Other	47 (34.3)	27 (29.3)	6 (23.8)	0.260
Any complication	73 (53.3)	48 (63.0)	11 (52.4)	0.775
Postoperative mortality	7 (5.1)	4 (4.3)	3 (14.3)	0.288
Side, N (%)				
Right	60 (43.7)	36 (39.1)	9 (42.8)	
Left	77 (56.2)	56 (60.9)	12 (57.1)	0.651

[a] Complications are not mutually exclusive categories; thus percentages in parentheses do not equal 100.

Table 3. Summary Statistics of ICU Length of Stay According to the Glasgow Prognostic Score

	Glasgow Prognostic Score	N	Mean (Median)	Minimum/ Maximum	*p* Value
ICU stay (d)	0	137	0.8 (0.0)	0/44	
	1	92	0.8 (0.0)	0/20	0.012
	2	21	5.0 (1.0)	0/38	
Hospital stay (d)	0	131	7.8 (7.0)	4/44	
	1	90	7.4 (6.0)	4/26	0.275
	2	19	11.4 (7.0)	5/48	

ICU = intensive care unit.

(OR, 4.98; $p = 0.005$), and having a GPS of 2 (OR, 3.21; $p = 0.016$) (Table 5). Multivariable analysis (full model) retained as significant risk factors age (OR, 1.08; $p = 0.004$), BMI (OR, 1.10, $p = 0.005$), and a GPS of 2 (OR, 3.82; $p = 0.049$). The multivariable analysis (reduced model) retained as significant risk factors BMI (OR, 1.10; $p = 0.005$) and a GPS of 2 (OR, 6.06; $p = 0.004$) (Table 5, Fig 1).

Comment

Thoracic surgery is 1 of the specialties that uses ICU resources most often, either electively for monitoring high-risk patients in the early postoperative period or in emergent cases for major cardiorespiratory complications requiring active life-supporting treatments, accounting for approximately 10% of all ICU admissions [12, 13].

The increased frequency of surgical procedures for elderly patients with several underlying comorbidities has contributed to a growing demand for expensive care; more specifically, the economic costs of ICU care are also increasing, amounting to approximately 20% to 30% of the total in-patient expenditure [14].

Although preoperative evaluation to identify patients at risk of major complications after pulmonary resection has been reviewed [15, 16], individual factors predicting the risk of major complications have been reported by only 1 scoring system designed to predict the risk of ICU admission [12]. This system was subsequently found to have only a moderate discriminating ability to predict the risk of ICU admission when applied to a cohort of patients in a different institution undergoing lung resection for NSCLC (area under the receiver operating characteristic curve, 0.66; 95% CI, 0.53–0.79) [17].

In a time of a chronic ICU bed shortages, effective prediction criteria for postoperative ICU admissions and length of stay may represent an effective clinical and management tool. From a clinical standpoint, preventive measures may be implemented for patients identified to be at increased risk of a postoperative emergency ICU admission in an attempt to improve their outcomes. These patients, for instance, may benefit from direct admission to the ICU rather than to a step-down unit or may be kept in the ICU longer if that is where they spend the first day [9]. In addition, patients can receive more detailed preoperative counseling about their perioperative risk. From a management point of view, surgical procedures may be restricted or postponed in patients at a higher risk of ICU admission to reduce the potential ICU demand, which is in line with position 9 of The American Thoracic Society statement on the fair allocation of ICU resources [18].

Because the increase in major infectious and pulmonary complications after resection can be explained by the combination of immunodeficiency and weakness of respiratory muscles in malnourished patients, the benefit of intensive nutritional support with branched-chain amino acids and medication for the improvement of appetite has been recently suggested for reducing the risks in lung cancer operations [19].

