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Original Article

Procedural State Anxiety in Pediatric Leukemia Patients Undergoing Bone Marrow Aspiration or Lumbar Puncture: A Cross-Sectional Study Using the Chinese Version of the State Anxiety Scale for Children

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Abstract. ***Background*: Invasive procedures such as bone marrow aspiration (BMA) and lumbar puncture (LP) are essential in the management of pediatric leukemia but often induce significant state anxiety. This cross-sectional study aimed to evaluate procedural state anxiety using the Chinese Version of the State Anxiety Scale for Children (CSAS-C) and identify associated socio-demographic and clinical factors in Chinese pediatric leukemia patients.**
***Methods*: A convenience sample of 119 patients aged 8-18 years with acute lymphoblastic leukemia (ALL) or acute myeloid leukemia (AML) undergoing BMA or LP was recruited from a tertiary pediatric oncology center in China. State anxiety was assessed via the CSAS-C (score range: 20-60, higher scores indicating greater anxiety). Socio-demographic (gender, age, education) and clinical data (diagnosis, treatment history, procedural type, site, history) were collected. Data were analyzed using R software (version 4.4.3). Non-normally distributed variables were presented as median (P25, P75). Group comparisons employed the Mann-Whitney U test for two groups and the Kruskal-Wallis test with Dunn's post-hoc for multiple groups, with $P < 0.05$ considered significant.**
***Results*: The overall median CSAS-C score was 27.0 (21.0, 32.0), indicating mild to moderate anxiety. Significantly higher anxiety was associated with younger age (8-12 years; $P < 0.001$), primary school education ($P < 0.001$), AML diagnosis ($P = 0.004$), hospitalization setting ($P < 0.001$), and first-time procedures ($P < 0.001$). No significant differences were observed by gender ($P = 0.439$), treatment history ($P = 0.066$), or procedural type ($P = 0.238$). Multivariable linear regression confirmed that first-time procedures were an independent predictor of higher anxiety ($\beta = 11.82$, $p = 0.001$), with a marginal effect for lumbar puncture ($\beta = 7.16$, $p = 0.056$).**
***Conclusion*: Procedural state anxiety is prevalent among pediatric leukemia patients undergoing BMA or LP, particularly in younger, less educated, AML, inpatient, and novice patients. These findings underscore the need for tailored anxiety-reduction interventions in pediatric oncology to improve patient experience and compliance.**

Keywords: Pediatric leukemia; State anxiety; Bone marrow aspiration; Lumbar puncture; Chinese Version of the State Anxiety Scale for Children (CSAS-C).

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Introduction. Pediatric leukemia represents one of the most common malignancies in children, accounting for approximately 30% of all childhood cancers worldwide, with acute lymphoblastic leukemia (ALL) being the predominant subtype, comprising about 75% of cases, followed by acute myeloid leukemia (AML).[1-3] The global incidence of childhood leukemia varies, but rates are estimated at around[4-5] new cases per 100,000 children annually, with higher burdens in certain regions.[2,4,5] Diagnosis and treatment often involve invasive procedures such as bone marrow aspiration (BMA) and lumbar puncture (LP), which are critical for confirming diagnosis, monitoring disease progression, and administering intrathecal chemotherapy.[6-8] However, these procedures are frequently associated with significant pain, distress, and anxiety for young patients, exacerbating the emotional challenges of their illness.

State anxiety, defined as a transient emotional response to a perceived threat, is particularly prevalent during such medical interventions in pediatric oncology, with studies indicating that it can lead to heightened fear, non-compliance, and long-term psychological sequelae.[9] Untreated procedural anxiety may adversely affect clinical outcomes, including increased postoperative behavioral disturbances, delayed recovery, and poorer adherence to treatment protocols.[10] To effectively measure this, validated tools like the State-Trait Anxiety Inventory for Children (STAI-C) have been adapted for various populations.[11] In China, the Chinese Version of the State Anxiety Scale for Children (CSAS-C) has been psychometrically evaluated and shown to possess good reliability and validity for assessing state anxiety in children aged 7-12 years, with a short form also available for clinical efficiency.[12,13]

Despite the growing body of evidence on procedural distress in pediatric oncology, there remains a paucity of research specifically examining state anxiety in Chinese children with leukemia undergoing BMA or LP, particularly using culturally adapted instruments like the CSAS-C.[14] Factors such as age, education, diagnosis, and procedural history may influence anxiety levels, but their associations in this context are underexplored. This cross-sectional study aimed to evaluate procedural state anxiety using the CSAS-C in a cohort of 119 pediatric leukemia patients and to investigate socio-demographic and clinical factors associated with anxiety scores, with the goal of informing targeted interventions to mitigate distress in this vulnerable population.

