Innovative analysis of predictors for overall survival from systemic non-Hodgkin T cell lymphoma using quantile regression analysis

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Abstract

Background: Non-Hodgkin T/NK cell lymphoma is a rare and widely variable type of lymphoma with the most dismal prognosis. This study aimed to investigate varied impact of the clinical indicators to the overall survival (OS).

Methods: We conducted a retrospective study to identify the non-invasive clinical features of T cell lymphoma that can predict prognosis with an innovative analysis method using quantile regression. A total of 183 patients who visited a top-tier hospital in Beijing, China, were enrolled from January 2006 to December 2015. Demographic information and main clinical indicators were collected including age, erythrocyte sedimentation rate (ESR), survival status, and international prognostic index (IPI) score.

Results: The median age of the patients at diagnosis was 45 years. Approximately 80% of patients were at an advanced stage, and the median survival time after diagnosis was 5.1 months. Multivariable analysis of the prognostic factors for inferior OS associated with advanced clinical staging [HR = 3.16, 95%CI (1.39–7.2)], lower platelet count [HR = 2.57, 95%CI (1.57–4.19), $P < 0.001$] and higher IPI score [HR = 1.29, 95%CI (1.01–1.66), $P = 0.043$]. Meanwhile, T cell lymphoblastic lymphoma [HR = 0.40, 95%CI (0.20–0.80), $P = 0.010$], higher white blood cell counts [HR = 0.57, 95%CI (0.34–0.96), $P = 0.033$], higher serum albumin level [HR = 0.6, 95%CI (0.37–0.97), $P = 0.039$], and higher ESR [HR = 0.53, 95%CI (0.33–0.87), $P = 0.011$] were protective factors for OS when stratified by hemophagocytic lymphohistiocytosis (HLH). Multivariable quantile regression between the OS rate and each predictor at quartiles 0.25, 0.5, 0.75, and 0.95 showed that the coefficients of serum β2-microglobulin level and serum ESR were statistically significant in the middle of the coefficient curve (quartile 0.25–0.75). The coefficient of IPI was negatively associated with OS. The coefficients of hematopoietic stem cell transplantation (HSCT) and no clinical symptoms were higher at the middle of the quartile level curve but were not statistically significant.

Conclusions: The IPI score is a comparatively robust indicator of prognosis at 3 quartiles, and serum ESR is stable at the middle 2 quartiles section when adjusted for HLH. Quantile regression can be used to observe detailed impacts of the predictors on OS.

Keywords: Systemic non-Hodgkin T cell lymphoma; Overall survival; Quantile regression analysis

Introduction

Non-Hodgkin T/NK cell lymphoma is a comparatively rare and widely variable type of lymphoma that has the most dismal prognosis due to different histological subgroups with durable remission and fatal outcome once disseminated.[1,2] Most studies have evaluated prognosis with the international prognostic index (IPI), which is considered the most powerful prediction tool.[3] We propose that the variant clinicopathological features (or clinical characteristics) of these patients, as indicated in clinical observations and records, can be used to predict prognosis, particularly overall survival (OS), but not invasive characteristics. For example, an elevated level of serum β2-microglobulin (β2MG) is a dismal prognostic factor in some patients with Hodgkin lymphoma,[4,5] B cell lymphoma[6,7] and NK/T cell lymphoma.[8] Several studies have shown that higher serum β2MG and lower albumin are predictive of a lower OS rate among patients with Hodgkin lymphoma who are receiving treatment.[4] Among patients with peripheral T cell lymphoma-not otherwise specified (PTCL-NOS), lower hemoglobin, lower albumin and elevated lactate dehydrogenase (LDH) levels are associated with a shorter OS duration.[9,10] Additionally, a higher erythrocyte sedimentation rate (ESR),[11] lower white blood cell (WBC) count[12] and lower platelet count[13] may be associated with the prognosis of B cell lymphoma.[14] However, the above clinical features have rarely been explored in patients with T cell lymphoma. ESR has been reported to be associated

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with Hodgkin lymphoma in children[15] but is seldom reported to be associated with non-Hodgkin T/NK cell lymphoma.

