Risk factors of pulmonary complications after minimally invasive surgery for elderly patients with vertebral compression fractures

Hua-Xing Zhang
Graduate school of Hebei Medical University and Hebei General Hospital

Yong Shen (shenyonghbgh2018@126.com)
The Third Affiliated Hospital of Hebei Medical University

Jia Chen
Hebei General Hospital

Long Zhang
Hebei General Hospital

Wei Lin
Graduate School of Hebei Medical University

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Abstract

Purpose: To determine the risk factors for pulmonary complications after minimally invasive surgery in elderly patients with vertebral compression fractures (VCFs).

Methods: We retrospectively analyzed 233 elderly patients (age ≥ 65 years) with VCFs who underwent percutaneous vertebroplasty (PVP) or percutaneous kyphoplasty (PKP) surgery at Hebei General Hospital from January 2011 to December 2016 . Risk factors and the effects of the model were determined by univariate logistic regression analyses and the receiver operating characteristic (ROC) curve, respectively. A risk assessment scale was established based on the risk factors and physiological and surgical scores for mortality and morbidity. The risk assessment scale prospectively evaluated risk factors of pulmonary complications after minimally invasive surgery for elderly patients with VCFs from January to June 2017.

Results: A total of 27 patients diagnosed with pulmonary complications (11.59%) among 233 detected patients. There were statistically significant differences in age, body mass index (BMI), smoking, cardiovascular diseases and old fractures between patients with and without pulmonary complications ($P<0.05$). Logistic regression analysis showed that smoking, cardiovascular diseases and old fractures were risk factors of pulmonary complications after PVP or PKP for elderly patients with VCFs ($P<0.05$) and area under the curve was 0.738 (95% confidence intervals (CI): 0.648-0.828). We assessed 53 elderly patients with VCFs, 5 of whom occurred pulmonary complications after PVP or PKP. Areas under the curve of preoperative and total risk assessment values were all 0.925.

Conclusions: Significant risk factors of pulmonary complications were BMI, cardiovascular diseases and old fractures for patients aged 65 years or elderly with VCFs after minimally invasive surgery. The risk assessment scale established by us gaining high accuracy.

Introduction

Patients with vertebral compression fractures (VCFs) would have a marked decrease in quality of life, for suffering persistent pain from the fractures. VCFs mostly affect the elderly, particularly females [1]. Elderly patients (aged 65 years or elderly) have a significantly increased risk of postoperative infection, of which pulmonary complications are particularly common in clinical treatment [2, 3]. More underlying diseases, bigger trauma after spinal surgery and longer operation time are all risk factors for increased incidence of postoperative pulmonary complications [4–6]. The occurrence of postoperative pulmonary complications significantly increased the in-hospital morbidity and mortality, as well as prolonged hospitalization, increased costs, and compromised quality of life [5, 7–10].

A previous research by Michael J. Lee et al has observed that age and surgical invasiveness were significant risk factors for patients who underwent spine procedures and developed complications during perioperative period [6]. Specialists believed that quantitative indicators based on these risk factors can help clinicians to stratify the risk of perioperative complications in patients undergoing spinal surgery. After stratifying the risk factors, measures of prevention and treatment of perioperative complications

were determined. All of these results could be used to establish prediction models whereby the probability of a postoperative complication can be predicted for each patient who undergoes spine surgery [6, 10].

Percutaneous vertebroplasty (PVP) and percutaneous kyphoplasty (PKP) are minimally invasive methods of treating VCFs. PVP is used to stabilize the fracture through injecting polymethylmethacrylate (PMMA) into the vertebral body. PKP use a balloon to raise the vertebral body height firstly and then inject PMMA. A systematic review suggested that minimally invasive surgery decreased blood loss, operative time, and complication rates in comparison to standard open spine surgery [11]. PVP and PKP are two preferred ways for elderly patients in VCFs surgery, for the benefits of smaller trauma and shorter needed time [12–14]. Pulmonary complications after minimally invasive surgery had also been reported. For example, complications of pulmonary embolism (PE), infection and paraplegia would occur after PVP and PKP [15–17]. However, the risk factors of pulmonary complications after minimally invasive surgery for elderly patients with VCFs have not been reported and no risk assessment table established.

Therefore, elderly patients (age≥65 years) with VCFs, treated by PVP or PKP at Hebei general hospital from January 2011 to December 2016, were included in this study. Univariate and binary logistic regression analyses were used to determine risk factors of pulmonary complications after minimally invasive surgery for elderly patients with VCFs, which were determined for the first time in our study. A risk assessment scale for such patients attempted to be established based on the relevant literatures and our findings. The risk assessment scale is efficient for doctors and nurses to assess the risk of postoperative pulmonary complications.

Patients And Methods

Patients

The research was approved by the ethics committee of Hebei general Hospital (NO. 201821). Written informed consent was obtained from all individual participants. We retrospectively collected the clinical data of patients who were treated with PVP or PKP at Hebei general hospital from January 2011 to December 2016. Inclusion criteria were as follows: 1) aged 65 years or elderly; 2) patients fulfilled the follow-up no less than one year after surgery; 3) patients with VCFs; 4) diagnosed by PVP or PKP surgery. The exclusion criteria were as follows: 1) patients with severe pulmonary disease before operation; 2)were diagnosed with combining fractures in other parts; 3) had incomplete data; 4) were younger than 65 years.