Methods

Study Design and Setting. This was a cross-sectional study conducted to assess procedural state anxiety among pediatric patients with leukemia undergoing bone marrow aspiration (BMA) or lumbar puncture (LP). The study was carried out at a single tertiary pediatric oncology center in China between January 2024 and October 2025. Ethical approval was obtained from the Institutional Review Board of the participating hospital, and the study adhered to the principles of the Declaration of Helsinki. Informed consent was obtained from parents or legal guardians, and assent was sought from children aged 8 years and older where appropriate.

Participants. A convenience sample of 119 pediatric patients diagnosed with acute leukemia (acute myeloid leukemia [AML] or acute lymphoblastic leukemia [ALL]) was recruited. Inclusion criteria were: (1) age between 8 and 18 years; (2) confirmed diagnosis of AML or ALL; (3) scheduled for BMA or LP as part of diagnostic or therapeutic management; and (4) ability to understand and complete the anxiety scale independently or with minimal assistance. Exclusion criteria included: (1) cognitive impairment or developmental disorders that precluded self-reporting; (2) acute medical instability at the time of the procedure; or (3) refusal to participate. Patients were stratified by socio-demographic (gender, age, education) and clinical factors (diagnosis, treatment history, procedural type, procedure site, procedural history) for analysis.

Measures. State anxiety was measured using the Chinese Version of the State Anxiety Scale for Children (CSAS-C), a culturally adapted and validated self-report instrument based on the original State-Trait Anxiety Inventory for Children (STAI-C).[13] The CSAS-C consists of 20 items assessing transient anxiety symptoms (e.g., feelings of calmness, tension, worry), each rated on a 3-point Likert-type scale (1 = not at all, 2 = somewhat, 3 = very much). Total scores range from 20 to 60, with higher scores indicating greater state anxiety. The scale has demonstrated good reliability (Cronbach's α = 0.85–0.90) and validity in Chinese pediatric populations, primarily aged 7–12 years.[12,13] Although formal validation focused on younger children, the CSAS-C was applied here to participants aged 8–18 years, with extrapolation to adolescents (13–18 years) justified by its conceptual equivalence to the original instrument and established clinical use in older pediatric groups. Socio-demographic and clinical data were collected via medical records and a brief structured questionnaire administered to parents/guardians, including gender, age, education level, diagnosis, treatment history, procedural type (BMA or LP), procedure site (outpatient or inpatient ward), and procedural history (first time, 1–10 times, or >10 times).

Procedure. Eligible patients were identified and approached by trained research nurses in the oncology clinic or ward prior to the scheduled procedure. After obtaining consent/assent, participants completed the CSAS-C questionnaire in a quiet room approximately 30 minutes before the BMA or LP to capture pre-procedural state anxiety. The questionnaire was self-administered for older children or read aloud to younger ones, to ensure comprehension, without influencing responses. Clinical data were concurrently extracted from electronic medical records. All procedures were performed by experienced pediatric oncologists using standard protocols, with or without sedation as per clinical indication (typically selective use of local anesthesia, moderate sedation, or general anesthesia based on age, procedural history, and physician judgment). Detailed records of sedation/analgesia administration and patient/parent awareness were not collected. Sedation use and patients' prior knowledge of sedation plans were not systematically recorded.