Several previous studies[16–18] have sought to identify such predictors of prognosis and have used general regression methods that may be invalid given some unmet assumptions. Other studies using linear regression, requires a normal distribution of the residuals, as well as homoscedastic.[19] To date, the significant predictive factors for T cell lymphoma have not yet been established. Linear regression is used to model the relationship between a response variable and several predictor variables to estimate the mean value of the response variable for given range of the predictor variables.[20] Other studies have used logistic or Cox regression based on outcome indicator categorization,[21,22] which may cause categories for the determination of cutoff values arbitrarily. Such methods often miss measuring the effect of covariates from the perspective of the whole distribution of the dependent variable.

Compared with logistic or linear regression, quantile regression enables studies of changing directional effects of a covariate on any section of the distribution.[19] Unlike logistic regression, quantile regression considers all the data, thereby avoiding information loss due to arbitrary categorization of response variables. Moreover, quantile regression has more benefits. It's helpful to measure statistical dispersion for a more comprehensive understanding of the relationship between variables, as well the central tendency.[23] Quantile regression has been used to identify predictive relationships between variables, while possible there is a weak association between the means of those variables. Ecologically, quantile regression has the advantage of identifying the complexity of interactions in reality, and it could disentangle the relationship of the data with unequal variation for different ranges of other variables.[24]

Therefore, we aimed to achieve two goals: first, to identify the non-invasive clinical features for T cell lymphoma prognosis prediction; and second, to explore the potential impact of most predictors using an interval of the variant curve with quantile regression, suggesting a comparatively new method in this research area.

Methods

Ethical approval

The study was performed in accordance with the ethical requirement of the Beijing Friendship Hospital Institutional Review Boards (No. 2018-P2-006-01) and complied with the *Declaration of Helsinki*. Patient consent was waived by the Ethics Committee due to the retrospective nature of this study.

Patients

A total of 183 patients with systemic non-Hodgkin T/NK cell lymphoma who were admitted to the Beijing Friendship Hospital from January 2006 to December 2015 and received first-line chemotherapy were enrolled in the study. Among them, 14 angioimmunoblastic T cell lymphoma

(AITL) received bortezomib+CHOP (cyclophosphamide, doxorubicin, vincristine and prednisone) regimen, all NK/T cell lymphoma received an aspargase+CHOP regimen and ten cases of NK/T lymphoma, nasal administrated additionally with radiology. The left cases were given a CHOP regimen. The median of chemotherapy cycles is six in our hospital. There were 87 (47.5%) cases of death.

Among these patients, there were 68 cases of NK/T cell lymphoma (37.2%), 40 cases of AITL, (21.9%), 34 cases of peripheral T cell lymphoma-not otherwise unspecified (PTCL-NOS 18.6%), 20 cases of T cell lymphoblastic lymphoma (T-LBL) (10.9%), eight cases of ALK+ (4.4%) anaplastic large cell lymphoma (ALCL), seven cases of ALK-(3.8%) ALCL, and six cases of subcutaneous panniculitis-like T cell lymphoma (SPTL) (3.3%). Among all patients, 128 patients presented with B symptoms (69.95%). The OS of peripheral T/NK-cell lymphoma and precursor T-cell lymphoma (T-LBL) of the included cases showed no different though two diseases differ in terms of biology and treatment strategy. That justifies our decision to observe the predictors to survival in the same cohort.

Data collection

Three physicians of the research team extracted the clinical information for each patient from medical records and entered the data into a standard clinical datasheet for computerization. Each record included admission No., record No., sex, date of birth, date of last follow-up, living or not, Ann Arbor stage and symptoms at diagnosis. Additional data and laboratory data were recorded, including hemoglobin (Hb), platelet count, WBC count, ESR, serum lactate dehydrogenase, $\beta2MG$, serum Ca^+ level, initial therapy and response, survival status and cause of death. In a few cases, some clinical information was missing due to the condition deteriorated quickly and no further testing.

The diagnosis was established according to the World Health Organization (WHO) 2003 classification (the WHO updated the classification in 2008, but there was no revision or update on T cell lymphoma). It was consistent with the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) as well.

