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ORIGINAL ARTICLE

Prognostic impact of genetic abnormalities in acute myeloid leukemia: a retrospective study at the university hospital of Oran

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ABSTRACT

Introduction. Acute myeloid leukemia (AML) is a heterogeneous hematologic malignancy characterized by the clonal proliferation of myeloid precursor cells. Its prognosis depends on several clinical, biological, and cytogenetic factors. **Objective.** To describe the epidemiological, clinical, biological, and cytogenetic characteristics of patients with AML and to assess their prognostic significance. **Materials and Methods.** This retrospective analytical study was conducted in the Hematology Department of the University Hospital of Oran between January 2020 and December 2025. Patients aged over 15 years with a confirmed diagnosis of AML who underwent comprehensive clinical and laboratory evaluation were included. Cytogenetic risk stratification was performed according to the 2022 European LeukemiaNet (ELN) criteria based exclusively on conventional karyotypic findings. Data were collected from medical records and analyzed using IBM SPSS Statistics version 26. **Results.** A total of 121 patients were included, with a median age of 49 years and a slight female predominance. The most common clinical manifestations were anemia, infection, and hemorrhagic symptoms. Severe thrombocytopenia (<50,000/mm³) and hyperleukocytosis (>100,000/mm³) were observed in 65.8% and 12.6% of patients, respectively. Among the 62 patients with available cytogenetic data, ELN 2022 risk stratification based solely on karyotypic findings classified 35.4% as having favorable-risk disease, 54.6% as intermediate-risk disease, and 10.0% as adverse-risk disease. At 24 months, overall survival was estimated at 50% in the favorable-risk group and 41% in the intermediate-risk group, whereas no patient in the adverse-risk group survived beyond 6 months. **Conclusion.** Cytogenetic abnormalities are major prognostic determinants in AML. Risk stratification according to the 2022 ELN classification provides valuable prognostic information and contributes to optimizing therapeutic decision-making.

Keywords: acute myeloid leukemia, cytogenetics, ELN 2022, overall survival, prognosis.

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1. INTRODUCTION

Acute myeloid leukemia (AML) is a clonal malignant hematological disorder characterized by the uncontrolled proliferation of immature myeloid precursors in the bone marrow, leading to progressive bone marrow failure [1]. It is the most common acute leukemia in adults and remains associated with high morbidity and mortality despite recent therapeutic advances [2]. The incidence of AML increases with age, with a median age at diagnosis between 60 and 70 years in Western series [3].

The pathophysiology of AML is based on the accumulation of cytogenetic and molecular abnormalities affecting the differentiation, proliferation, and survival of hematopoietic cells [4]. Advances in conventional cytogenetics and molecular biology techniques have

led to a better understanding of leukemogenic mechanisms and a significant improvement in prognostic stratification [1,5].

Recent classifications from the World Health Organization (WHO) and the European Leukemia Net (ELN 2022) currently play a central role in the diagnosis and prognostic evaluation of AML [1,6]. The ELN 2022 prognostic classification divides patients into favorable, intermediate, and unfavorable groups based on identified cytogenetic and molecular abnormalities, thus guiding therapeutic decisions and estimating overall survival [1].

Clinically, AML manifests primarily as bone marrow failure syndrome, including anemia, infectious syndrome, and hemorrhagic syndrome [7]. Other manifestations may be observed, including altered general condition, prolonged fever, or extramedullary involvement [2]. Diagnosis is based on bone marrow cytology, supplemented by immunophenotyping, conventional cytogenetics, and molecular analyses [5].

Despite advances in therapeutic management, the prognosis of AML remains poor and depends on several factors, including age, performance status, cytogenetic and molecular abnormalities, and response to treatment [8-11]. In this context, studying the epidemiological, clinical, biological, and genetic characteristics of AML patients remains essential to improve diagnostic and therapeutic strategies, particularly in resource-limited countries where data are scarce.

The objective of our study was to describe the epidemiological, clinical, biological, and cytogenetic characteristics of AML patients treated at the University Hospital of Oran and to analyze the prognostic impact of genetic abnormalities on overall survival.

2. MATERIALS AND METHODS

Study Design

This was a retrospective observational analytical study based on the medical records of patients diagnosed and followed for AML at the University Hospital of Oran.

Study Setting

The study was conducted in the Hematology Department of the University Hospital Center of Oran, Algeria.

Study Population

We included 121 patients aged 15 years and older diagnosed with AML between January 2020 and December 2025.

Inclusion Criteria

The following patients were included: patients aged ≥15 years; patients with confirmed de novo AML.