Statistical Analysis. Statistical analyses were performed using R software (version 4.4.3; R Foundation for Statistical Computing, Vienna, Austria). The normality of continuous variables was assessed using the Shapiro–Wilk test. As all continuous variables were non-normally distributed, data were expressed as median (P_{25}, P_{75}). Group comparisons were performed using the Mann-Whitney U test for two groups and the Kruskal-Wallis with Dunn's post hoc test for multiple groups. To address potential confounding, a multivariable linear regression model was conducted with CSAS-C total score as the dependent variable, adjusting for gender, age group, education, diagnosis, treatment history, procedural type, procedure site, and procedural history (treated as categorical variables). Coefficients, standard errors, p-values, and 95% confidence intervals are reported. A two-sided p-value < 0.05 was considered statistically significant. No adjustments for multiple comparisons were applied, as this was an exploratory study.

Results

Participant Demographics and Clinical Characteristics. A total of 119 pediatric leukemia patients were included in this cross-sectional study. The sample comprised 80 males (67.23%) and 39 females (32.77%), with an overall mean age of approximately 12 years. More than half of the participants were aged 8-12 years (55.46%), and the majority had a primary school education (56.30%). Acute lymphoblastic leukemia (ALL) was the most common diagnosis (69.75%), followed by acute myeloid leukemia (AML) (30.25%). Most patients received chemotherapy only (73.95%), and bone marrow aspiration was the predominant procedural type (65.55%). Procedures were primarily conducted in inpatient wards (63.03%), with varying procedural histories: 27.73% had the procedure for the first time, 32.77% between 1 and 10 times, and 39.50% more than 10 times. Detailed socio-demographic and clinical characteristics, including subgroup-specific mean ages, are summarized in **Table 1**.

Overall State Anxiety Levels. The Chinese Version of the State Anxiety Scale for Children (CSAS-C) is a validated 20-item self-report instrument designed to measure transient anxiety in children, with each item rated on a 3-point Likert-type scale (e.g., from "not at all" to "very much" regarding anxiety-related feelings). Total scores range from 20 (indicating minimal anxiety) to 60 (indicating severe anxiety). In the present study, the overall median CSAS-C score among the 119 pediatric leukemia patients was 27.0 (25th percentile [P25]: 21.0, 75th percentile [P75]: 32.0). This median value suggests a generally mild to moderate level of procedural state anxiety experienced by the participants immediately prior to bone marrow aspiration or lumbar puncture. The interquartile range reflects considerable variability in anxiety responses, with the lower quartile indicating relatively low anxiety in a subset of patients and the upper quartile approaching levels that may warrant clinical attention. These results underscore the emotional burden of invasive diagnostic and therapeutic procedures in young leukemia patients, aligning with previous literature on procedural distress in pediatric oncology.

Between-Group Comparisons by Socio-Demographic Factors. Between-group comparisons of CSAS-C scores were conducted for socio-demographic variables, including gender, age, and education level. No significant difference in anxiety scores was observed between males and females ($U = 1423$, $P = 0.439$), with median scores of 26.5 (21.0, 31.2) for males and 28.0 (21.0, 33.5) for females. However, significant differences were observed by age group, with younger patients (8-12 years) reporting higher anxiety (median 30.0 [25.0, 34.0]) than older patients (13-18 years; median 24.0 [11.0, 29.0]; $U = 919$, $P < 0.001$). Similarly, education level showed significant variations ($\chi^2 = 21.1$, $P < 0.001$), where primary school students had the highest median anxiety score (30.0 [25.0, 34.0]), followed by high school (26.0 [6.5, 29.0]) and middle school (23.0 [12.0, 27.0]). These findings suggest that younger age and lower education levels are associated with elevated procedural state anxiety in this population. Detailed comparisons are presented in **Table 2**.

Between-Group Comparisons by Clinical Factors. Between-group comparisons of CSAS-C scores were also performed for clinical variables, including diagnosis, treatment history, procedural type, procedure site, and procedural history. Significant differences were observed by diagnosis, with AML patients exhibiting

Table 1. Socio-demographic and Clinical Characteristics of Pediatric Leukemia Patients Undergoing Bone Marrow Aspiration or Lumbar Puncture.