Risk factors

Gender, age, BMI (body mass index), smoking, alcohol abuse, diabetes, cardiovascular diseases, prior spine surgery, surgical procedure, surgical site, surgical levels, old fractures, preoperative hospitalization days, hospitalization days and grade of visual analogue score (VSA) were used to analyze the risk factors

of pulmonary complications after minimally invasive surgery for elderly patients with VCFs. The duration of old fractures are defined as three weeks and more.

Establishment of the risk assessment scale

A risk assessment scale about elderly patients (age ≥ 65 years) with VCFs after treating by PVP or PKP surgery was established based on physiological and surgical scores for mortality and morbidity as well as our finding [7] (*Table 3)*. Assessment indicators included age, BMI smoking duration, the number of combined diseases, duration of VCFs, bed rest duration. The highest score was 19 of all these indicators (*Table 3)*.. Preoperative hospitalization days, type of anesthesia, duration of operation would also be involved in postoperative evaluation. Each index owned scores which is separated by three level, 1 point, 2 point and 3 point, respectively. The highest total score is 28 points (*Table 3)*.. A total of 53 elderly patients with VCFs were enrolled in the study to test the accuracy of the risk assessment scale. Inclusion criteria: 1) age ≥ 65 years; 2) patients with VCFs who would be treated with PVP or PKP; 3) in general good condition; 4) patients without bedridden. Exclusion criteria: 1) patients with severe pulmonary disease before operation; 2) combining with fractures other than the spine 3) requiring other operations.

Statistical Analysis

Statistical analysis was performed using SPSS 21.0 (IBM). Continuous variables were expressed as means ± standard deviation and analyzed by independent samples T test. χ^2 test was used for categorical and discrete variables. Risk factors were searched by unconditional binary logistic regression, which were independent variables with univariate analysis of P<0.05, and the dependent variables were with or without pulmonary complication. The ROC curve was used to evaluate the effect of the logistic regression model. P value of less than 0.05 was considered significant.

Results

A total of 249 patients were considered in this study. A number of 13 patients with severe pulmonary disease before operation and 3 patients without following up were excluded. Finally, a total of 233 patients were included in this retrospective study, among which 27 patients (11.59%) had pulmonary complications after surgery including pleural effusion in 7 patients and pulmonary infection in 20 patients. The mean age of these 27 patients was 78.89±7.65 years, including 11 females and 16 males. The average age of remaining 206 patients (88.41%) without pulmonary complications was 75.56±6.62 years, including 148 females and 58 males. There were statistically significant differences in age, BMI, smoking, cardiovascular diseases, old fractures between patients with and without pulmonary complications (P<0.05) (*Table 1)*..

Meaningful factors (age, BMI, smoking, cardiovascular diseases, old fractures) and risk factors (smoking and age) considered by clinical experts were added to unconditional binary logistic regression analysis. Logistic regression analysis showed that BMI, cardiovascular diseases and old fractures were risk factors of pulmonary complications after PVP or PKP surgery for elderly patients with VCFs. ($P<0.05$) (*Table 2)*.. Area under the receiver operating characteristic curve (AUC) can be used to measure the reliability of the model, with values close to 1.0 indicating high diagnostic accuracy [6, 18]. AUC was 0.738 (95% CI: 0.648–0.828) (*Fig 1)* which meant the indicators listed above were reliability.

Based on the relevant literatures referred to Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity (POSSUM) [6, 19] and our finding, we established a risk assessment table for such patients (*Table 3)*.. There were 9 evaluation indicators including preoperative and postoperative evaluation indicators. Age, BMI, smoking duration, number of combined diseases, duration of vertebral compression fractures and bed rest duration were preoperative evaluation indicators. Preoperative hospitalization days, type of anesthesia and duration of operation were postoperative evaluation indicators. Each index scored 1, 2 and 3 points respectively. The highest total score was 28 (*Table 3)*.. We assessed 53 elderly patients with VCFs from January to June 2017, pulmonary complications occurred in 5 patients after PVP or PKP (3 patients with pleural effusion and 2 patients with pulmonary infection) (*Table 4)*. Three of the five patients with pulmonary complications were male and two were female. The ages ranged from 94 to 72, with an average age of 84.6. Nine of the 48 patients without pulmonary complications were male and 39 were female. The ages ranged from 90 to 65, with an average age of 74.3. Risk assessment table was used to assess the specific values (*Table 4)*.. Above data were analyzed by ROC curve and the area under the curve could evaluate the accuracy of the assessment. Area under the curve of preoperative and total risk assessment values were all 0.925, which revealed the evaluation with high accuracy (*Fig 2–3)*.. Risk assessment values suggested that patients with preoperative assessment scores more than 10.5 or total over 14.5 had a high risk of complications (*Table 5–6)*..

Discussion

The World Health Organization has found that VCFs are the most common type of osteoporotic fractures, which mainly affect the elderly. A previous study has estimated that at least 700,000 people in the United States suffered from osteoporotic VCFs every year [20]. In recent years, about 20 million patients are prone to affecting osteoporotic VCFs [21]. The prevalence of VCFs in China increased from 15% in 50 years old to 36.6% among women aged 80 years or elderly [22, 23]. VCFs would cause severe pain and confine spin activity and decrease quality of life. Treatments for VCFs include both nonsurgical and surgical treatment. Nonsurgical treatment of VCFs includes the administration of anti-osteoporotic drugs, pain control, bed rest, support and physical therapy [1]. However, more than 30% of patients are compelled to be hospitalized due to ineffective nonsurgical treatment. In addition, traditional spinal surgery has been abandoned due to the large trauma site and potentially high incidence of complications [24].