Data Collection

Data were retrospectively collected using a standardized form including epidemiological data, clinical manifestations, biological parameters, cytological and cytogenetic findings, disease evolution, and survival status. AML diagnosis was suspected based on peripheral blood abnormalities, including cytopenia or leukocytosis, and confirmed by bone marrow aspiration showing ≥20% blasts. Immunophenotyping was performed by flow cytometry. Conventional cytogenetic analysis was carried out on bone marrow metaphases using standard culture techniques and interpreted according to the International System for Human Cytogenetic Nomenclature (ISCN). Cytogenetic analysis was available in 51% of patients.

Cytogenetic risk stratification: The prognostic stratification was performed according to European LeukemiaNet (ELN) 2022 recommendations. However, due to the lack of molecular data in our setting, risk assessment was based exclusively on cytogenetic abnormalities (karyotype). Therefore, this classification represents a partial adaptation of the ELN 2022 criteria (karyotype only), limited to cytogenetic data into favorable-risk (class A), intermediate-risk (class B), and adverse-risk (class C) groups. Overall survival was analyzed using the Kaplan–Meier method.

Ethical Considerations

This study was conducted in accordance with the principles of the Declaration of Helsinki. Given the retrospective nature of the study, formal informed consent was waived, and strict patient anonymity and data confidentiality were fully ensured. No identifying patient information was included in the manuscript

3. RESULTS

General Characteristics

Among the 121 included patients, 52% were women and 48% were men, with a male-to-female ratio of 0.92. The median age at diagnosis was 49 years [15–90]. The most represented age group was 20–40 years (28.1%) (Figure 1).

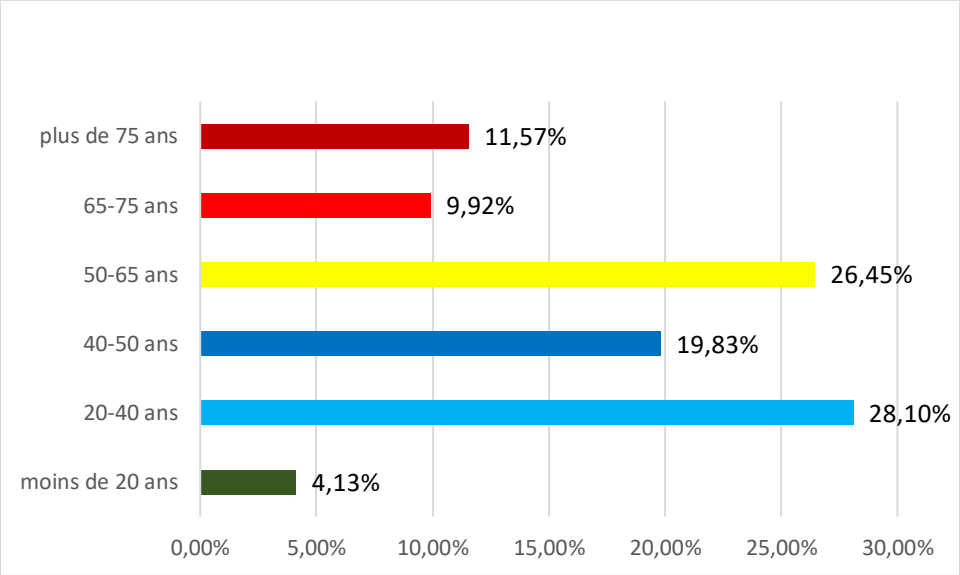

Figure 1. Distribution according to age.

Clinical Presentation

Performance status: The distribution of patients according to performance status (PS) shows that 54.55% of patients have a PS of 1, while 29.75% have a PS of 2. Patients with a PS of 3 represent 12.40%, while those with a PS of 4 constitute 3.31% of the total. Anemic syndrome was found in 90.9% of patients, hemorrhagic syndrome in 45.5%, and infectious syndrome in 40.5%. Tumoral syndrome included splenomegaly in 20.7% of cases, hepatomegaly in 16.5%, and lymphadenopathy in 16.5%. In our study of 121 cases, retinal abnormalities were predominantly represented by retinal hemorrhage, observed in 37.8% of patients, while retinal edema was found in 4.9% of the cohort.