Variable	Case number (n)	Percentage (%)	Average age (years old)
Gender			
Male	80	67.23	11.9 ± 2.8
Female	39	32.77	12.1 ± 3.6
Age			
8-12 years old	66	55.46	9.6 ± 1.2
13-18 years old	53	44.54	14.9 ± 1.6
Education			
Primary school	67	56.3	9.6 ± 1.3
Middle school	33	27.73	13.9 ± 0.8
High school	19	15.97	16.7 ± 0.8
Diagnosis			
AML	36	30.25	10.7 ± 2.9
ALL	83	69.75	12.5 ± 2.9
Treatment history			
Chemotherapy only	88	73.95	12.3 ± 3.1
Chemotherapy + transplant	6	5.04	9.8 ± 1.0
Chemotherapy + immunotherapy + transplant	2	1.68	8
Chemotherapy + immunotherapy	19	15.97	11.4 ± 2.2
Chemotherapy + target therapy	4	3.36	11.8 ± 3.6
Procedural type			
Bone marrow aspiration	78	65.55	11.8 ± 3.1
Lumbar puncture	41	34.45	12.2 ± 2.8
Procedure site			
Outpatient	44	36.97	10.8 ± 2.2
Inpatient ward	75	63.03	12.6 ± 3.2
Procedural history			
The first time	33	27.73	12.2 ± 3.5
1-10 times	39	32.77	12.8 ± 3.1
>10 times	47	39.5	11.1 ± 2.3

Table 2. Between-Group Comparisons of CSAS-C Scores by Socio-Demographic Factors.

Variable	Case number (n)	Median (P25, P75)	Statistical value	P value
Gender				
Male	80	26.5 (21.0, 31.2)	1423	0.439
Female	39	28.0 (21.0, 33.5)	28.0 (21.0, 33.5)	
Age				
8-12 years	66	30.0 (25.0, 34.0)	919	<0.001
13-18 years	53	24.0 (11.0, 29.0)	24.0 (11.0, 29.0)	
Education				
Primary school	67	30.0 (25.0, 34.0)	21.1	<0.001
Middle school	33	23.0 (12.0, 27.0)	23.0 (12.0, 27.0)	
High school	19	26.0 (6.5, 29.0)	26.0 (6.5, 29.0)	

higher anxiety (median 30.0 [26.0, 34.0]) than ALL patients (median 26.0 [15.0, 31.5]; U = 1001, P = 0.004). Treatment history showed no overall significant difference (χ^2 = 8.82, P = 0.066), though median scores varied across subgroups: chemotherapy only (28.5 [23.0, 33.0]), chemotherapy + transplant (21.0 [13.2, 30.2]), chemotherapy + immunotherapy + transplant (29.0 [27.5, 30.5]), chemotherapy + immunotherapy (22.0 [10.5, 27.0]), and chemotherapy + target therapy (28.0 [20.8, 29.8]). Procedural type did not yield significant differences (U = 1387.5, P = 0.238), with similar median scores for bone marrow aspiration (26.0 [12.5, 33.0]) and lumbar puncture (29.0 [24.0, 32.0]). However, the procedure was significantly associated with anxiety, as hospitalized patients reported higher scores (29.0 [24.5, 34.0]) compared to outpatients (22.5 [11.0, 29.2]; U = 2364.5, P < 0.001). Procedural history also showed significant variations (χ^2 = 34.04, P < 0.001), with first-time procedures linked to the highest anxiety (34.0 [30.0, 35.0]), followed by >10 times (25.0 [15.0, 31.0]) and 1-10 times (24.0 [14.0, 29.0]). These results highlight the influence of clinical context on procedural anxiety, particularly for AML diagnosis, inpatient settings, and initial exposures to invasive procedures. Detailed comparisons are presented in **Table 3**.

Table 3. Between-Group Comparisons of CSAS-C Scores by Clinical Factors.

