Predictors associated with perioperative blood transfusion and intraoperative blood loss in thoracolumbar tuberculosis

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Research article

Abstract

Background During operation on thoracic and lumbar tuberculosis infection, patients can lose a significant amount of blood and receive a perioperative blood transfusion. However, the risk factors were not identified for increased intraoperative blood loss and perioperative blood transfusion. The aim of this retrospective study is to determine the predictors associated with perioperative blood transfusion and intraoperative blood loss in thoracolumbar tuberculosis. Methods From 2008 to 2018, 336 patients who met the inclusion criteria were enrolled in the study. The predictors of allogenic blood transfusion were identified in a univariate and multivariate logistic regression analysis. Univariate and multivariate linear regression was attempted to investigate the factors influencing intraoperative blood loss. Results Altogether, 336 adult patients with thoracic and lumbar tuberculosis were included in this study. The mean patient age was 49.6 ± 15.5 (range 14-85) years for those patients. Our data revealed a significant relationship between blood transfusions and female gender, BMI, vertebral collapse/Kyphosis and intraoperative blood loss. Multivariable linear regression analysis revealed that BMI, levels of instrumentation, surgical approach and operative time were independent factors influencing intraoperative blood loss. Conclusions This study identified some clinical predictors for perioperative blood transfusion and intraoperative blood loss in patients undergoing thoracic and lumbar tuberculosis surgery. These results may contribute to preoperative blood transfusion planning and minimize intra- or post-operative complications.

Background

Subacute and chronic spinal infections is usually caused by a wide spectrum of pathogens, of which Mycobacterium tuberculosis is considered the most common.[24] The typical spinal tuberculosis is spondylodiscitis. In the last two decades, there has been a resurgence of tuberculosis in developed countries.[21] However, there are still challenges in the management of spinal tuberculosis.[4,6] Surgical treatment is indicated for those whose infections are resistant to antibiotic therapy or who have bone destruction, kyphosis, neurologic impairment and severe pain[4,5,18,25]. Generally, debridement and bone graft are the surgical procedures of first choice.[16,31]

In spite of advances in surgical techniques, the operation of spinal tuberculosis is still associated with substantial blood loss and many patients need perioperative blood transfusion.[4,27] Owning to tuberculosis is a systemic disease, the use of autologous blood transfusion is not recommended for such patients. In addition to issues regarding shortages and cost, allogeneic blood transfusion can be associated with serious complications and prolonged length of stay in spine surgery.[1,15] Thus, characterizing patients at high risk of intraoperative blood loss and the need for perioperative blood transfusion is an important step to improve postoperative outcomes, reduce complications and minimize health resource utilization.[7,19,20]

To date, few studies have elucidated influencing factors of blood loss during spinal tuberculosis surgery. It is not identified which clinical predictors affect perioperative blood transfusion and blood loss in

patients undergoing debridement and reconstruction procedure. Therefore, the objective of the present study was to identify predictors of perioperative blood transfusion as well as high intraoperative blood loss from our series.

Methods

This study was approved by the university review board. A total number of 336 patients with thoracic and lumbar spinal tuberculosis underwent surgery was identified from two independent hospitals between January 2010 and November 2018. Diagnosis of spinal tuberculosis was based on the following criteria reported previously[9,27]: clinical manifestations, radiological evidence, response to antimicrobial therapy and results of microbiological examination. Indication for surgery including vertebral collapse and spinal instability, severe kyphotic deformity or progressive worsening of kyphosis, spinal cord compression by abscess or necrosis, formation of a hollow or sequestrum or no improvement in antimicrobial therapy. The study population consisted of patients > 18 years old. Patients with recurrence at the lesion site and who underwent deformity surgery without debridement was excluded.

The variables extracted for analysis includes patient age, gender, preoperative hemoglobin, Body mass index (BMI), location of the lesion (thoracic, thoracolumbar, lumbar or lumbosacral spine), vertebral collapse or kyphosis, discitis involved, levels of instrumentation, paraspinal/epidural abscess, surgical approach (anterior, posterior and combined procedure) and operative time, the amount of intraoperative blood loss and allogenic blood transfusion (Table 1). The recorded intraoperative blood loss was obtained from the anesthetist case records which also was confirmed by surgeons. The blood loss was further checked from the electronic records in the institutional database. The amount of blood loss over 30% of total blood volume during surgery was set as the cutoff for high levels of intraoperative blood loss. The total blood volume was calculated according to the previously reported method.[3] [20] The surgical procedures were classified into three categories. The anterior approach was performed by anterior or lateral-anterior debridement, autologous or allograft bone graft and instrumentation. The posterior approach was performed by posterior debridement, autologous or allograft bone graft and instrumentation. The combined approach was performed by posterior instrumentation combined with anterior debridement and autologous or allograft bone graft.