It has been shown that PVP and PKP can effectively stabilize the spine, relieve pain and significantly improve the quality of life [11, 24–26]. PVP is a process of injecting bone cement into the fractured vertebra under local anesthesia, which is performed under the guidance of fluoroscopy. A disposable bone biopsy needle or trocar is inserted into the vertebral body for operation through the safe path under imaging guiding. PKP, an improvement of PVP, uses an expandable bone filler to restore the vertebral body to its original height while creating a cavity to be filled with bone cement [27, 28]. PVP and PKP are the preferred treatment for elderly patients with VCFs [24].

Complications such as pulmonary complications after minimally invasive surgery could lead to a straight decline in the survival rate of elderly patients with VCFs [15–17]. Previous studies have showed that obesity was considered as risk factor for pulmonary complications after spinal surgery [2, 29, 30]. Obesity has been illustrated to reduce lung volume and change ventilation pattern, which is more likely to occur in the elderly patients [31]. Obesity was also revealed to be a risk factor of PE after spinal surgery [32]. Patients with hypertension carried greatest risk of complication after spinal surgery [33, 34]. Cardiovascular diseases can lead to a decline in the cardiopulmonary function of patients, which has been validated and correlated with possibility of surgery on patients [35–37]. Pulmonary function of the patients with spinal fractures was significantly reduced, which might be due to the loss of lung volume caused by VCFs, as indicated by previous research [38–40]. We retrospectively evaluated elderly patients (65 years old and elderly) diagnosed with VCFs who underwent PVP or PKP surgery. The incidence of pulmonary complications after surgery reached 11.59% in 233 enrolled patients because of the special study population and strict research criteria. As a result, age, BMI, smoking, cardiovascular diseases and old fractures were significantly different between patients with and without pulmonary complications. We found that elderly average age and higher average BMI were observed in patients with pulmonary complications compared to those without. Most of patients with pulmonary complications harbor old fractures, smoke, or have cardiovascular diseases. Logistic regression analysis showed that BMI, cardiovascular diseases and old fractures were risk factors of pulmonary complications following PVP or PKP surgery for elderly patients with VCFs. Area under the ROC curve was 0.738, which supported the accuracy of the logistic regression model. Moreover, the risk assessment table obtained desirable accuracy (AUC = 0.925) which was used to prospectively evaluate the risk of pulmonary complications in elderly patients with VCFs from January to June 2017. Risk assessment values suggested that patients with preoperative assessment scores more than 10.5 or total above 14.5 had a higher risk of pulmonary complications.

Patients with VCFs would suffer different degrees of back pain. Patients generally choose conservative treatment within the range of tolerance. Pain caused by fractures could limit the patients' physical activities, and subsequently affect the respiratory movement of their lungs [38]. When the fracture time is more than three weeks, delayed union or nonunion of fractures and even necrosis of vertebral body may occur. Patients with VCFs, especially elderly patients, are more likely to develop pulmonary infection if they stay in bed, as well as further increasing pulmonary complications after surgery.

This study has several limitations. Firstly, our data were retrospectively collected in a single center. Therefore, selection bias might lead to an unavoidable. Secondly, we excluded the patients who had severe pulmonary disease before operation in order to avoid confounding factors. However, some other potential risk factors, such as operative duration, technical level of the operator, the type of compression fractures and so on, were not taken into consideration in this study due to incomplete medical records. In addition, surgeons' familiarity with surgical indications may affect the incidence of pulmonary complications. Furthermore, the sample sizes in this study are relatively small, and further study with a larger number of samples is warranted. These limitations notwithstanding, the risk factors of pulmonary complications after minimally invasive surgery for elderly patients with VCFs were determined for the first time in our study. Furthermore, the risk assessment table could help doctors and nurses assess the risk of postoperative pulmonary complications.

In conclusion, targeted prevention interventions should be used to prevent pulmonary complications after minimally invasive surgery for elderly patients with VCFs, in order to comprehensively manage risk factors in the perioperative period. In our research, BMI, cardiovascular diseases and old fractures were defined significant risk factors of pulmonary complications. The established risk assessment scale could help prospectively evaluated risk factors of pulmonary complications after minimally invasive surgery for elderly patients with VCFs.

Declarations

Ethics approval and consent to participate: Hebei General Hospital Ethics Committee approved this study, and all participants signed an approved informed-consent form. We also obtained consent to publication of their medical data, including medical records, photographs, and images. All procedures were performed in accordance with the World Medical Association's Declaration of Helsinki.

Consent to Publish: All of participants were given written informed consent.

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Authors' contributions: Hua-Xing Zhang and Yong Shen conceived the design and wrote the manuscript. Hua-Xing Zhang, Jia Chen, Long Zhang provided study materials or patients. Hua-Xing Zhang, Jia Chen collected and assembly the data. Hua-Xing Zhang and Wei Lin analyzed and interpreted the data. All the authors have read and approved the final manuscript.

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References

1.Kim DH, Vaccaro AR: Osteoporotic compression fractures of the spine; current options and considerations for treatment. *Spine Journal* 2006, 6(5):479–487.

2.Schoenfeld AJ, Carey PA, Iii AWC, Bader JO, Bono CM: Patient factors, comorbidities, and surgical characteristics that increase mortality and complication risk after spinal arthrodesis: a prognostic study based on 5,887 patients. *Spine Journal* 2013, 13(10):1171–1179.

