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Original Article

Risk factors for low back pain following percutaneous vertebroplasty in patients with osteoporotic vertebral compression fracture

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Abstract: Objective: To investigate the occurrence and risk factors for low back pain post-percutaneous vertebroplasty (PVP) in osteoporotic vertebral compression fractures (OVCF) patients. Methods: A retrospective analysis was conducted of 148 OVCF patients treated from March 2020 to 2023. The incidence of low back pain post-PVP was recorded, and logistic regression analysis was used to identify associated risk factors. Results: Low back pain occurred in 34 out of 148 patients (22.97%). Logistic regression identified age (>75) (P=0.039), number of fractured vertebrae (≥2) (P=0.004), presence of lumbar spine comorbidity (P=0.019), emotional status (P=0.006), site of fracture (P=0.006), and preoperative fascial injury (P=0.039) as independent risk factors influencing the development of low back pain after PVP in OVCF patients. Receiver operating characteristic (ROC) curve analysis showed that age (>75), number of fractured vertebrae (≥2), lumbar spine comorbidities, and site of fracture had area under the curve (AUC) values of 0.626, 0.614, 0.623, and 0.667, respectively, in predicting low back pain post-PVP. Conclusion: Age, number of fractured vertebrae, presence of lumbar spine comorbidities, emotional status, site of fracture, and preoperative fascial injury are significant independent risk factors for the occurrence of low back pain after PVP in patients with OVCF. These findings are crucial for alleviating postoperative low back pain and provide valuable insight for postoperative pain management.

Keywords: Percutaneous vertebroplasty, low back pain, risk factors, osteoporotic vertebral compression fracture

Introduction

Osteoporotic vertebral compression fractures (OVCF) are a common skeletal disorder predominantly affecting the elderly, characterized by decreased bone density and bone thinning [1]. This condition often results in vertebral fractures under stress [2]. The primary symptom of OVCF is severe back pain, typically accompanied by restricted movement, postural changes, and height loss [3, 4]. Additionally, patients may exhibit pathologic alterations such as vertebral collapse, narrowing of intervertebral spaces, and abnormal spinal curvature [5, 6].

The primary goal in treating OVCF is to alleviate pain, restore function, and prevent subsequent fractures. Treatment approaches include conservative management and interventional procedures [7, 8], such as percutaneous vertebroplasty (PVP) [9, 10] and percutaneous balloon kyphoplasty (PBK) [11, 12]. PVP, in particular, has been extensively used in managing OVCF,

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demonstrating significant effectiveness in pain relief, spinal stability restoration, and functional improvement [13, 14].

Despite these benefits, some OVCF patients experience low back pain following PVP, presenting new challenges to their recovery and quality of life [15, 16]. Thus, exploring the incidence and risk factors for low back pain post-PVP holds significant clinical relevance.

The necessity and novelty of this study stem from its focus on the specific issue of low back pain following PVP in OVCF patients. While PVP is a prevalent treatment option, comprehensive research on the incidence and risk factors of low back pain post-PVP remains limited. Previous studies have often provided broader assessments of pain relief and functional recovery without detailed analysis of these specific outcomes. This research seeks to address these gaps, offering insight that may optimize treatment strategies for OVCF patients undergoing PVP.

Therefore, the objectives of this study are to assess the occurrence of low back pain in OVCF patients post-PVP and to identify its risk factors, aiming to provide insight for developing postoperative pain management strategies and rehabilitation programs.

Materials and methods

Study cohort

This retrospective study was conducted at Dongying People's Hospital and approved by its Medical Ethics Committee. The medical records of patients with OVCF treated between March 2020 and 2023 were reviewed. Records included basic personal information, pathologic findings, radiological results, laboratory data, and follow-up details.

A total of 220 OVCF patients sought treatment during the study period. The inclusion criteria were: (1) Patients diagnosed with OVCF who underwent PVP [17]. (2) Age 65 years or older. (3) Fractures located between T11-L5. (4) No history of lumbar spine surgery. (5) Pain originating from somatic referred pain or non-radicular pain. (6) Absence of spinal tumors, infections, or other complicating diseases. (7) Low back pain not accompanied by pain in two or more other locations.