We have already demonstrated that obese and overweight patients undergoing pneumonectomy for lung cancer have a 5-fold higher pulmonary complication rate compared with patients with a normal BMI [20]. Although BMI as a categorical variable did not influence ICU length of stay in the univariate analysis in the present study, it was included in the multivariate analysis because of its borderline value as a continuous variable in the univariate analysis. In other words, the increased risk of spending 1 or more days in the ICU for patients with a GPS of 2 (OR, 4.45) is similar to that of patients who were smokers (current or ex-smokers) (OR, 4.54) (Table 5, Fig 1). It is well known that the GPS offers interesting

Table 4. Univariate Risk of Postoperative Complications by Levels of the Glasgow Prognostic Score

Complication	Glasgow Prognostic Score	OR	95% CI	*p* Value
Lung	0	Reference	. . .	
	1	1.29	0.61–2.71	0.552
	2	2.64	0.91–7.70	0.103
Heart	0	Reference	. . .	
	1	0.86	0.46–1.60	0.532
	2	1.17	0.42–3.24	0.654
Other	0	Reference	. . .	
	1	0.79	0.45–1.41	0.938
	2	0.60	0.21–1.73	0.454
Any complication	0	Reference	. . .	
	1	1.00	0.59–1.70	0.802
	2	1.17	0.46–2.95	0.734
Side (left versus right)	0	Reference		
	1	1.21	0.71–2.08	0.483
	2	1.04	0.41–2.63	0.936
Postoperative mortality	0	Reference		
	1	0.84	0.23–2.97	0.243
	2	3.10	0.73–13.1	0.083

CI = confidence interval; OR = odds ratio.

Table 5. Univariate and Multivariate Risk (Odds Ratio) Estimates of ICU Stay (≥1 Day vs None)

Univariate Risk Factor	Events/ Patients	OR (95% CI)	*p* Value
Age, y	102/250	1.09[a] (1.05–1.13)	*<0.001*
BMI (continuous)	102/250	1.06[a] (1.00–1.12)	0.062
FEV_1	102/246	0.45[a] (0.30–0.69)	*<0.001*
FEV_1 %	102/247	0.98[a] (0.96–0.99)	*<0.001*
DLCO %	98/241	0.99[a] (0.98–1.01)	0.321
V/Q	98/234	0.99[a] (0.96–1.01)	0.200
$ppoFEV_1$	98/232	0.97[a] (0.95–1.00)	*0.019*
ppoDLCO	94/226	1.00[a] (0.98–1.01)	0.661
Sex			
Female	14/51	Reference	
Male	88/199	2.10 (1.07–4.12)	*0.032*
Smoking status			
No	4/26	Reference	
Yes	76/160	4.98 (1.64–15.1)	*0.005*
BMI (categorical)			
Underweight/normal	35/88	Reference	
Overweight	43/116	0.89 (0.51–1.58)	0.169
Obese	24/46	1.65 (0.81–3.39)	0.089
Side			
Left	66/145	Reference	
Right	36/105	0.63 (0.37–1.05)	0.075
Presurgical treatment			
No	51/127	Reference	
Yes	51/123	1.06 (0.64–1.75)	0.834
Glasgow prognostic score			
0	51/137	Reference	
1	37/92	1.13 (0.66–1.95)	0.140
2	14/21	3.37 (1.28–8.91)	*0.017*
Glasgow prognostic score			
0-1	88/229	Reference	
2	14/21	3.21 (1.25–8.25)	*0.016*

Multivariate Risk Factors (Full Model)	OR (95% CI)	*p* Value
Age	1.08[a] (1.03–1.14)	*0.004*
BMI	1.12[a] (1.04–1.22)	*0.005*
FEV_1	0.67[a] (0.30–1.48)	0.322
$ppoFEV_1$	0.99[a] (0.96–1.03)	0.750
Sex		
Female	Reference	
Male	1.70 (0.53–5.42)	0.371
Smoking status		
No	Reference	
Yes	2.71 (0.69–10.7)	0.155
Glasgow prognostic score		
0–1	Reference	
2	3.82 (1.00–14.5)	*0.049*
Multivariate Risk Factors (Reduced Model)[b]		
BMI	1.10[a] (1.03–1.18)	*0.005*

(*Continued*)

Table 5. Continued

Multivariate Risk Factors (Full Model)	OR (95% CI)	*p* Value
Glasgow prognostic score		
0–1	Reference	
2	6.06 (1.81–20.4)	*0.004*

[a] For each unit increase. [b] stratified by age.