3.Memtsoudis SG, Vougioukas VI, Yan M, Gaber-Baylis LK, Girardi FP: Perioperative morbidity and mortality after anterior, posterior, and anterior/posterior spine fusion surgery. *Spine* 2011, 36(22):1867–1877.

4.Cotton BA, Pryor JP, Chinwalla I, Wiebe DJ, Reilly PM, Schwab CW: Respiratory complications and mortality risk associated with thoracic spine injury. *Journal of Trauma-Injury Infection & Critical Care* 2005, 59(6):1400.

5.Masuda K, Chikuda H, Yasunaga H, Hara N, Horiguchi H, Matsuda S, Takeshita K, Kawaguchi H, Nakamura K: Factors affecting the occurrence of pulmonary embolism after spinal surgery: data from the national administrative database in Japan. *Spine Journal* 2012, 12(11):1029–1034.

6.Lee MJ, Konodi MA, Cizik AM, Bransford RJ, Bellabarba C, Chapman JR: Risk factors for medical complication after spine surgery: A multivariate analysis of 1,591 patients. *Spine* 2012, 12(3):197–206.

7.Guyot JP, Cizik A, Bransford R, Bellabarba C, Lee MJ: Risk factors for cardiac complications after spine surgery. *Evidence-Based Spine-Care Journal* 2010, 1(02):26–33.

8.Bohl DD, Mayo BC, Massel DH, Iantorno SE, Ahn J, Basques BA, Grauer JN, Singh K: Incidence and Risk Factors for Pneumonia Following Posterior Lumbar Fusion Procedures: An ACS-NSQIP Study. *Spine* 2016, 41(12):1058–1063.

9.Bohl DD, Ahn J, Rossi VJ, Tabaraee E, Grauer JN, Singh K: Incidence and risk factors for pneumonia following anterior cervical decompression and fusion procedures: an ACS-NSQIP study. *Spine Journal* 2016, 16(3):335–342.

10.Fineberg SJ, Matthew O, Patel AA, Kern S: Incidence, risk factors, and mortality associated with aspiration in cervical spine surgery. *Spine* 2013, 38(19):1189–1195.

11.Molina CA, L. GZ, M. SD: A Systematic Review of the Current Role of Minimally Invasive Spine Surgery in the Management of Metastatic Spine Disease. *Int J Surg Oncol* 2011, 2011(2090–1402):598148.

12.Ren H, Shen Y, Zhang Y-z, Ding W-y, Xu J-x, Yang D-l, Cao J-m: Correlative Factor Analysis on the Complications Resulting From Cement Leakage After Percutaneous Kyphoplasty in the Treatment of Osteoporotic Vertebral Compression Fracture. *Journal of Spinal Disorders & Techniques* 2010, 23(7):e9.

13.Fribourg D, Tang C, Sra P, Delamarter R, Bae H: Incidence of Subsequent Vertebral Fracture after Kyphoplasty. *Spine* 2004, 29(20):2270–2276.

14.Lavelle WF, Cheney R: Recurrent fracture after vertebral kyphoplasty. *Spine Journal* 2006, 6(5):488–493.

15.Chen H-L, Wong C-S, Ho S-T, Chang F-L, Hsu C-H, Wu C-T: A Lethal Pulmonary Embolism During Percutaneous Vertebroplasty. *Anesthesia & Analgesia* 2002, 95(4):1060–1062.

16.Olmos MA, González AS, Clemente JD, Tomé CV: Infected Vertebroplasty Due to Uncommon Bacteria Solved Surgically: A Rare and Threatening Life Complication of a Common Procedure. *Spine* 2006, 31(20):770–773.

17.Lee BJ, Lee SR, Yoo TY: Paraplegia as a Complication of Percutaneous Vertebroplasty With Polymethylmethacrylate: A Case Report. *Spine* 2002, 27(19):419–422.

18.Rosner B, Tworoger S, Qiu W: Correcting AUC for Measurement Error. *Journal of biometrics & biostatistics* 2015, 6(5).

19.Imposti F, Cizik A, Bransford R, Bellabarba C, Lee MJ: Risk factors for pulmonary complications after spine surgery. *Evid Based Spine Care J* 2010, 1(2):26–33.

20.Melton LJ: Epidemiology of spinal osteoporosis. *Spine* 1997, 22(22):2S–11S.

21.Hasegawa K,., Homma T,., Uchiyama S,., Takahashi HE: Osteosynthesis without instrumentation for vertebral pseudarthrosis in the osteoporotic spine. *Journal of Bone & Joint Surgery British Volume* 1997, 79(3):452.

22.Mcmillan LB, Zengin A, Ebeling PR, Scott D: Prescribing Physical Activity for the Prevention and Treatment of Osteoporosis in Older Adults. *Healthcare* 2017, 5(4):85.

23.Ling X,., Cummings SR, Mingwei Q,., Xihe Z,., Xioashu C,., Nevitt M,., Stone K,. Vertebral fractures in Beijing, China: the Beijing Osteoporosis Project. *Journal of Bone & Mineral Research the Official Journal of the American Society for Bone & Mineral Research* 2010, 15(10):2019–2025.

24.Tang H, Zhao J, Hao C: Osteoporotic vertebral compression fractures: surgery versus non-operative management. *Journal of Functional Materials* 2007, 39(4):1438.

25.Pasquale DN, Tiziana T, Gianluca P, Pasqualina M: Treatment of painful osteoporotic or traumatic vertebral compression fractures by percutaneous vertebral augmentation procedures: a nonrandomized comparison between vertebroplasty and kyphoplasty. *Clinical Journal of Pain* 2007, 23(5):425–430.