The personally identifiable patient information was removed, and informed consent for possible academic research purpose was obtained from all patients upon admittance.

The OS time was the main outcome indicator and was measured from the date of diagnosis to the date of death or last follow-up. Surviving patients at the last contact date of follow-up were classified as censored.

The continuous variables, such as serum albumin, $\beta2MG$, ESR, and WBC, were primarily categorized by median value; Hb was categorized with a normal range, and Ca+ was categorized by 20th percentile values at a statistically significant cutoff value (Supplementary File 1, http://links.lww.com/CM9/A12).

Statistical analysis

The data were analyzed with SAS 9.4 (SAS Institute Inc., Cary, North Carolina, USA). Non-normally distributed continuous data were presented as the median, interquartile range (IQR), and range. The OS rate was compared between groups using Pearson χ^2 test. The univariate lifetest analysis was calculated by the Kaplan-Meier method to generate the product-limit survival. Multiple Cox regression was performed to identify prognostic factors for OS, and the hazard ratio (HR) was stratified by hemophagocytic lymphohistiocytosis (HLH). We calculated the HR and its 95% confidence interval (CI) with Cox regression. Significant variables in the univariate analyses were considered for inclusion in the multivariable Cox regression model. These values were selected by a stepwise regression with an entry criterion of $P \leq 0.05$ and exit criterion of $P \geq 0.10$.

We computed the regression models and made statistical inferences on the parameters estimation by PROC QUANTREG in SAS 9.4. Quantile regression is a robust method with which to estimate either the conditional median or other quantiles of the response variable. This method does not make a distributional assumption for the errors in modeling and is more robust against outliers in the measurements of dependent variable.[23] The CIs estimation employed the inversion of a rank test with QReg.[19] The regression coefficients of each variable changed over the range of the curve based on other covariates, indicating the different impact on OS. The most clinically relevant impact in different sections of the distribution on OS was detected by a significance testing of the coefficients variation over the different quartiles of the QReg. The response variable OS for each individual variable was considered over the study period. We also considered the quartiles of OS values, and the 25th, 50th, 75th, and 95th percentiles.

Results

The demographic characteristics of the patients are presented in Table 1. Among 183 participants, the median age was 45 years with a range of 12 to 85 years; 127 (69.4%) individuals were male; 163 (89.1%) individuals were diagnosed with peripheral T cell lymphoma; 38 individuals (20.8%) had HLH; 128 (70.0%) patients presented with clinical symptoms at diagnosis; 87 (47.5%) patients died; and 14 (7.6%) individuals underwent hematopoietic stem cell transplantation (HSCT, frontline) (five cases underwent autologous HSCT and nine underwent allogeneic HSCT) [Table 1]. The distribution of follow-up time was highly skewed and the median time of follow-up was 5.0 months, different with the mean as 17.2 months.

Table 2 presents the OS rate stratified by sociodemographic and clinical characteristics. The univariate analysis showed that higher serum albumin level, serum Ca level, ESR, Hb level, WBC count at diagnosis (above median), and platelet count at diagnosis and patients free of HLH were associated with a higher survival rate, whereas lower serum LDH level, lower IPI score and earlier Ann Arbor

Table 1: Clinical characteristics of the patients with systemic non-Hodgkin T/NK cell lymphoma (n=183)

Characteristics	Values
Age (years)	45 (28–61)
Sex	
Male	127 (69.4)
Female	56 (30.6)
Diagnosed with	
PTCL	163 (89.1)
Non-PTCL	20 (10.9)
Had HLH	
Yes	38 (20.8)
No	145 (79.2)
Clinical staging with symptoms	
Yes	55 (30.0)
No	128 (70.0)
Underwent stem cell transplantation	
Yes	14 (7.7)
No	169 (92.3)
Death	
Yes	87 (47.5)
No	96 (52.5)

Values were shown as median (Q1–Q3) or n (%). HLH: Hemophagocytic lymphohistiocytosis; PTCL: Peripheral T cell lymphoma.

clinical stage were associated with a higher survival rate. The median duration of survival after diagnosis was 5.1 months (Q1–Q3 = 1.1–24.5). No significant differences presented in sex, age (below or above 60 years) and serum β2MG level between 2 groups classified by median values and HSCT [Table 2]. The OS rate based on the product-limit survival distribution was significantly associated with the Ann Arbor clinical stage (stage = I–II, $P < 0.001$), having HLH or not ($P < 0.001$), the IPI score (IPI = 0–1, $P < 0.001$), and having B symptoms or not ($P < 0.001$); however, OS was not associated with age above 60 years or sex [Figure 1].