The exclusion criteria were: (1) Incomplete clinical data. (2) Pain in areas other than the low back. (3) Radicular symptoms. (4) Spinal tumors. (5) Extraspinal spinal cord disorders. (6) Infections. (7) Other diseases. Ultimately, 148 patients met these criteria and were included in the study.

Study variables

Patient records were analyzed to identify covariates such as age, gender, cement leakage, number of fractured vertebrae, body mass index (BMI), lumbar spine comorbidities, emotional status, site of fracture, and preoperative fascial injury. The variables were defined as follows: (1) Age: recorded in years at the time of treatment. (2) Gender: male or female. (3) Cement leakage: presence or absence. (4) Number of fractured vertebrae: one or more. (5) BMI: calculated from weight and height at the time of treatment. (6) Lumbar spine comorbidities: presence or absence. (7) Emotional status: classified as anxiety or normal. (8) Site of fracture: T11-L1 or L2-L5. (9) Preoperative fascial injury: presence or absence.

Statistical analysis

The analysis used percentages (%) to express the proportional relationship among different groups. The chi-square test (χ^2) determined significant differences in categorical data. Logistic regression was employed to identify risk factors for low back pain following PVP in OVCF patients. A significance level of $P<0.05$ was used. Data analysis was performed using GraphPad Prism 8 and SPSS 20.0, facilitating visual presentation of results and trends. The predictive value of independent risk factors was assessed using receiver operating characteristic (ROC) curve analysis.

Results

Sample collection process

After the initial screening, a total of 148 patients met the study criteria and were included for retrospective analysis (**Figure 1**).