26.J Brian G, Mark K, Chin PC, Yan Z, Robert S: Comparing pain reduction following kyphoplasty and vertebroplasty for osteoporotic vertebral compression fractures. *Chinese Journal of Osteoporosis* 2009,

10(4):583–590.

27.Phillips FM, Erling H, Marion CH, Thomas MN, Wetzel F, Todd, Pernendu G: Early radiographic and clinical results of balloon kyphoplasty for the treatment of osteoporotic vertebral compression fractures. *Spine* 2003, 28(19):2265–2267.

28.Ledlie JT, Renfro M: Balloon kyphoplasty: one-year outcomes in vertebral body height restoration, chronic pain, and activity levels. *Journal of Neurosurgery* 2003, 98(1):36–42.

29.Kalanithi PA, Arrigo R, Boakye M: Morbid obesity increases cost and complication rates in spinal arthrodesis. *Spine* 2012, 37(11):982–988.

30.Yang R, Wu Y, Yao L, Xu J, Zhang S, Du C, Chen F: Risk factors of postoperative pulmonary complications after minimally invasive anatomic resection for lung cancer. *Therapeutics and clinical risk management* 2019, 15:223–231.

31.Mancuso P: Obesity and lung inflammation. *Journal of Applied Physiology* 2010, 108(3):722–728.

32.De lGRR, Goodwin CR, Abu-Bonsrah N, Jain A, Miller EK, Huang N, Kebaish KM, Sponseller PD, Sciubba DM: Patient and operative factors associated with complications following adolescent idiopathic scoliosis surgery: an analysis of 36,335 patients from the Nationwide Inpatient Sample. *J Neurosurg Pediatr* 2016, 25(6):1–7.

33.Hsueh-Lin C, Chih-Shung W, Shung-Tai H, Fang-Lin C, Che-Hao H, Ching-Tang W: A lethal pulmonary embolism during percutaneous vertebroplasty. *Anesthesia & Analgesia* 2002, 95(4):1060–1062.

34.Lee MJ, Konodi MA, Cizik AM, Weinreich MA, Bransford RJ, Carlo B, Jens C: Risk factors for medical complication after cervical spine surgery: a multivariate analysis of 582 patients. *Spine* 2012, 12(3):197–206.

35.Ufoaroh CU, Ele PU, Anyabolu AE, Enemuo EH, Emegoakor CD, Okoli CC, Umeh EO, Anyabolu EN: Pre-operative pulmonary assessment and risk factors for post-operative pulmonary complications in elective abdominal surgery in Nigeria. *African health sciences* 2019, 19(1):1745–1756.

36.Agostini PJ, Lugg ST, Adams K, Smith T, Kalkat MS, Rajesh PB, Steyn RS, Naidu B, Rushton A, Bishay E: Risk factors and short-term outcomes of postoperative pulmonary complications after VATS lobectomy. *Journal of cardiothoracic surgery* 2018, 13(1):28.

37.Strøm C, Rasmussen LS, Steinmetz J: Practical Management of Anaesthesia in the Elderly. *Drugs & Aging* 2016, 33(11):765–777.

38.Gangi A, Sabharwal T, Fg, Buy X, Morales J, Adam A: Quality assurance guidelines for percutaneous vertebroplasty. *Cardiovascular & Interventional Radiology* 2006, 29(2):173–178.

39.Ross PD: Clinical consequences of vertebral fractures. *American Journal of Medicine* 1997, 103(2A):30S.

40.Schlaich C, Minne HW, Bruckner T, Wagner G, Gebest HJ, Grunze M, Ziegler R, Leidig-Bruckner G: Reduced Pulmonary Function in Patients with Spinal Osteoporotic Fractures. *Osteoporosis International* 1998, 8(3):261–267.

Tables

Table 1. Univariate analysis of related factors between patients with and without pulmonary complications.

Risk Factors	Patients with pulmonary complications (n=27)	Patients without pulmonary complications (n=206)	Odds Ratio	95% CI	p-value
Gender					
Male	11	58	1.754	0.768-4.005	0.178
Female	16	148			
Age	78.89±7.65	75.56±6.62		0.606-6.046	0.017
BMI	25.19±2.84	23.56±3.05		0.397-2.841	0.01
Smoking					
Yes	11	47	2.326	1.010-5.354	0.043
No	16	159			
Alcohol abuse					
Yes	4	35	0.85	0.277-2.610	0.992
No	23	171			
Diabetes					
Yes	6	36	1.349	0.508-3.580	0.736
No	21	170			
Cardiovascular diseases					
Yes	19	99	2.567	1.075-6.128	0.029
No	8	107			
Prior spine surgery					
Yes	5	58	0.58	0.210-	0.289

				1.604	
No	22	148			
Surgical procedure					
PKP	9	47	1.691	0.713-4.012	0.229
PVP	18	159			
Surgical site					
Thoracic	11	86			0.78
Lumbar	13	105			
Thoracic + Lumbar	3	15			
Lumbar Lumbar Lumbar					
Surgical levels					
1	22	151	1.603	0.579-4.440	0.361
≥2	5	55			
Elderly fractures					
Yes	7	20	3.255	1.226-8.643	0.031
No	20	186			
Preoperative hospitalization days					
	2.85±3.49	1.92±1.72		-0.470-2.329	0.185
Total Hospitalization days					
	5.59±4.72	5.79±6.49		-2.741-2.354	0.881
Grade of VSA					
≤5	22	158	1.337	0.480-	0.577

						3.7119
□5	5		48			

CI: confidence intervals; BMI: body mass index; PKP: percutaneous kyphoplasty; PVP: percutaneous vertebroplasty; VSA: visual analogue scor

Table 2. Unconditional binary logistic regression analysis of risk factors for pulmonary complications.