After adjustments for other variables, multivariable analysis of prognostic factors for OS showed that patients with advanced clinical stage and symptoms have a 3.16-times greater HR compared to those without symptoms (the adjusted HR is 3.16, 95% CI: 1.39–7.20); this value is based on stratification by HLH. The HR for patients with a lower platelet count was 2.57 (95% CI: 1.57–4.19), and the HR for patients with a higher IPI score was 1.29 (95% CI: 1.01–1.66), suggesting that with each unit increasing in IPI score, the HR increase by approximately 1.3 times. Additionally, T-LBL (HR = 0.40, 95% CI: 0.20–0.80), higher white cell counts at diagnosis (HR = 0.57, 95% CI: (0.34–0.96), higher levels of serum albumin at diagnosis (HR = 0.6, 95% CI: 0.37–0.97; ref = "≥34 g/L") and a higher ESR (HR = 0.53, 95% CI: 0.33–0.87; ref = "≥23 mm/h") were protective factors for OS (Table 3).

Table 4 presents the results of the multiple variable quantile regression between the OS rate and each predictor at quartiles 0.25, 0.5, 0.75, and 0.95. Approximating the lower boundary of the quartile level, the coefficients of IPI, clinical stage with symptoms and WBC count at diagnosis

Table 2: Overall survival rate stratified by sociodemographic and clinical characteristics (n=183)

Factors	Values	Survival cases at the last follow-up (n)	Total cases of the subgroup (N)	OS rate* (%)	χ^2	P
Sex					0.20	0.658
Male		68	127	53.5		
Female		28	56	50.0		
Age (years), median (Q₁–Q₃)	45 (28–61)				2.50	0.113
<60		65	133	48.9		
≥60		31	50	62.0		
Serum albumin levels (g/dL), median (Q₁–Q₃)	34.4 (28.6–38.8)				16.7	<0.0001
<34		35	93	37.6		
≥34		61	90	67.0		
Serum β2MG levels (mg/L), median (Q₁–Q₃)	2.9 (2.1–4.2)				0.05	0.815
<2.9		59	111	53.2		
≥2.9		37	72	51.4		
Serum Ca levels at diagnosis (g/dL), median (Q₁–Q₃)	2.14 (1.99–2.24)				6.62	0.010
<1.9		8	27	29.6		
≥1.9		88	156	56.4		
ESR at diagnosis (g/dL), median (Q₁–Q₃)	23 (9–46)				6.62	0.010
<23		47	106	44.3		
≥23		49	77	63.64		
Hemoglobin levels at diagnosis (g/dL), median (Q₁–Q₃)	110 (87–132)				21.3	<0.0001
<120		43	111	38.7		
≥120		53	72	73.6		
LDH levels at diagnosis (g/dL), median (Q₁–Q₃)	233 (150–469)				15.2	<0.0001
<233		62	93	66.7		
≥233		34	90	37.8		
Platelet levels at diagnosis (g/dL), median (Q₁–Q₃)	157 (64–234)				Fisher	<0.000
<53		4	40	10.0		
≥53		92	143	64.3		
White cell count at diagnosis (/L), median (Q₁–Q₃)	5.05 (2.96–7.80)				16.5	<0.0001
<5		34	91	37.4		
≥5		62	92	67.4		
International prognostic index (IPI)[†]					29.2	<0.0001
0/1		44	52	84.6		
2/3		45	111	40.5		
4/5		7	18	38.9		
Ann Arbor clinical stage					21.5	<0.0001
I&II		32	37	86.5		
III&IV		64	146	43.8		
Underwent stem cell transplantation					0.04	0.850
Yes		7	14	50.0		
No		89	169	52.7		
Had HLH					33.81	<0.0001
Yes		4	38	10.5		
No		92	145	63.5		
Survival time after diagnosis (months)	5.1 (1.1–24.5)					