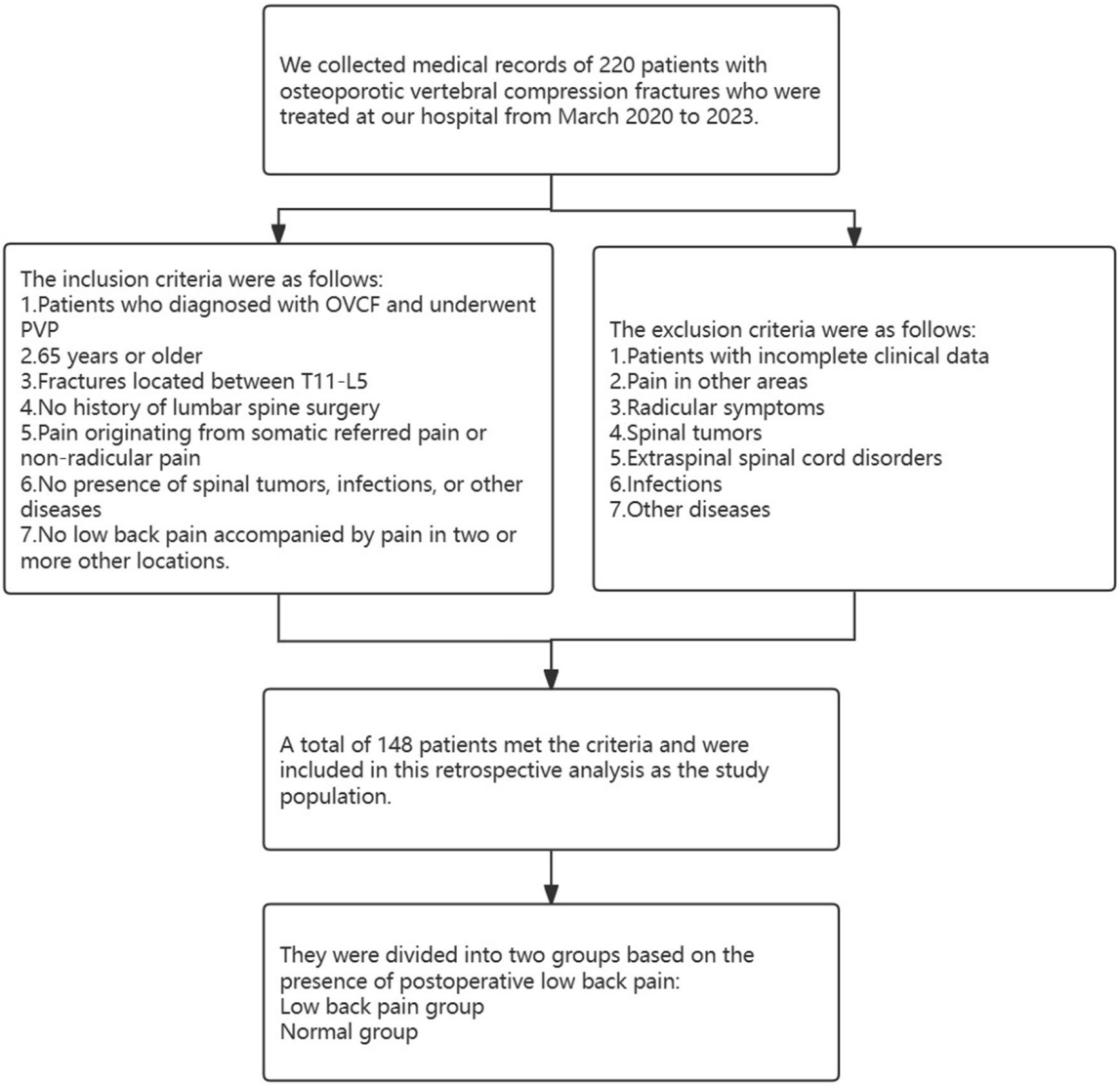

Figure 1. Flow chart. OVCF, Osteoporotic vertebral compression fractures; PVP, percutaneous vertebroplasty.

Step I: Collection: We collected the medical records of 220 patients with osteoporotic vertebral compression fractures who were treated at Dongying People's Hospital from March 2020 to 2023.

Step II: Screening: The study included patients aged 65 years or older who were diagnosed with osteoporotic vertebral compression fractures, underwent percutaneous vertebroplasty (PVP), and had fractures located between T11 and L5. Patients with a history of lumbar spine surgery, incomplete clinical data, pain in other areas, radicular symptoms, spinal tumors, spinal cord disorders, infections, or other diseases were excluded.

Step III: Sample confirmation: A total of 148 patients met these criteria and were included in this retrospective analysis.

Step IV: Grouping: The patients were divided into two groups based on the presence of postoperative low back pain: Low back pain group; Normal group.

Proportion of patients with low back pain

The patients were categorized based on the occurrence of low back pain after PVP surgery. Of the total, 34 patients experienced low back pain after PVP, representing 22.97% of the study population and were categorized as the

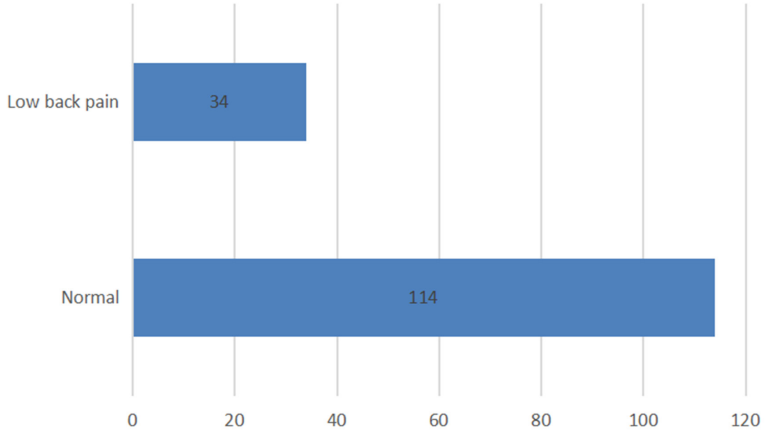

Figure 2. Proportion of patients with low back pain. Alt text: This bar chart illustrates the proportion of patients experiencing low back pain after PVP surgery. PVP, percutaneous vertebroplasty.

low back pain group. The remaining 114 patients did not experience low back pain post-surgery, constituting 77.03% of the total, and were the normal group (**Figure 2**).

Univariate analysis

The analysis and comparison of basic characteristics between the two groups revealed no significant differences in gender, bone cement leakage, or BMI (P>0.05). However, significant differences were observed in age, number of fractured vertebrae, lumbar spine comorbidities, emotional status, fracture location, and preoperative fascial injury. These factors were identified as significant risk factors influencing the occurrence of low back pain in patients with OVCF after PVP (P<0.05, **Table 1**).