Italics represent only statistically significant values.

Between-model χ^2 comparison, $p = 0.435$.

BMI = body mass index; CI = confidence interval; DLCO = diffusing capacity of lung for carbon monoxide; FEV_1 = forced expiratory volume in the first second of expiration; ICU = intensive care unit; OR = odds ratio; ppo = predicted post operative; V/Q = ventilation/perfusion.

long-term prognostic information in patients with many different types of solid tumors, both in resectable stages and in advanced (metastatic) stages, who are receiving chemotherapy [21–24]; moreover, it has been demonstrated that the GPS is a useful prognostic indicator of the overall survival in patients undergoing lung cancer operations, mainly elderly patients with clinical stage I NSCLC. In addition, it predicts worse overall survival for patients with small-cell lung cancer [25–28]. Conversely, the GPS has never been used as an immediate short-term prognostic factor, and hence no data are available on its efficacy in predicting the postoperative course in patients undergoing major pulmonary resection for lung cancer.

The GPS predictive value for postresectional admission and ICU length of stay after pneumonectomy may result from the fact that both nutritional status and systemic inflammation are severely impaired in these very fragile patients, who benefit maximally from ICU care and thus spend more days in the ICU after surgical procedures.

We have previously demonstrated that standard pneumonectomy is a safe procedure even after induction chemotherapy, with a mortality rate on the order of 5%, although it increases in patients older than 70 years [8]. In the present study, the univariate analysis did not show any significant correlation with presurgical treatments.

Limitations of the Study

Although data were collected prospectively and entered into our institutional general thoracic database at the point of care, this is an observational retrospective study and thus suffers from the common bias of a nonrandomized retrospective study. Moreover, although the reported series represents 1 of the largest in the modern literature, it comes from a single-institution experience, and thus the criteria of ICU admissions and discharge may be influenced not only by clinical factors but also by structural conditions and triage pressure.

Conclusions

A GPS of 2 effectively predicts prolonged ICU length of stay in patients undergoing pneumonectomy for lung cancer. The GPS may be used as an economical easy-to-determine tool to select patients needing postoperative ICU