Risk Factors	β	OR	95% CI	Standardized error	Wald χ^2	P-value
BMI	1.032	2.807	1.14-6.94	0.462	4.999	0.025
Cardiovascular diseases	1.622	5.065	1.72-14.88	0.550	8.710	0.003
Elderly fractures	1.214	3.368	1.45-7.83	0.431	7.951	0.005

CI: confidence intervals; BMI: body mass index

Table 3. Risk assessment scale of pulmonary complications after minimally invasive surgery for elderly patients with VCFs.

Stage	Items	Grading rules and scores			Score
		1	2	3	
Preoperative assessment	1. Age (years)	65-74	75-84	≥85	
	2. BMI	18-23	24-29	≥30, □ 18	
	3. Smoking duration (years)	□10	11-20	≥21	
	4.1 The number of combined diseases (DM, Chronic cardiovascular and cerebrovascular diseases)	1	2	≥3	
	4.2 Suffering from chronic pulmonary diseases	Yes			
	5. Duration of VCFs (days)	≤7 days	8-20	≥21	
	6. Bed rest duration (days)	≤7 days	8-20	≥21	
	Preoperative assessment scores				
Postoperative assessment	7. Preoperative hospitalization days	1	2	≥3	
	8. Type of anesthesia	Local	Spinal	General	
	9. Duration of operation (minutes)	□30	□60	□90	
Total scores					

BMI: body mass index; DM: diabetes mellitus

Table 4. Scores of 53 patients assessed by assessment table

Whether pneumonia occurs		Pulmonary complications (5 cases)	No pulmonary complications (48 cases)
Gender	Male	3	9
	Female	2	39
Age (years)	65-74	1	28
	75-84	2	14
	≥85	2	6
BMI	18-23	1	12
	24-29	4	34
	≥30, □18	0	2
Smoking duration (years)	No smoking	2	36
	□10	0	6
	10-20	3	1
	≥21	0	5
The number of combined diseases	1	0	12
(DM, Chronic cardiovascular	2	2	12
	3	0	6
and cerebrovascular diseases)	≥3	3	7
Suffering from chronic pulmonary diseases	Yes	3	2
Duration of vertebral compression fractures	≤7 days	1	20
(days)	7-20	1	17
	≥21	3	11
Bed rest duration (days)	≤7 days	3	41
	7-20	0	7
	≥21	2	0
Preoperative hospitalization days	1	2	25
	2	0	10
	≥3	3	13

Type of anesthesia	Local anesthesia	5	48
	Spinal anesthesia	0	0
	General anesthesia	0	0
Duration of operation (minutes)	30 minutes	3	39
	60 minutes	2	9
	90 minutes	0	0

Table 5. Test result variable(s): Preoperative risk assessment values

Positive if Greater Than or Equal To[a]	Sensitivity	1 - Specificity
3.00	1.000	1.000
4.50	1.000	0.979
5.50	1.000	0.917
6.50	1.000	0.667
7.50	1.000	0.479
8.50	1.000	0.396
9.50	1.000	0.250
10.50	1.000	0.167
11.50	0.600	0.083
12.50	0.200	0.042
14.00	0.200	0.000
16.00	0.000	0.000

The test result variable(s): Preoperative has at least one tie between the positive and negative actual state groups.

a: The smallest cutoff value is the minimum observed test value minus 1, and the largest cutoff value is the maximum observed test value plus 1. All the other cutoff values are the averages of two consecutive ordered observed test values.

Table 6. Test result variable(s): Total risk assessment values

Positive if Greater Than or Equal To[a]	Sensitivity	1 - Specificity
6.00	1.000	1.000
7.50	1.000	0.979
8.50	1.000	0.938
9.50	1.000	0.750
10.50	1.000	0.625
11.50	1.000	0.479
12.50	1.000	0.396
13.50	1.000	0.292
14.50	1.000	0.229
15.50	0.800	0.146
16.50	0.600	0.063
17.50	0.200	0.021
18.50	0.200	0.000
20.00	0.000	0.000

The test result variable(s): Total has at least one tie between the positive and negative actual state groups.

a. The smallest cutoff value is the minimum observed test value minus 1, and the largest cutoff value is the maximum observed test value plus 1. All the other cutoff values are the averages of two consecutive ordered observed test values.