Logistic regression analysis

Logistic regression analysis was performed with low back pain as the dependent variable and age, number of fractured vertebrae, lumbar spine comorbidities, emotional status, fracture location, and preoperative fascial injury as the covariates (**Table 2**).

Multivariate analysis

A multivariate logistic regression analysis was conducted to identify the risk factors influencing the occurrence of low back pain in patients with OVCF after PVP. The analysis identified age (>75), number of fractured vertebrae (≥2), lumbar spine comorbidities, emotional status, fracture location, and preoperative fascial injury as independent risk factors (**Table 3**).

Predictive value of independent risk factors

ROC curve analysis was used to evaluate the predictive value of the identified risk factors. The area under the curve (AUC) values for age (>75), number of fractured vertebrae (≥2), lumbar spine comorbidities, emotional status, fracture site, and preoperative fascial injury were 0.626, 0.614, 0.623, 0.376, 0.667, and 0.381, respectively. Sensitivity values were 51.75%, 64.04%, 57.02%, 0.00%, 57.02%, and 0.00% respectively, while specificity values were 73.53%, 58.82%, 67.65%, 100.00%, 76.47%, and 100.00% respectively (**Table 4** and **Figure 3**).

Discussion

Osteoporosis is a skeletal disorder characterized by diminished bone tissue quality and density, resulting in brittle and fragile bones, which are more susceptible to fracture [18, 19]. This condition impairs the bone's ability to withstand compressive forces, thereby increasing the likelihood of fractures under minimal stress [20, 21]. Compression fractures, a frequent complication of osteoporosis, most commonly affect the spinal vertebrae, particularly in the thoracic and lumbar regions [22, 23]. The reduced bone density and subsequent bone loss from osteoporosis render these bones prone to compression fractures during normal activities or even minor external forces [24]. Such fractures can exacerbate osteoporosis progression; deformation and instability of the fractured vertebrae alter load distribution, increasing pressure on adjacent vertebrae and heightening the risk of further fractures [25-27]. This vicious cycle can lead to multiple vertebral fractures, significantly worsening the patient's pain and functional impairment.

PVP is a minimally invasive treatment known for its abbreviated recovery time and reduced surgical trauma, often resulting in substantial pain relief shortly after the procedure for many

Table 1. Univariate analysis

Factors	Low back pain group (34)		Normal group (114)		χ^2	P
	Number of cases	Percentage	Number of cases	Percentage		
Age					6.741	0.009
≤75	25	73.53%	55	48.25%		
>75	9	26.47%	59	51.75%		
Sex					0.007	0.930
Female	26	76.47%	88	77.19%		
Male	8	23.53%	26	22.81%		
Bone cement leakage					0.015	0.902
Yes	8	23.53%	28	24.56%		
No	26	76.47%	86	75.44%		
Number of fractured vertebrae					5.648	0.018
1	14	41.18%	73	64.04%		
≥2	20	58.82%	41	35.96%		
Body mass index (BMI)					0.553	0.457
≤24	14	41.18%	39	34.21%		
>24	20	58.82%	75	65.79%		
Lumbar spine comorbidities					6.377	0.012
Yes	23	67.65%	49	42.98%		
No	11	32.35%	65	57.02%		
Emotional status					6.544	0.011
Anxiety and depression	26	76.47%	59	51.75%		
Normal	8	23.53%	55	48.25%		
Site of fracture					11.75	0.001
T_{11}-L_1	8	23.53%	65	57.02%		
L_2-L_5	26	76.47%	49	42.98%		
Preoperative fascia injury					6.749	0.009
Yes	29	85.29%	70	61.40%		
No	5	14.71%	44	38.60%		

Table 2. Assignments

Assignment		
Covariate		
Age	>75=1	≤75=0
Number of fractured vertebrae	≥2=1	1=0
Lumbar spine comorbidities	Yes =1	No =0
Emotional status	Anxiety and depression =1	Normal =0
Site of fracture	L_2-L_5=1	T_{11}-L_1=0
Preoperative fascia injury	Yes =1	No =0
Dependent variable		
Low back pain	Yes =1	No =0

patients [28, 29]. However, some patients may experience low back pain post-PVP, a potential complication that can impact their recovery and quality of life. This study aimed to investigate the occurrence of low back pain in patients with OVCF post-PVP and to analyze risk factors.