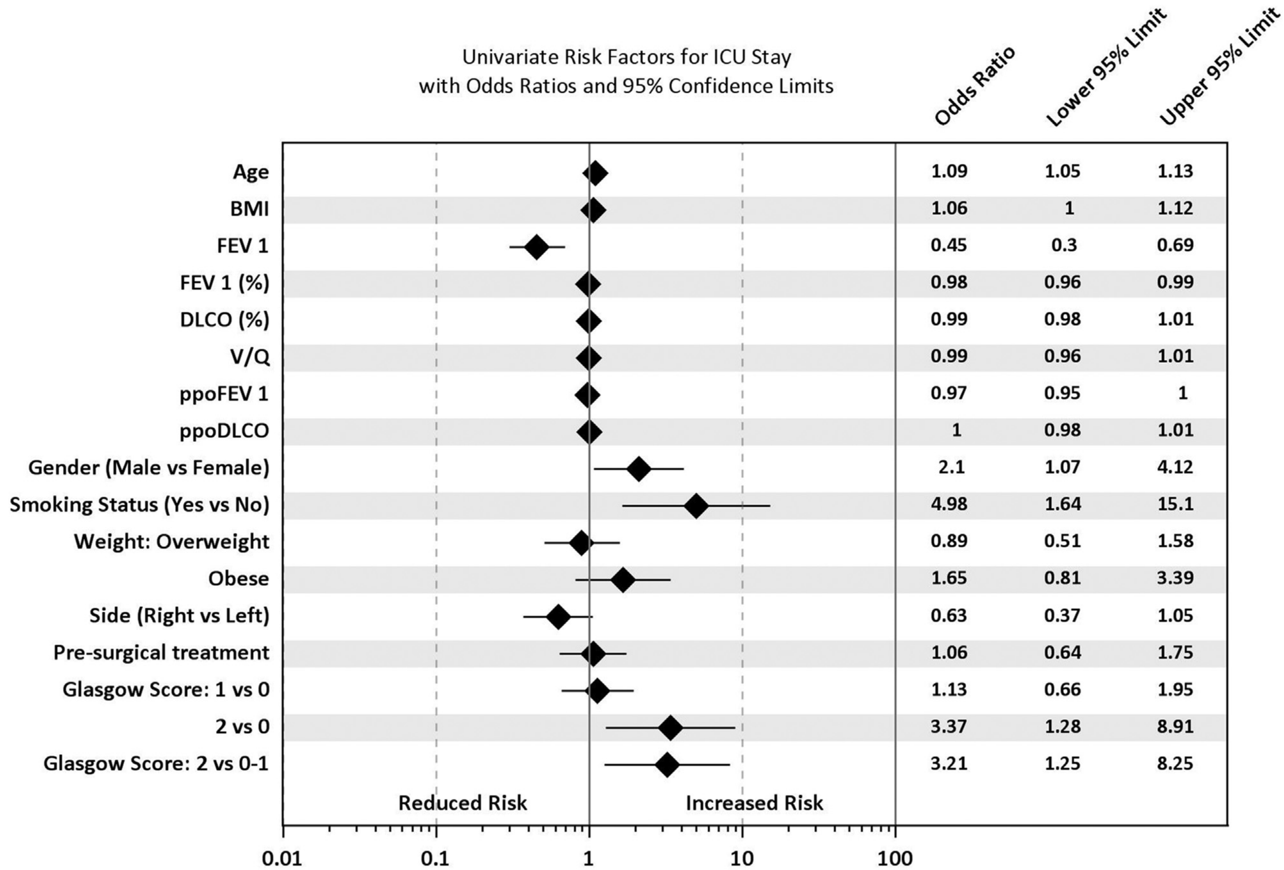

Fig 1. Multivariate risk estimates for intensive care unit (ICU) stay. (BMI = body mass index; DLCO = diffusing capacity of lung for carbon monoxide; FEV_1 = forced expiratory volume in the first second of expiration; ppo = predicted post operative; V/Q = ventilation/perfusion.)

admission and prolonged care and to optimize the allocation of ICU resources in high-volume thoracic surgical centers. Further studies are required to extend the use of the GPS as a prognostic tool for all major lung resections.

References

1. Proctor MJ, Morrison DS, Talwar D, et al. An inflammation-based prognostic score (mGPS) predicts cancer survival independent of tumour site: a Glasgow inflammation Outcome Study. Br J Cancer 2011;104:726–34.
2. Forrest LM, McMillan DC, McArdle CS, Angerson WJ, Dunlop DJ. Evaluation of cumulative prognostic scores based on the systemic inflammatory response in patients with inoperable non-small cell lung cancer. Br J Cancer 2003;89:1028–30.
3. Forrest LM, McMillan DC, McArdle CS, Angerson WJ, Dunlop DJ. Comparison of an inflammation-based prognostic score (GPS) with performance status (ECOG) in patients receiving platinum-based chemotherapy for inoperable non-small cell lung cancer. Br J Cancer 2004;90:1704–6.
4. Brown DJF, Milroy R, Preston T, McMillan DC. The relationship between an inflammation-base prognostic score (Glasgow Prognostic Score) and changes in serum biochemical variables in patients with advanced lung and gastrointestinal cancer. J Clin Pathol 2007;60:705–8.
5. Roxburgh CS, McMillan DC. Role of systemic inflammatory response in predicting survival in patients with primary operable cancer. Future Oncol 2010;6:149–63.
6. Clarke SJ, Chua W, Moore M, et al. Use of inflammatory markers to guide cancer treatment. Clin Pharmacol Ther 2011;90:475–8.
7. McMillan DC. The systemic inflammation-based Glasgow Prognostic Score: a decade of experience in patients with cancer. Cancer Treat Rev 2013;39:534–40.
8. Leo F, Solli P, Veronesi G, et al. Does chemotherapy increase the risk of respiratory complications after pneumonectomy? J Thorac Cardiovasc Surg 2006;132:519–23.
9. Charlson ME, Pompei P, Ales KL, Mackenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373–83.
10. Chang SH, Krupnick AS. Perioperative antibiotics in thoracic surgery. Thorac Surg Clin 2012;22:35–45.
11. Ivanovic J, Al-Hussaini A, Al-Shehab D, et al. Evaluating the reliability and reproducibility of the Ottawa Thoracic Morbidity and Mortality classification system. Ann Thorac Surg 2011;91:387–93.
12. Brunelli A, Ferguson MK, Rocco G, et al. A scoring system predicting the risk for intensive care unit admission for complications after major lung resection: a multicenter analysis. Ann Thorac Surg 2008;86:213–8.
13. Parker A, Wyatt R, Ridley S. Intensive care services; a crisis of increasing expressed demand. Anaesthesia 1998;53:113–20.
14. Halpern NA, Bettes L, Greenstein R. Federal and nationwide intensive care units and healthcare costs: 1986-1992. Crit Care Med 1994;22:2001–7.
15. Deslauriers J, Ginsberg RJ, Piantadosi S, Fournier B. Prospective assessment of 30-day operative morbidity for surgical resections in lung cancer. Chest 1994;106(6 Suppl):329S–30S.