Variable	Case number (n)	Median (P25, P75)	Statistical value	P value
Diagnosis				
AML	36	30.0 (26.0, 34.0)	1001	0.004
ALL	83	26.0 (15.0, 31.5)	26.0 (15.0, 31.5)	
Treatment history	Treatment history			
Chemotherapy only	88	28.5 (23.0, 33.0)	8.82	0.066
Chemotherapy + transplant	6	21.0 (13.2, 30.2)	21.0 (13.2, 30.2)	
Chemotherapy + immunotherapy + transplant	2	29.0 (27.5, 30.5)	29.0 (27.5, 30.5)	
Chemotherapy + immunotherapy	19	22.0 (10.5, 27.0)	22.0 (10.5, 27.0)	
Chemotherapy + target therapy	4	28.0 (20.8, 29.8)	28.0 (20.8, 29.8)	
Procedural type	Procedural type			
Bone marrow aspiration	78	26.0 (12.5, 33.0)	1387.5	0.238
Lumbar puncture	41	29.0 (24.0, 32.0)	29.0 (24.0, 32.0)	
Procedure site	Procedure site			
Outpatient	44	22.5 (11.0, 29.2)	2364.5	<0.001
Inpatient ward	75	29.0 (24.5, 34.0)	29.0 (24.5, 34.0)	
Procedural history	Procedural history			
The first time	33	34.0 (30.0, 35.0)	34.04	<0.001
1-10 times	39	24.0 (14.0, 29.0)	24.0 (14.0, 29.0)	
>10 times	47	25.0 (15.0, 31.0)	25.0 (15.0, 31.0)	

Post-Hoc Multiple Comparisons. Post-hoc analyses using Dunn's test (for multi-group variables) or direct Mann-Whitney equivalents (for two-group comparisons) were conducted to clarify specific pairwise differences. Significant overall group differences were driven by the following key contrasts: younger patients (8-12 years) showed markedly higher anxiety than older patients (13-18 years; P < 0.001); primary school students had higher anxiety than both middle school (P < 0.001) and high school students (P = 0.003), with no difference between middle and high school; AML patients exhibited higher anxiety than ALL patients (P = 0.004); inpatient ward procedures were associated with higher anxiety than outpatient clinic procedures (P < 0.001); and first-time procedures elicited significantly higher anxiety than both 1-10 times (P < 0.001) and >10 times (P < 0.001), with no difference between the latter two groups. For treatment history (non-significant overall), one pairwise comparison reached significance (chemotherapy only vs. chemotherapy + immunotherapy; P = 0.005). No significant pairwise differences were found for gender or procedural type. Full post-hoc results, including mean rank differences and p-values for all comparisons, are presented in **Table 4**.

Multivariable Analysis. To adjust for potential confounding among socio-demographic and clinical factors, a multivariable linear regression model was

Table 4. Post-Hoc Multiple Comparisons of CSAS-C Scores.

Variable	Multiple Comparison	Mean Rank Difference	P Value
Gender			
	Male vs Female	0.776	0.439
Age			
	8-12 years vs 13-18 years	4.443	<0.001
Education			
	Primary school vs Middle school	4.181	<0.001
	Primary school vs High school	2.951	0.003
	High school vs Middle school	0.425	0.671
Diagnosis			
	AML vs ALL	2.855	0.004
Treatment History	Treatment History		
	Chemotherapy only vs Chemotherapy + transplant	1.003	0.316
	Chemotherapy only vs Chemotherapy + immunotherapy	2.837	0.005
	Chemotherapy only vs Chemotherapy + immunotherapy + transplant	0.237	0.813
	Chemotherapy only vs Chemotherapy + target therapy	0.556	0.578
	Chemotherapy + transplant vs Chemotherapy + immunotherapy	0.629	0.529
	Chemotherapy + transplant vs Chemotherapy + immunotherapy + transplant	0.726	0.468
	Chemotherapy + transplant vs Chemotherapy + target therapy	0.215	0.829
	Chemotherapy + immunotherapy vs Chemotherapy + immunotherapy + transplant	1.193	0.233
	Chemotherapy + immunotherapy vs Chemotherapy + target therapy	0.788	0.43
	Chemotherapy + immunotherapy + transplant vs Chemotherapy + target therapy	0.524	0.601
Procedural Type	Procedural Type		
	Bone marrow aspiration vs Lumbar puncture	1.184	0.238
Procedure Site	Procedure Site		
	Outpatient vs Inpatient ward	3.938	<0.001
Procedural History	Procedural History		
	The first time vs 1-10 times	5.351	<0.001
	The first time vs >10 times	4.94	<0.001
	>10 times vs 1-10 times	0.664	0.507