In our study, the results revealed that 34 out of 148 patients (22.97%) experienced low back

Table 3. Multivariate analysis

	B	S.E.	Wals	Sig.	Exp (B)	95% C.I. for EXP (B)
Age (>75)	1.036	0.501	4.27	0.039	2.817	1.055-7.523
Number of fractured vertebrae (≥2)	1.441	0.506	8.129	0.004	4.227	1.569-11.385
Lumbar spine comorbidities	1.138	0.484	5.523	0.019	3.120	1.208-8.060
Emotional status	1.490	0.541	7.597	0.006	4.438	1.538-12.806
Site of fracture	1.397	0.505	7.658	0.006	4.045	1.503-10.882
Preoperative fascia injury	1.196	0.579	4.261	0.039	3.305	1.062-10.285

Table 4. Predictive value of independent risk factors

	AUC	Confidence interval (CI)	Sensitivity	Specificity	Youden index
Age (>75)	0.626	0.538-0.715	51.75%	73.53%	25.28%
Number of fractured vertebrae (≥2)	0.614	0.519-0.709	64.04%	58.82%	22.86%
Lumbar spine comorbidities	0.623	0.531-0.715	57.02%	67.65%	24.67%
Emotional status	0.376	0.291-0.462	0.00%	100.00%	0.00%
Site of fracture	0.667	0.582-0.753	57.02%	76.47%	33.49%
Preoperative fascia injury	0.381	0.305-0.456	0.00%	100.00%	0.00%