Table 1 Characteristics of the Study Patients

Statistical Analysis

The independent factors used for prognostic modeling analysis were measured on either categorical or continuous variables. The logistic regression model was used in the univariable or multivariable analysis to identify the predictors of perioperative blood transfusion. To estimate the effect of different factors on intraoperative blood loss, both the univariate and multivariate linear regression was exploited. The level

Characteristics	N	%	Mean± SD
Age (Years old)	336		49.5 ± 15.6
Gender			
Male	158	47%	
Female	178	53%	
BMI			22.24 ± 3.69
Preoperative hemoglobin (g/L)			122.04 ± 17.37
Location			
Thoracic	117	34.8	
Thoracolumbar	15	4.5	
Lumbar/Lumbosacral	204	60.7	
Vertebral collapse/Kyphosis			
Without	266	79.4%	
With	69	20.6%	
Abscess (paravertebral or epidural)			
Without	99	29.5	
With	237	70.5	
Levels of instrumentation			
Two	186	55.9%	
Three	67	20.1%	
Four or more	80	24.0%	
Surgical approach			
Anterior	204	60.7%	
Posterior	109	32.4%	
Combined	23	6.8%	
Operative time (min)			244.98 ± 107.51
Intraoperative blood loss			661.37 ± 557.54
Blood transfusion			
Yes	221	34.0%	
No	114	66.0%	

of significance was set at 0.05 in all analyses. Statistical analyses were performed using IBM SPSS statistical software (version 23.0, Armonk, NY, USA).

Table 2 Univariate and Multivariate Logistic Regression Analysis to Identify Predictors of Perioperative Blood Transfusion

Variable	Perioperative Blood Transfusion			
	Univariate analysis		Multivariate analysis	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Age (years)	1.00 (0.99-1.02)	0.797	1.02 (0.98-1.68)	0.233
Gender				
Male	Ref.		Ref.	
Female	1.50 (0.95-2.36)	0.081	4.59 (1.56-13.47)	0.006
Preoperative hemoglobin (g/L)	0.99 (0.98-1.01)	0.791	1.01 (0.98-1.03)	0.455
BMI	0.71 (0.91-1.06)	0.709	0.84 (0.71-0.99)	0.039
Location				
Thoracic	Ref.		Ref.	
Thoracolumbar	0.86 (0.67-1.10)	0.17	4.07 (0.38-44.14)	0.250
Lumbar/Lumbosacral	0.76 (0.47-1.23)	0.26	1.43 (0.50-4.11)	0.501
Vertebral collapse/Kyphosis				
Without	Ref.		Ref.	
With	1.13 (0.64-1.99)	0.673	4.74 (1.34-16.79)	0.016
Discitis				
One	Ref		Ref	
Two	2.02 (1.11-3.70)	0.020	1.00 (0.12-8.73)	0.705
Three or more	2.83 (1.35-5.97)	0.006	1.34 (0.18-10.12)	0.997
Levels of instrumentation				
Two	Ref.		Ref.	
Three	2.37 (1.27-4.41)	0.007	3.92 (0.70-22.15)	0.121
Four or more	4.57 (2.31-8.99)	<0.001	3.27 (0.18-59.30)	0.424
Abscess (paravertebral or epidural)				
Without	Ref.		Ref.	
With	0.96 (0.58-1.57)	0.862	0.48 (0.16-1.41)	0.183
Approach				
Anterior	Ref.		Ref.	
Posterior	1.49 (0.91-2.46)	0.11	0.88 (0.06-14.19)	0.933
Combined	14.3 (1.89-108.26)	0.01	0.92 (0.06-14.47)	0.928
Operative time	1.01 (1.00-1.02)	<0.001	1.00 (0.99-1.01)	0.486
Intraoperative Blood Loss	1.01 (1.01-1.01)	<0.001	1.01 (0.98-1.03)	<0.001

Results

Patient Demographics and Clinical characteristics

A total of 336 patients with thoracic and lumbar tuberculosis who underwent surgery were evaluated for this study. The mean patient age was 49.6 ± 15.5 (range 14-85) years for those patients. There were 178 female and 158 male patients, and the mean preoperative hemoglobin was 122.04 ± 17.37 g/L. Perioperative blood transfusion was received in 66.1 % of the cases. 11.3% of patients (38) had high intraoperative blood loss during surgery. For the entire cohort, the mean intraoperative blood loss was 661.37 ± 557.54 ml. The mean blood loss was 832.13 ± 590.17 ml for the patients who received blood transfusion and 276.75± 187.19 ml for the patients who did not. Table I demonstrates the characteristics of the study patients.