Figures

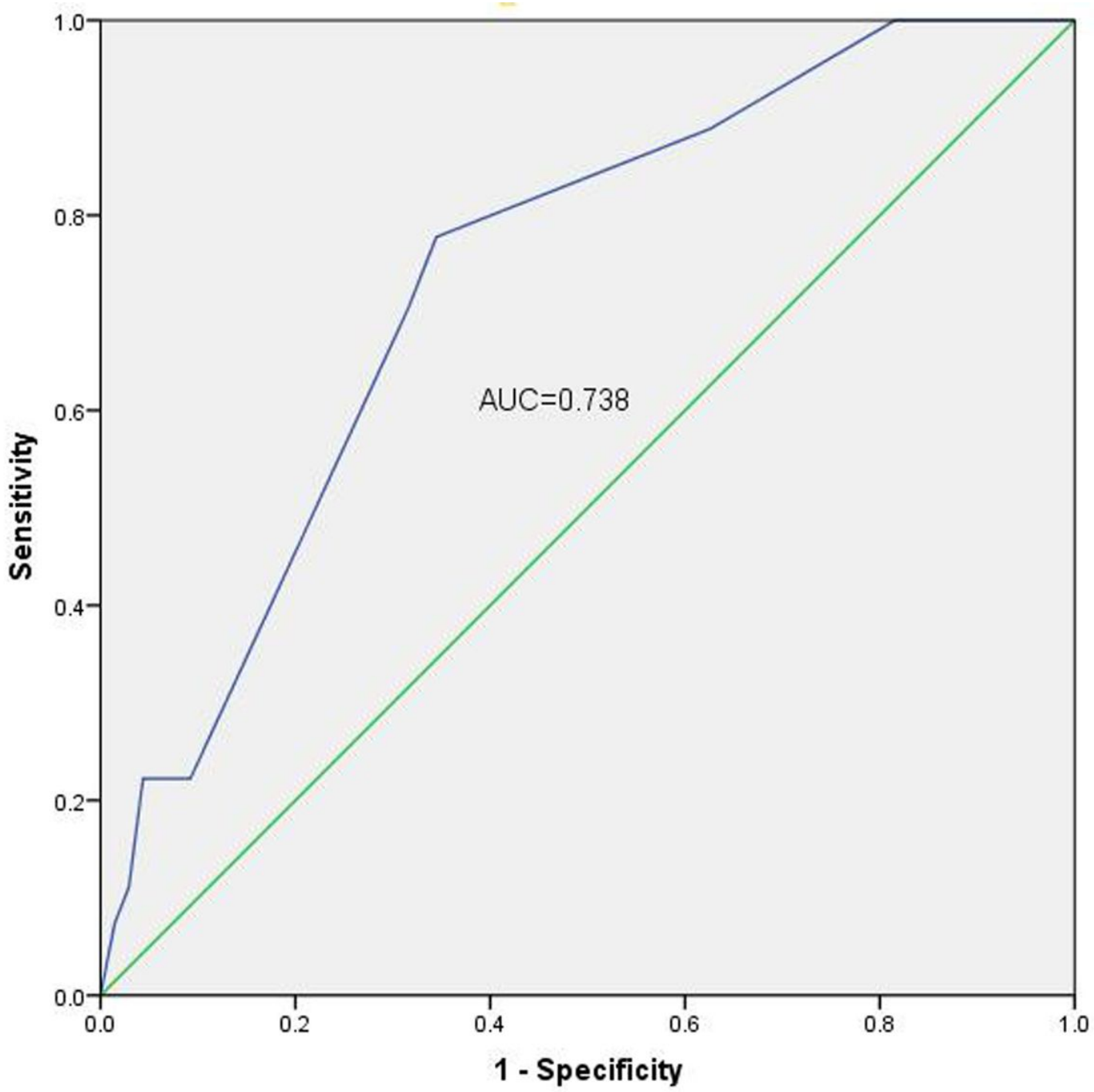

Figure 1

Area under the curve of the predicted meaningful and risk factors.