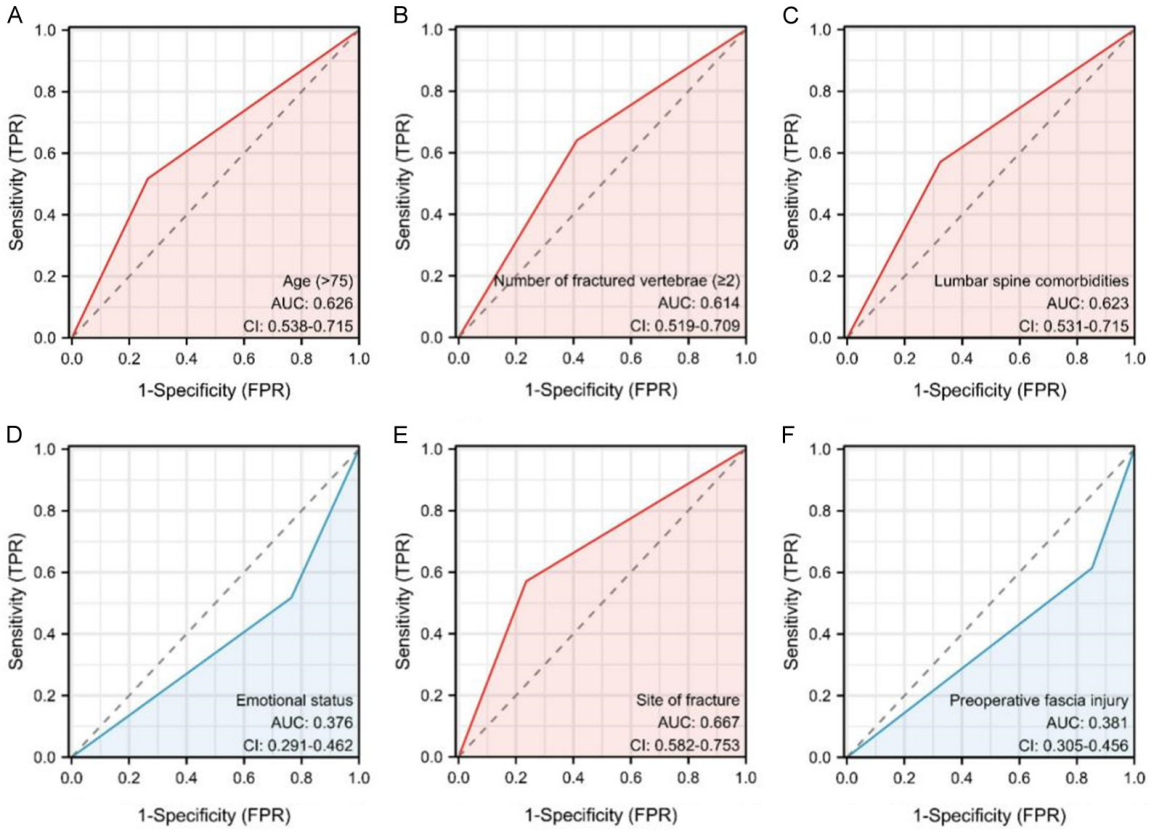

Figure 3. Predictive value of independent risk factors. A: ROC curve for age (>75) for predicting low back pain. B: ROC curve for the number of fractured vertebrae (≥2) for predicting low back pain. C: ROC curve for lumbar spine comorbidities for predicting low back pain. D: ROC curve for emotional status for predicting low back pain. E: ROC curve for site of fracture for predicting low back pain. F: ROC curve for preoperative fascia injury for predicting low back pain.

pain after PVP. Logistic regression analysis identified age (>75), number of fractured vertebrae (≥2), lumbar spine comorbidities, emotional status, fracture location, and preoperative fascial injury as independent risk factors.

The analysis highlighted that the greater the number of fractured vertebrae, the higher the risk of experiencing low back pain. This relationship is attributed to the nature of PVP, where each vertebral fracture requires targeted intervention, thus increasing the scope and complexity of the surgical procedure. Patients with multiple fractures undergo longer and more extensive surgeries, which can lead to greater trauma and an increased inflammatory response in the surrounding tissues. Furthermore, multiple fractures raise the possibility of cement leakage, which can irritate peripheral nerve endings and induce low back pain. Although PVP aims to stabilize and enhance vertebral structure, surgical interventions involving multiple vertebral bodies may significantly alter the mechanical characteristics of the spine. This alteration can affect load distribution on the facet joints and surrounding soft tissues, possiblyincreasing the risk of low back pain.

The presence of lumbar spine comorbidities, such as lumbar disc herniation, is closely associated with postoperative low back pain. After PVP, patients often require rehabilitation and a gradual resumption of activities to aid in recovery. However, lumbar spine comorbidities can complicate the rehabilitation process. For instance, a lumbar disc herniation may compress nerve roots, causing pain and restricted mobility, thereby exacerbating inflammation triggered by the treatment of fractured vertebral bodies during surgery [30].

In addition to lumbar spine comorbidities, this study identified other significant factors influencing the occurrence of low back pain, including age, unstable emotional status, the site of fracture (thoracic or lumbar vertebrae), and preoperative fascial injury. An unstable emotional state, such as anxiety, depression, or stress, can heighten the perceived level of postoperative pain, complicating pain management and rehabilitation. Furthermore, the fascia-connective tissue covering muscles and bones - plays a crucial role in maintaining tissue structure and function. Pre-existing fascial injuries related to fractures can increase the risk of postoperative low back pain [31].

Wang et al.'s study corroborates these findings, identifying low bone mineral density, multiple vertebral fractures, and posterior fascial injury as independent risk factors for residual back pain post-PVP [32]. Posterior fascial injury may lead to chronic pain through disruption of the muscular and fascial structures supporting the spine, causing persistent inflammation and nerve irritation.

This study also presents limitations due to its retrospective nature, such as the inability to control all intervention factors and potential bias from individual patient differences. A future study with a larger sample sizes and a prospective design is recommended to further elucidate the impact of these risk factors on postoperative low back pain.

In conclusion, age, number of fractured vertebrae, presence of lumbar spine comorbidities, emotional status, fracture site, and preoperative fascial injury are significant independent risk factors for low back pain post-PVP in patients with OVCF. Recognizing these risk factors early allows clinicians to predict postoperative low back pain and tailor preoperative assessment and intraoperative intervention accordingly. By managing these risk factors effectively, we can optimize rehabilitation outcomes and improve patients' quality of life.

Disclosure of conflict of interest

None.

Abbreviations

OVCF, Osteoporotic vertebral compression fracture; PVP, Percutaneous Vertebroplasty; PBK, Percutaneous Balloon Kyphoplasty; BMI, Body Mass Index; ROC, Receiver operator characteristic.

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