Predictors of perioperative blood transfusion

In univariable regression analysis (Table 2), numbers of involved discitis, levels of instrumentation, surgical approach, operative time and intraoperative blood loss was significantly associated with the perioperative blood transfusion. Furthermore, multivariable logistic regression analysis was performed to adjust for interaction between covariates and revealed the four predictors of allogeneic blood transfusion in the perioperative period (Table 2). The risk of allogenic blood transfusion increased with the female, vertebral collapse/kyphosis, and intraoperative blood loss. Higher levels of BMI decreased the risk of allogeneic blood transfusion in patients.

Factors influencing intraoperative blood loss

Through univariable linear regression analysis (Table 3), BMI, number of involved discitis, levels of instrumentation, surgical approach and operative time was found that correlated to the intraoperative blood loss. Moreover, multivariable linear regression analysis revealed that higher BMI, more levels of instrumentation, combined approach and prolonged operative time were linked to higher intraoperative blood loss (Table 3). The result showed that the amount of blood loss rises by increasing BMI (18.42 mL per $1kg/m^2$ increase) and operative time (2.33 ml per min increase). In patients undergoing combined surgical approach increased the amount of blood loss by 325.78 ml. The amount of intraoperative blood loss was significantly higher in patients with four or more levels of instrumentation (514 ml more)

Table 3 Results of univariate and multivariate analysis to determine intraoperative blood loss among different exposure variables

Discussion

During operation on spinal tuberculosis infection, patients can lose a significant amount of blood, which may result in the patient receiving a blood transfusion. Therefore, it is important to evaluate the different risk factors for increased intraoperative blood loss and perioperative blood transfusion, which potentially can be used for preoperative planning and also for risk stratification to evaluate outcomes.

Through autologous blood transfusion contributed to reduce perioperative blood loss, the fact that spinal tuberculosis or brucellosis is the complication of a systematic disease makes it impossible to perform preoperative autologous blood donation and intraoperative autologous blood transfusion. Several

	Univariate analysis			Multivariate analysis		
Variable	Regression coefficient (b)	95% CI	P	Regression coefficient (b)	95% CI	P
Age (years)	-1.51	-5.34-2.33	0.44			
Gender						
Male	1					
Female	3.30	-116.75-123.36	0.96			
Preoperative hemoglobin (g/L)	1.28	-2.20-4.75	0.47			
BMI	30.24	11.35-49.13	0.002	18.416	0.79-36.04	0.04
Location						
Thoracic	1					
Thoracolumbar	64.86	-225.20-354.92	0.66			
Lumbar/Lumbosacral	-116.91	-238.95-5.14	0.06			
Vertebral collapse/Kyphosis						
Without	1					
With	49.71	-98.55-197.98	0.51			
Discitis						
One	1					
Two	61.06	-85.13-207.26	0.412	-37.62	-285.96-210.72	0.765
Three or more	261.98	98.49-425.48	0.002	-168.55	-437.66-10.55	0.218
Abscess (paravertebral or epidural)	-106.04	-236.98-24.91	0.11			
Approach						
Anterior	1					
Posterior	91.81	-35.80-219.42	0.158	124.82	-3.92-253.55	0.057
Combined	282.30	46.97-517.64	0.019	325.77	87.11-564.43	0.008
Levels of instrumentation						
Two	1					
Three	56.09	-94.10-206.28	0.463	245.11	-17.58-507.81	0.067
Four or more	432.05	298.97-565.14	<0.001	536.54	309.21-763.88	0
Operative time	2.71	2.23-3.18	<0.001	2.33	1.64-3.02	<0.001

previous studies have investigated risk factors associated with risk of transfusion in spine surgical patient populations. In lumbar fusion surgery, ASA>1, prolonged operative time, multilevel fusion, sacrum involvement, and open posterior approach are predictors of transfusion.[19] Similarly, Durand reported operative duration, surgical invasiveness, hematocrit, weight, and age as the most influential variables predicting blood transfusion.[7] In addition, it is reported that preoperative hemoglobin level is an important

predictor of allogenic blood transfusion in perioperative duration for patients underwent surgery. However, through our analysis, preoperative hemoglobin is not a predictor of perioperative blood transfusion for patients with spinal tuberculosis. Our data revealed that preoperative hemoglobin level had a significant correlation with intraoperative high blood loss . A previous study showed that preoperative low hemoglobin level increases the postoperative complications for patients with spinal tuberculosis.[30] In addition, several studies showed that preoperative anemia is associated with poor outcomes after surgery and increased health care use.[8,10] Therefore, correction of preoperative anemia may contribute to improve the outcome in spinal tuberculosis surgery.