β2MG: Beta-2 microglobulin; HLH: Hemophagocytic lymphohistocytosis; IPI: International prognostic index; LDH: Lactate dehydrogenase; OS: Overall survival. Stem cell transplantation includes autologous and allogeneic transplantation without further classification due to limited cases. *OS rate (%)=Survival cases at the last follow-up (n) / Total cases of the subgroup (N)×100. [†]Two cases missed IPI score.

were statistically significant. The coefficients of serum β2MG level and serum ESR were statistically significant at the middle of the coefficient curve. The coefficient of IPI was consistently negatively associated with OS (IPI ≥2), suggesting that higher IPI scores had a greater impact on the OS time than lower IPI scores; however, these values were not significant at Q3. To obtain a more detailed understanding of the impacts of the coefficient variation for each variable on OS, we could, for example, observe the effects of every 5 percent change in each quartile on OS [Figure 2]. The coefficient of IPI (IPI ≥2) was negatively associated with quartile level, which suggests that higher IPI scores have a greater impact on the OS time than lower IPI scores. The same trend was observed in the coefficients of platelet count, serum Ca+ level, and serum β2MG level; while the coefficient of serum Ca+
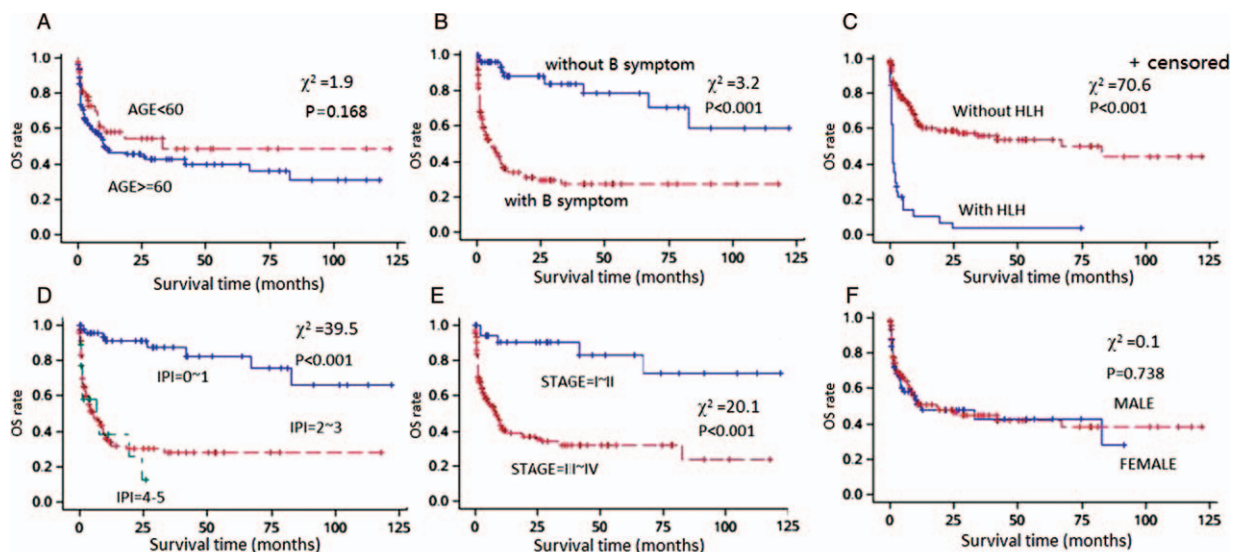
Figure 1: Product limit survival distribution generated by Kaplan-Meier plot of survival time. (A–F) illustrated overall survival rate changes stratified by age (</≥60 years), with/without B symptom, HLH, IPI (0-1/2-3/4-5), stage (I-II/III-IV), and gender (male/female).

