ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN SURVIVAL PREDICTION IN CHRONIC LYMPHOCYTIC LEUKEMIA

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INTRODUCTION

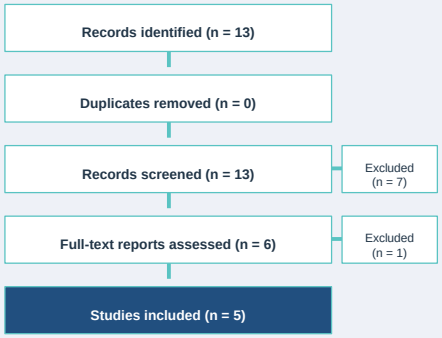
Chronic lymphocytic leukemia (CLL) has marked clinical heterogeneity, ranging from indolent disease to rapid progression, treatment failure, and premature mortality. Established prognostic tools such as the CLL-IPI may not capture complex interactions among clinical, molecular, immunologic, and treatment-related factors. AI/ML can integrate these multidimensional data to support individualized prediction.

AIM

To systematically review AI/ML models used to predict survival and prognostic outcomes in CLL and compare their performance with conventional prognostic tools.

METHODOLOGY

PRISMA 2020-guided systematic review (2010-2026). Risk of bias and applicability were assessed using PROBAST+AI across participants/data sources, predictors, outcomes, and analysis.



Keywords: CLL • artificial intelligence • machine learning • survival prediction • systematic review

RESULTS

- **Treatment failure: AUC 0.95 vs 0.78 for CLL-IPI**
- **Infection risk: HR 20.47 vs 1.79 for CLL-IPI**
- **Survival clustering: OS p=0.016**
- **Composite/PFS outcomes: p<0.001**

STUDY CHARACTERISTICS

STUDY	MODEL	OUTCOME	KEY RESULT
Hoffmann 2023	ALPODS XAI + logistic regression	Treatment failure	AUC 0.95 vs 0.78; p<0.0001
Mouazer 2025	RSF / Decision Tree / Cox	OS; time to treatment	Risk scores; C-index and time-AUC
Parviz 2022	Ensemble ML (+BL)	Death; treatment; infection; composite	+BL > IPI; infection HR 20.47 vs 1.79
Coombes 2020	k-medoids PAM clustering	OS; TTT; TTP	OS p=0.016; TTT p=0.004; TTP p=0.045
Ladyzynski 2022	Dynamic Bayesian Network	60-month OS	Simulated survival aligned with registry curves

OS: overall survival; TTT: time to first treatment; TTP: time to progression; PFS: progression-free survival.

KEY OUTCOMES

Treatment failure • infection-related outcomes • overall survival • time to first treatment • progression-free survival

CONCLUSIONS

AI/ML improved prediction across clinically important CLL outcomes, with the greatest gains in treatment-failure and infection risk. These findings support the potential of multidimensional models to augment conventional prognostic tools. Prospective multicenter validation is required before routine clinical use.

PROBAST+AI ASSESSMENT

Risk of bias and applicability were reviewed across participants/data sources, predictors, outcomes, and analysis. Validation was predominantly internal (bootstrap, train/test split, or cross-validation); one study used a single cohort and one compared simulated survival with external registries. No patient-based model had independent external validation.

CLINICAL IMPLICATIONS

- AI/ML may improve individualized risk estimation beyond CLL-IPI.
- Models using routinely available clinical variables may be more feasible for implementation.
- Future studies should report calibration, decision-curve analysis, fairness, and workflow impact.
- Multicenter prospective validation remains the essential next step.

STUDY INFORMATION

Study type: Systematic review
Funding: No external funding reported
Conflicts of interest: None stated in supplied materials
Contact: Lakshmi Chandana Velaga, Northwest Medical Center, Tucson, Arizona

INCLUDED STUDIES

Hoffmann (2023) • Mouazer (2025) • Parviz (2022) • Coombes (2020) • Ladyzynski (2022)