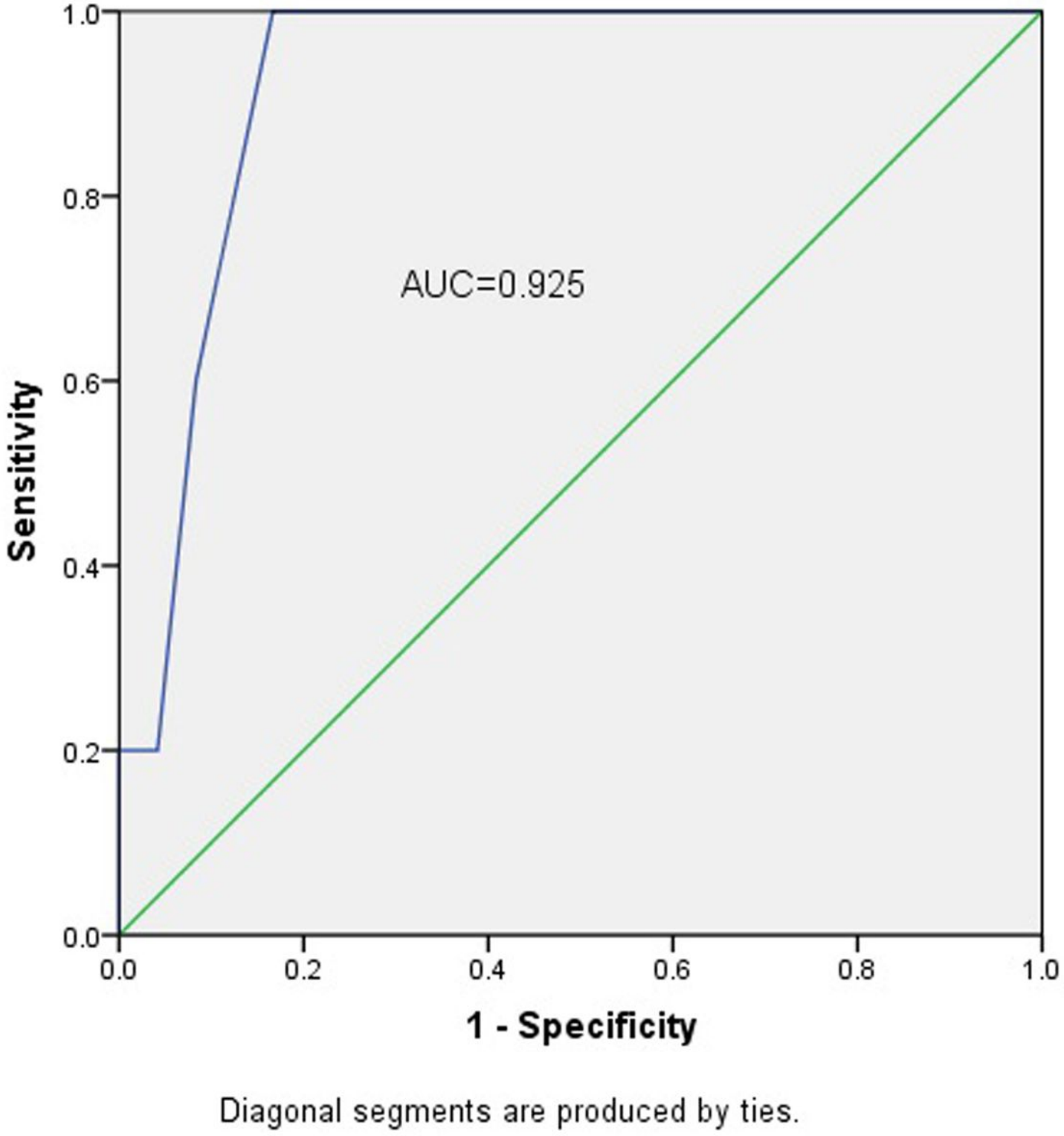

Figure 2

Area under the curve of preoperative risk assessment values.

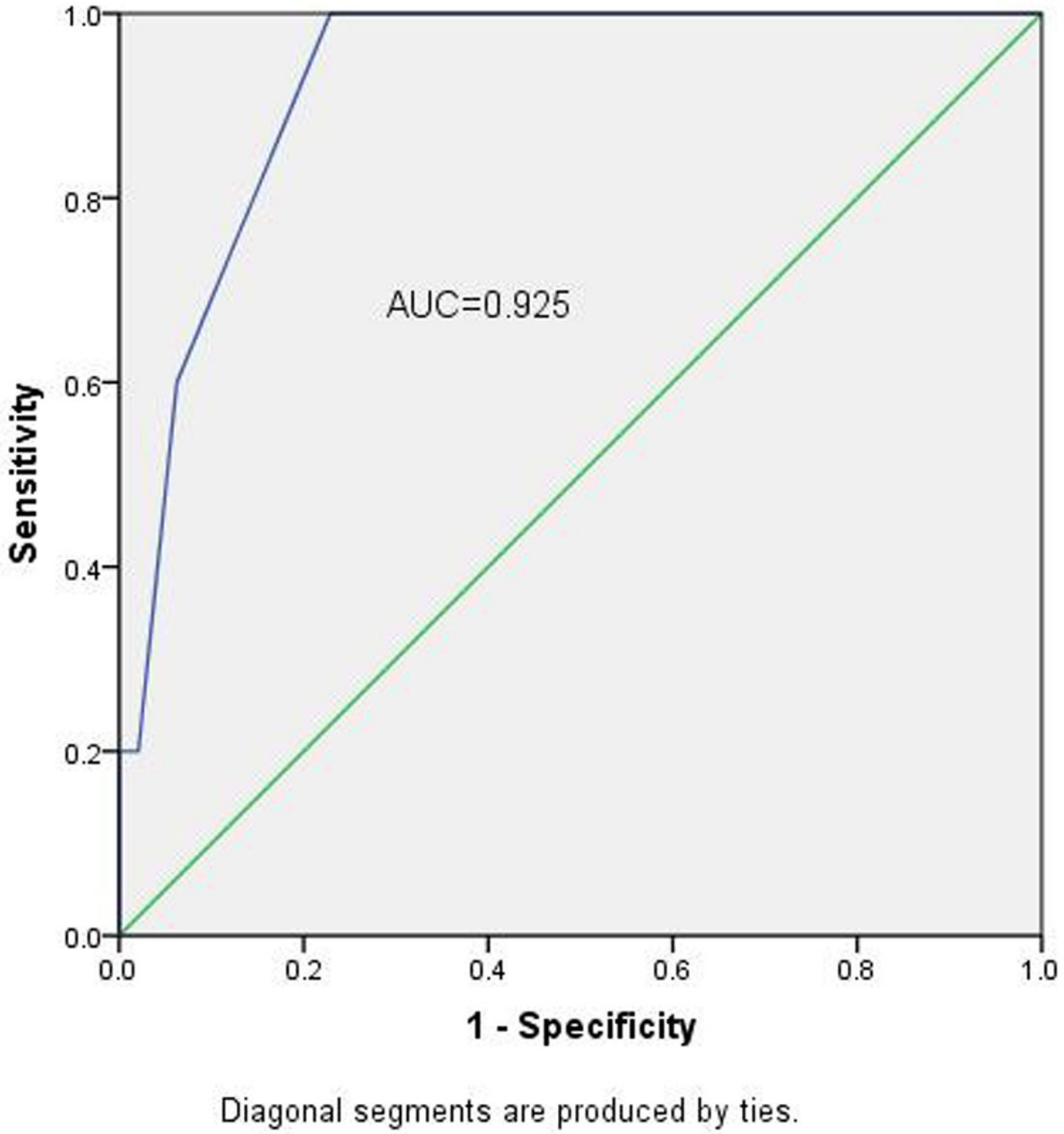

Figure 3

Area under the curve of total risk assessment values.