Table 3: Multivariate analysis of prognostic factors for inferior overall survival (stepwise)[*]

Clinical factors	Ref	HR (95% CI)	P
ESR level	≥23 mm/h	0.53 (0.33–0.87)	0.011
Clinical staging with symptoms	No	3.16 (1.39–7.2)	0.006
Platelet count	$<53 \times 10^9$/L	2.57 (1.57–4.19)	<0.001
IPI	0	1.29 (1.01–1.66)	0.043
T-LBL	Yes	0.40 (0.20–0.80)	0.010
White cell count	$\geq5 \times 10^9$/L	0.57 (0.34–0.96)	0.033
Serum albumin at diagnosis	≥34 g/L	0.6 (0.37–0.97)	0.039

[*]The HR was stratified by HLH. CI: Confidence interval; ESR: Erythrocyte sedimentation rate; HR: Hazard ratio; IPI: International prognostic index; T-LBL: T cell lymphoblastic lymphoma.

Table 4: Adjusted parameter estimates (β) and P values for survival time using quantile regression at quartile values of 0.25, 0.50, 0.75, and 0.95

Parameters	Q1 = 0.25		Q2 = 0.50		Q3 = 0.75		Q4 = 0.95	
	β	P	β	P	β	P	β	P
Intercept	10.0	0.105	34.0	0.082	105.8	0.005	32.3	0.484
Age at diagnosis	0	0.057	0.1	0.338	0.1	0.549	0.3	0.155
Serum β2MG level	−0.4	0.336	−2.5	0.057	−8.5	0.001	0.1	0.975
Serum ESR	0	0.182	0.1	0.010	0.2	0.020	0	0.908
IPI	−1.2	0.024	−3.2	0.049	−4.0	0.189	−24.9	<.0001
clinical stage with symptoms	−3.4	0.007	−4.9	0.206	−14.1	0.060	13.4	0.150
Platelet level at diagnosis	0	0.060	0	0.292	0	0.110	0	0.759
White cell count at diagnosis	−0.2	0.040	−0.3	0.147	−0.8	0.090	0.1	0.814
Serum calcium level	0.1	0.971	−3.0	0.705	−13.6	0.369	22.4	0.237

β2MG: Beta-2 microglobulin; ESR: Erythrocyte sedimentation rate; IPI: International prognostic index.