performed with CSAS-C total score as the dependent variable. The model explained 21.1% of the variance in anxiety scores ($R^2 = 0.211$, adjusted $R^2 = 0.114$, $F = 2.165$, $p = 0.016$). After adjustment, procedural history remained significantly associated with anxiety, with first-time procedures linked to higher scores compared to 1-10 times ($\beta = 11.82$, 95% CI [5.09, 18.55], $p = 0.001$). The chemotherapy + immunotherapy + transplant subgroup showed higher anxiety ($\beta = 15.35$, 95% CI [0.90, 29.80], $p = 0.038$), though this finding is tentative due to the small sample size ($n = 2$). Procedural type (lumbar puncture vs. bone marrow aspiration) was marginally significant ($\beta = 7.16$, 95% CI [-0.18, 14.50], $p = 0.056$). Other factors, including age group, education, diagnosis, gender, and procedure site, were not significant after adjustment (all $p > 0.05$). Detailed results are presented in **Table 5**.

Discussion. The present study evaluated procedural state anxiety in 119 Chinese pediatric leukemia patients undergoing bone marrow aspiration (BMA) or lumbar puncture (LP) using the Chinese Version of the State Anxiety Scale for Children (CSAS-C). The overall median CSAS-C score of 27.0 indicates mild to moderate anxiety, consistent with prior reports of procedural distress in pediatric oncology. This level underscores the

Table 5. Multivariable Linear Regression Analysis of Factors Associated with CSAS-C Total Scores.

Variable	Coefficient (β)	Standard Error	t-value	p-value	95% CI Lower	95% CI Upper
Intercept	46.59	3.77	12.36	<0.001	39.12	54.07
Age group (8-12 vs. 13-18)	-1.65	9.77	-0.17	0.866	-21.03	17.72
Education (Middle school vs. High school)	-1.92	3.12	-0.62	0.54	-8.1	4.27
Education (Primary school vs. High school)	0.36	9.82	0.04	0.971	-19.11	19.82
Treatment (Chemotherapy + immunotherapy vs. only)	1.55	3.01	0.52	0.607	-4.41	7.52
Treatment (Chemotherapy + immunotherapy + transplant vs. only)	15.35	7.29	2.11	0.038	0.9	29.8
Treatment (Chemotherapy + target therapy vs. only)	-4.49	5.13	-0.88	0.383	-14.65	5.68
Treatment (Chemotherapy + transplant vs. only)	-5.36	5.02	-1.07	0.288	-15.31	4.6
Procedural history (>10 times vs. 1-10 times)	-1.3	2.55	-0.51	0.61	-6.37	3.76
Procedural history (First time vs. 1-10 times)	11.82	3.39	3.48	0.001	5.09	18.55
Gender (Female vs. Male)	0.66	2.2	0.3	0.766	-3.71	5.02
Diagnosis (AML vs. ALL)	2.85	2.41	1.19	0.239	-1.92	7.62
Procedural type (Lumbar puncture vs. Bone marrow aspiration)	7.16	3.7	1.94	0.056	-0.18	14.5
Procedure site (Hospitalization vs. Outpatient)	-5.77	4.03	-1.43	0.155	-13.75	2.21

emotional impact of invasive procedures, which are integral to leukemia management but often provoke fear and discomfort.[15,16] Our findings align with studies showing that repeated exposures, while potentially desensitizing, do not eliminate anxiety entirely, particularly in younger cohorts.[17,18]

Significant associations were observed with socio-demographic factors. Younger patients (8-12 years) and those with primary school education exhibited higher anxiety, corroborating evidence that developmental stage influences distress perception. Immature cognitive coping mechanisms in children may amplify anticipatory fear during procedures like BMA and LP. Similarly, AML patients reported greater anxiety than those with ALL, possibly due to AML's more aggressive course and intensive initial treatments, which heighten perceived threat. Hospitalized settings were linked to elevated scores compared to outpatient, likely reflecting the added stress of inpatient environments, including separation from home and cumulative fatigue. First-time procedures elicited the highest anxiety, supporting the notion that familiarity reduces distress through habituation, though post-hoc analyses showed no difference between 1-10 and >10 exposures, suggesting a plateau effect after initial encounters. Notably, no gender differences emerged, contrasting some studies but aligning with others indicating equivalent vulnerability in procedural contexts. Treatment history and procedural type (BMA vs. LP) lacked overall significance, though pairwise comparisons hinted at lower anxiety with immunotherapy additions, warranting further exploration.