Several clinical factors, including the higher number of involved discitis, higher levels of instrumentation and combined surgical approach, was found that corelated to the increased rate of blood transfusion and intraoperative blood loss However, after adjusting for interaction between covariates by multivariate analysis, the influence of these factors was not significant, and only the odds of transfusion increased by 4.5 times for the patients with pathological fracture or kyphosis. The choice of surgical approach was reported to be linked to the intraoperative blood loss.[28,29] Previous studies reported that one-stage anterior operation had advantages when compared to posterior instrumentation, as both instrumentation and grafting are done as single-stage surgery through the same incision, which may minimize total blood loss.[12,29] In contrast, other studies illustrated that posterior approach favors less intraoperative blood loss. This difference may be attributed to the preference and experience of the surgeons. Usually, combined approach often leads to prolonged operative time and more blood loss, which may be associated with significant kyphosis and multiple-level lesion.[22] Furthermore, our investigation revealed that increased operative duration is strongly associated with higher likelihood of blood transfusion and higher amount of blood loss. Four or more levels of instrumentation is also a risk factor of intraoperative high blood loss. In fact, operating time and blood loss are associated with an increase in the number of levels fused or instrumentation in spine surgery.[17,19] Kumar reported results of their review of 243 patients undergoing surgery for metastatic spinal tumors and identified primary tumor, type of surgery, and prolonged surgery time as factors predicting increased blood loss.[17]

Our results showed that female and lower BMI were risk factors for blood transfusion. The possible explanation for the relationship of gender and BMI to blood transfusion is that smaller body size may increases the intraoperative blood loss.[14] In our cohort, the mean age is 49.5 ± 15.6 years old. In North America, Europe and China, tuberculous spondylodiscitis is more commonly seen in adult patients with a mean age of 40 years.[24,26]. It has been reported that advanced age did not increase the morbidity associated with spinal operation.[23] For most patients, robust compensatory mechanisms render hypotension an insensitive indicator of shock until more than 30% of the patient's blood volume has been lost, therefore intraoperative blood loss over 30% of the total blood volume was set as cutoff in this study. Intraoperative cues indicative of intraoperative blood transfusion includes low hematocrit and hemoglobin (<70 g/L), higher heart rate (>120 beats/min), a weak peripheral pulse, cool extremities with pale or mottled skin and so on.[2]

There were several limitations to the study. This was a retrospective study and may have been limited sample size. A multicentered study is still warranted. Almost all the patients in this cohort were spondylodiscitis. Atypical form of spondylitis without disc involvement was not included in this study. There is also a lack of clinical information on commodities, medications, nutritional status and other variables. Tranexamic acid was not applied on patients in this cohort, therefore its effect on spinal tuberculosis surgery was not evaluated. It is reported that tranexamic acid could reduce both intraoperative-perioperative allogeneic transfusion rates and operative time in spinal surgeries.[13] A recent study demonstrated that Tranexamic acid contributes to reduce the drainage and blood transfusion perioperative duration of tuberculosis patients, but it can't decrease intraoperative blood loss.[11] Additionally, the cause of transfusion was not collected, but patients typically get transfused when their hemoglobin is less than 70 g/L and they present a change of symptomatic or vital signs. However, despite such limitations, we believe that we collected several important clinical variables that allowed us to calculate relationships between the evaluated surgeries and blood loss and risk of blood transfusions.

Conclusions

In conclusion, the findings from this study have substantial implications for perioperative management in patients with spinal tuberculosis. The study showed a significant variation in perioperative transfusion based on gender, vertebral collapse/kyphosis, BMI and intraoperative blood loss. Furthermore, the relationship between increased intraoperative blood loss and predictors was identified, including higher BMI, more levels of instrumentation, combined approach and prolonged operative time were linked to higher intraoperative blood loss. An understanding of these factors may contribute to preoperative planning and minimize postoperative complications.

Abbreviations

BMI：Body Mass Index

Declarations

Ethics approval and consent to participate：All subjects were familiarized with the experimental procedure and associated risks and the informed consent obtained from study participants was verbal. Because this study concealed relevant information such as patient's identifiable name, date of birth, contact information, and only retained the patient's gender, age, diagnosis, cause of disease, related auxiliary examination results, related medical history, and treatment effects. Essential information for identity research.This study was approved by The second affiliated Hospital of Haerbin Medical University review board and the committee's reference number is KY2019-246.

Consent for publish: All authors and the patients consent the manuscript for publication.

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