level was significantly and negatively associated with OS above the 85th percentile, a high serum Ca+ level had a negative impact on the OS time when controlled for other factors. The coefficients of serum ESR and diagnosis with PTCL increased with the OS time but were statistically significant only at higher quartiles. The coefficients of HSCT and no clinical symptoms were greater at the middle of the quartile curve, showing a greater impact on the central quartile when controlled for other factors.
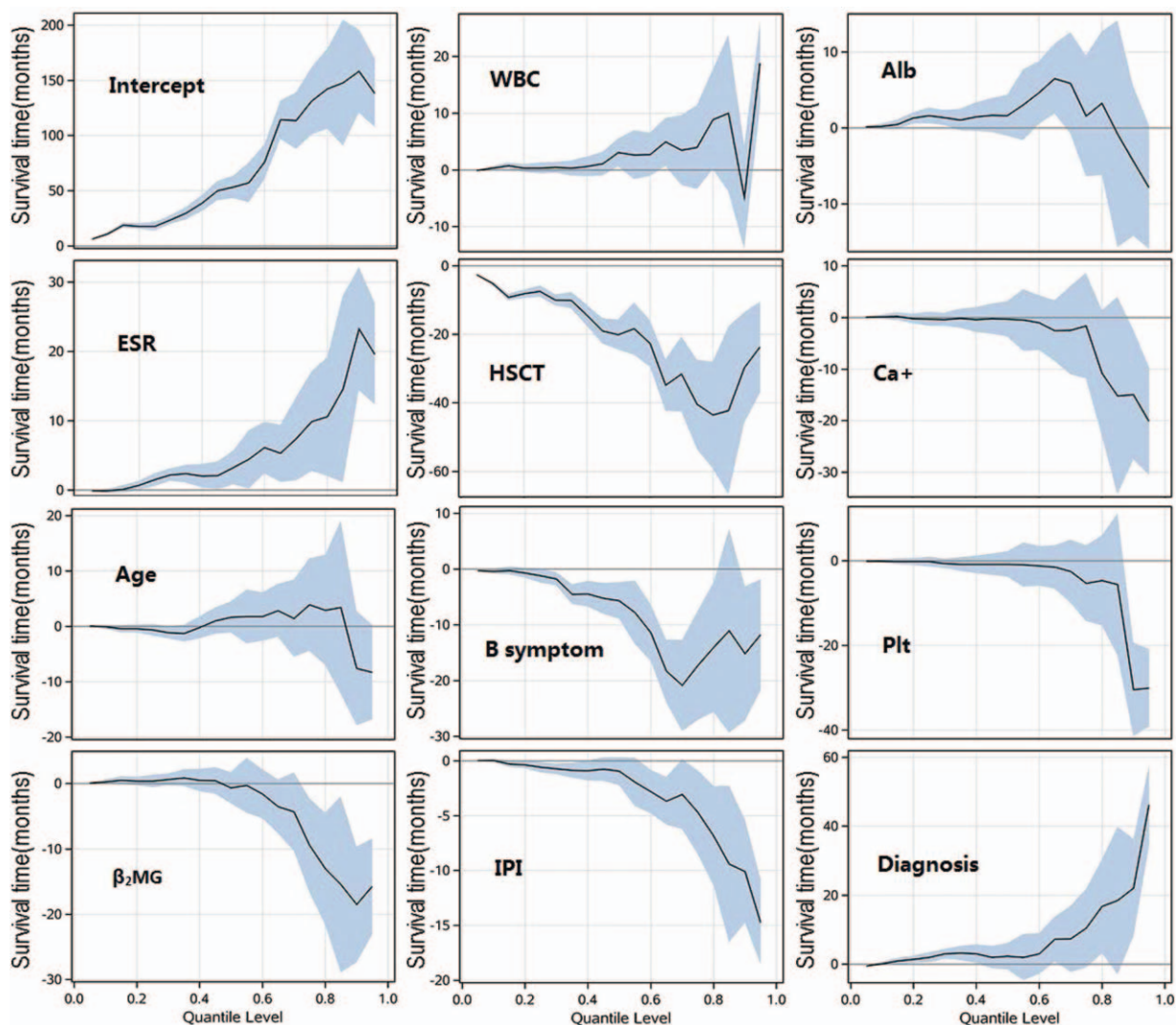
Figure 2: Estimated parameters by quantile level for live months with 95% confidence interval. Alb: Albumin; ESR: Erythrocyte sedimentation rate; HSCT: Hematopoietic stem cell transplantation; IPI: International prognostic index; WBC: White blood cell; β2MG: β2-microglobulin.

Discussion

To our knowledge, this study added evidence to explore the predictors of survival time in patients with non-Hodgkin T/NK lymphoma and presenting their varied impact over different percentile levels using a quantile regression model rather than linear or logistic regression. Our main findings were that the IPI has a consistent negative association with OS (IPI ≥2) and that higher IPI score showed more impact on the survival time. The quantile regression also showed that the IPI score is a highly robust prognostic indicator after adjusting for other factors and statistically significant at 3 quartiles of the curve. In addition, serum ESR is also comparatively stable at the middle 2 quartiles of the curve as a prognostic indicator. The same trend was observed in the coefficients of platelet count, serum Ca+ level, and serum β2MG level, while HSCT and clinical stage without clinical symptoms impacted the survival time only in the middle section of the curve; the lower and upper concentration levels had no significant impact on the survival time. These findings are

interesting and are worthy of further observation. Most of the prognostic indicators were validated with Federico et al[25] and Xu et al,[26] but we presented with a more specified way in term of concrete section of the distribution of the curve.