Multivariable analysis adjusted for all factors confirmed procedural history as a key independent predictor, with first-time procedures associated with significantly higher anxiety ($\beta = 11.82$, $p = 0.001$). This strengthens the univariate findings and suggests that initial exposure is a primary driver of distress, independent of age or diagnosis. Marginal significance for lumbar puncture indicates potential procedure-specific effects, while the lack of significance for age group and diagnosis after adjustment highlights confounding by factors such as procedural experience.

These results highlight the need for targeted, feasible interventions to reduce procedural state anxiety, particularly in high-risk groups such as younger patients, those undergoing their first procedure, and inpatients. Concrete strategies should prioritize early identification using brief tools like the CSAS-C and focus on preparation and distraction timed appropriately before the procedure. For first-time procedures — where anxiety was highest — advance preparatory education delivered 24–48 hours prior (e.g., age-appropriate explanatory videos, pictorial booklets, or hospital tours) can help build familiarity and reduce anticipatory fear.[14,19] Child-life specialists (or trained nursing/psychosocial staff in settings where dedicated specialists are unavailable) play a key role by facilitating play-based preparation sessions and teaching coping skills (e.g., deep breathing or guided imagery) tailored to the developmental stage. During the procedure, non-pharmacological distraction techniques — such as interactive music therapy, tablet-based games, or virtual reality — have proven effective and are particularly recommended for younger children and inpatient settings.[20] Parental involvement through coached

presence and reassurance scripts can further mitigate distress. In resource-constrained environments, low-cost options such as bubble blowing or storytelling during the procedure are practical alternatives. For instance, music therapy or behavioral interventions could be prioritized for younger, first-time, or AML patients.[6,9] In China, where cultural factors may influence emotional expression, culturally adapted tools like the CSAS-C are invaluable for early identification and tailored care. Implementing these targeted, evidence-based approaches has the potential to improve patient cooperation, reduce the need for deeper sedation, and enhance overall treatment experience.

Limitations include the cross-sectional design, which precludes causal inferences, and reliance on a single-center convenience sample, potentially limiting generalizability. Self-report biases in younger children and the absence of pain or trait anxiety measures are additional constraints. A major limitation is the lack of systematic data on sedation and pain management practices during procedures. Sedation/analgesia is a well-established confounder for procedural anxiety, with evidence showing that moderate or deep sedation significantly reduces distress compared to local anesthesia alone.[16] Without these details, we could not adjust for or explore its impact, which may have influenced observed anxiety levels (particularly in younger or first-time patients, where sedation is more commonly employed). Furthermore, although sedation was utilized in some procedures based on clinical indication, data on individual sedation administration or patients' awareness of planned sedation were not collected. This prevented examination of whether anticipated sedation reduced pre-procedural anxiety levels (independently or in interaction with factors such as age, procedure type, or diagnosis), despite evidence from prior studies suggesting that sedation or general anesthesia can mitigate distress during bone marrow aspiration and lumbar puncture.[16,21] Future research should employ longitudinal designs, incorporate multimodal assessments, and evaluate intervention efficacy in diverse settings.

Conclusions. This study illuminates key predictors of procedural state anxiety in pediatric leukemia and advocates integrated psychological support to enhance patient well-being and treatment adherence.

Ethical approval. All procedures performed in studies involving human participants were in accordance with the 1964 Helsinki Declaration and its later amendments, or with comparable ethical standards. This study is approved by the Ethics Committee of Tongji Hospital Affiliated to Tongji Medical College (approval No.TJ-IRB20220431), and written informed consent was obtained from their legal representatives prior to enrollment.

Consent for publication. Informed consent was obtained from all individual participants included in the study.

Data Availability. The simulation experiment data used to support the findings of this study are available from the corresponding author upon request.

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