16. Stéphan F, Boucheseiche S, Hollande J, et al. Pulmonary complications following lung resection: a comprehensive analysis of incidence and possible risk factors. Chest 2000;118:1263–70.
17. Okiror L, Patel N, Kho P, et al. Predicting risk of intensive care unit admission after resection for non-small cell lung cancer: a validation study. Interact Cardiovasc Thorac Surg 2012;14:31–3.
18. Fair allocation of intensive care unit resources. American Thoracic Society. Am J Respir Crit Care Med 1997;156(4 Pt 1): 1282–301.
19. Thomas PA, Berbis J, Falcoz PE, EPITHOR Group. National perioperative outcomes of pulmonary lobectomy for cancer: the influence of nutritional status. Eur J Cardiothorac Surg 2014;45:652–9.
20. Petrella F, Radice D, Borri A, et al. The impact of preoperative body mass index on respiratory complications after pneumonectomy for non-small-cell lung cancer. Results from a series of 154 consecutive standard pneumonectomies. Eur J Cardiothorac Surg 2011;39:738–44.
21. Alifano M, Mansuet-Lupo A, Lococo F, et al. Systemic inflammation, nutritional status and tumor immune microenvironment determine outcome of resected non-small cell lung cancer. PLoS One 2014;9:e106914.
22. Pinato DJ, Shiner RJ, Seckl MJ, Stebbing J, Sharma R, Mauri FA. Prognostic performance of inflammation-based prognostic indices in primary operable non-small cell lung cancer. Br J Cancer 2014;110:1930–5.
23. Alifano M, Falcoz PE, Seegers V, et al. Preresection serum C-reactive protein measurement and survival among patients with resectable non-small cell lung cancer. J Thorac Cardiovasc Surg 2011;142:1161–7.
24. Allin KH, Bojesen SE, Nordestgaard BG. Baseline C-reactive protein is associated with incident cancer and survival in patients with cancer. J Clin Oncol 2009;27:2217–24.
25. Kawashima M, Murakawa T, Shinozaki T, et al. Significance of the Glasgow Prognostic Score as a prognostic indicator for lung cancer surgery. Interact Cardiovasc Thorac Surg 2015;21:637–43.
26. Miyazaki T, Yamasaki N, Tsuchiya T, et al. Inflammation-based scoring is a useful prognostic predictor of pulmonary resection for elderly patients with clinical stage I non-small cell lung cancer. Eur J Cardiothorac Surg 2015;47:e140–5.
27. Tomita M, Ayabe T, Chosa E, Nakamura K. Prognostic significance of pre- and postoperative Glasgow prognostic score for patients with non-small cell lung cancer. Anticancer Res 2014;34:3137–40.
28. Zhou T, Hong S, Hu Z, Hou X, et al. A systemic inflammation-based prognostic scores (mGPS) predicts overall survival of patients with small-cell lung cancer. Tumour Biol 2015;36:337–43.