There is no consensus on the efficacy of HSCT in the treatment of non-Hodgkin T/NK lymphoma. Some studies have focused on small populations characterized by mixed histology, varying disease status at transplantation, and treatments with diverse regimens. Other studies have excluded patients with chemo-refractory or poor-risk disease who were not eligible for HSCT, which may incur selection bias.[1] Studies[27-29] have also shown that HSCT could improve the prognosis of peripheral T cell lymphoma. However, the results of the present study did not show that HSCT could increase the OS rate in the multivariable analysis. These results were consistent with those of Tse,[30,31] showing that allogeneic HSCT should be reserved for patients who are at high risk of relapse; moreover, the role of allogeneic HSCT in NK/T cell

lymphoma must be strictly evaluated. These findings might be true or might be due to the limited number of selected research participants, the aggressive nature of these diseases or the frequency at which the disease relapses. However, HSCT might have an impact on OS among the average patients at the central quantile.

The findings of the present study on the correlation between serum ESR and OS are consistent with those of Bien et al[15]; moreover, these results may be attributed to quantile regression. The correlation of ESR with OS does not present a linear prediction, central 2 quartiles have good predicting roles in OS. In addition, platelet count was an independent prognostic indicator in patients with diffuse large B cell lymphoma, which was consistent with the others' findings,[26,32] but the impact of platelet count was more significant at extremely low levels according to the percentage curve.

Gui et al and Bien et al[15,27] found that serum β2MG levels could predict the OS of patients with peripheral T cell lymphoma or Hodgkin lymphoma. We, however, observed a statistically significant impact from serum β2MG on OS only in the middle section, although the impact of serum β2MG on OS seemed to increase with increasing quartile level.

According to our multiple Cox proportional hazards regression analysis and quantile regression analysis, absolute WBC count might be a promising predictor for OS, though significant only in the lower boundary of the quantile regression curve. But the predicting power of WBC count is validated by a European study named "T cell score" for modeling PTCL-NOS prognosis based on 4 covariates (serum albumin, performance status, stage and absolute neutrophil count).[33] In most occasions, absolute neutrophil count is consistent with WBC count of patients with non-Hodgkin T/NK cell lymphoma.

The strength of this study included: We used quantile regression and revealed some interesting findings on the impact of different indicators on the prediction of OS over a quantile distribution. These effects might be underestimated by least squares regression. There were paucity of researches focus on predictors of OS in B cell lymphoma patients, while few studies conducted among non-Hodgkin T/NK cell lymphoma patients. As the largest study center for HLH in China, our hospital admits quite high proportion of HLH patients. In the present study, we included 30 HLH patients. Most HLH patients have really poor prognoses[18]; therefore, to control for the potential confounding factor of HLH, we stratified patients based on HLH status for a clearer understanding of the predictive values of clinical manifestations/indicators on OS than other studies that might mix HLH patients with other participants.

This study had also some limitations. As a retrospective study, we collected data on OS time and prognostic factors but no other information on survival, such as progress-free survival (PFS) or disease-free survival (DFS), in a single institution. There might be bias during patient selection, data collection and even data analysis. These findings may

not be generalizable throughout China. Most patients who sought treatment in Beijing, a comparatively mega-metropolitan city, had advanced disease stages or better economic conditions. Discharged patients who did not live in Beijing presented challenges in the follow-up. In addition, patients with different disease types or stages and received heterogeneous treatment undoubtedly had different clinical outcomes and treatment responses; thus, the serum indicators may vary. Therefore, we reported whether the lower bound, middle bound or upper bound of the indicators had greater impact on survival. Furthermore, considering the number of systemic lymphoma patients, the impact of prognostic factors may not be generalizable. However, 183 patients could shed some light on the prediction of prognostic outcomes. We did not consider the impact of the histological subtype on autologous stem cell transplantation (ASCT), and as the DFS or PFS time is much shorter for patients with diseases such as NK/T cell lymphoma, we selected the OS rate as the only indicator to compare with more conventional risk factors, such as the IPI.

In summary, we used an innovative statistical method, quantile regression, to explore the prognostic predictors of OS among systemic lymphoma patients. The IPI score was determined to be a robust indicator of prognosis at 3 quartiles, and serum ESR is stable at the middle 2 quartiles section when adjusted for HLH. In addition, platelet count, and serum β2MG level could predict OS among non-Hodgkin's T/NK cell lymphoma patients at different percentage levels.

Conflicts of interest

None.

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