Biological Characteristics

In our series, the median hemoglobin level was 7.96 g/dL (2.8-12.9 g/dL), with 50.4% of patients having a level ≥ 8 g/dL and only 18.2% having a level < 6 g/dL. Leukopenia <4,000/mm³ was observed in 24.4% of cases. Hyperleukocytosis between 10,000 and 50,000/mm³ was found in 30.3% of patients, whereas severe hyperleukocytosis >100,000/mm³ concerned 12.6% of cases. Thrombocytopenia <50,000/µL was observed in 65.8% of cases. Bone marrow blast infiltration exceeded 80% in 37.5% of patients. In our series, the median LDH level was 698.64 IU/L. The majority of patients (48.9%) had an LDH level between 300 and 850 IU/L, while 30.7% had a normal LDH level (< 300 IU/L) and 20.5% had an elevated LDH level (> 850 IU/L). AML3 represents a distinct clinicobiological entity with specific therapeutic implications and accounts for 7.4% of acute myeloid leukemia cases

Cytogenetic Abnormalities

Genetic testing was only performed on 62 patients. 45.16% of patients had no genetic abnormalities, and t (8;21), and t (15;17) were found in 16.13% and 14.51% of patients, respectively. Other abnormalities were rare, as shown in Table 1. According to cytogenetic risk stratification based on ELN 2022 criteria (karyotype only), prognostic stratification could not be applied to the entire cohort (n = 121), as cytogenetic data were available for only 62 patients. Consequently, the reported proportions (35.4% favorable, 54.6% intermediate, and 10% adverse risk) refer exclusively to this subgroup of 62 patients, which represents 100% of the evaluable population, rather than to the overall study cohort.

Table 1. Distribution according to genetic abnormalities.

Genetic abnormality	n	%
Monosomy 7 with short arm rearrangements of chromosomes 12 and 17	1	1.61
Monosomy 7	1	1.61
Interstitial deletion of chromosome 5	1	1.61
Hyperploidy and t(3;21)	1	1.61
46,XY, del(3)(q13q26), del(5)(q13q34), add(7)(p15), ins(8;3)(q22;q13q26)	1	1.61
t(15;17)	9	14.51
t(8;21)	10	16.13
Hyperploidy and trisomy 8	1	1.61
inv(16)(q13q22)	1	1.61
t(11;17) variant of AML with t(15;17)	1	1.61
No cytogenetic abnormality	28	45.16
t(x;10)	1	1.61
t(9;11)	1	1.61
t(9;12)(q34;p13)	1	1.61
Trisomy 21	1	1.61
Hyperdiploidy (52 chromosomes)	1	1.61
Trisomy 8	1	1.61
Total	62	100.00

Survival

Overall Survival

In our cohort of patients with acute myeloid leukemia, the prognosis remains poor, with only 32 patients alive at the end of follow-up. The overall survival curve highlights a rapid decline in the probability of survival during the first few months after diagnosis, reflecting significant early mortality. The median overall survival is short, estimated at approximately 2 to 3 months, indicating that half of the patients die during this initial period. Subsequently, the curve tends to stabilize, plateauing at around 20–25% in the long term (beyond 20 months), corresponding to patients with a better response to treatment or more favorable prognostic factors.

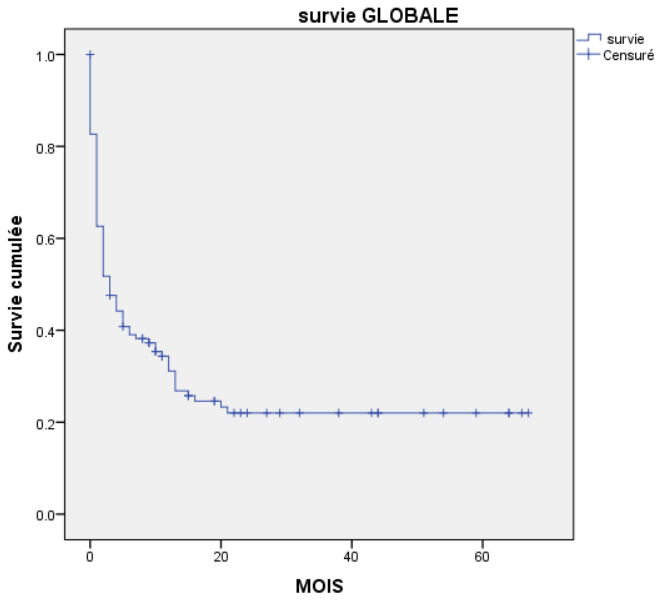

Figure 2. Overall survival curve of acute myeloid leukemia (AML).

Overall Survival According to Genetic Abnormalities

The figure represents the overall survival curves for the 62 patients studied, categorized into favorable karyotype (class A) (blue curve), intermediate karyotype (class B) (green curve), and unfavorable karyotype (class C) (yellow curve). Twenty-four-month survival was estimated at 50% for class A (favorable risk), indicating a relatively better prognosis, whereas it decreased to 41% for class B (intermediate risk), suggesting a less favorable evolution. In contrast, class C (adverse risk) was characterized by an extremely poor prognosis, with no survival beyond the sixth month.

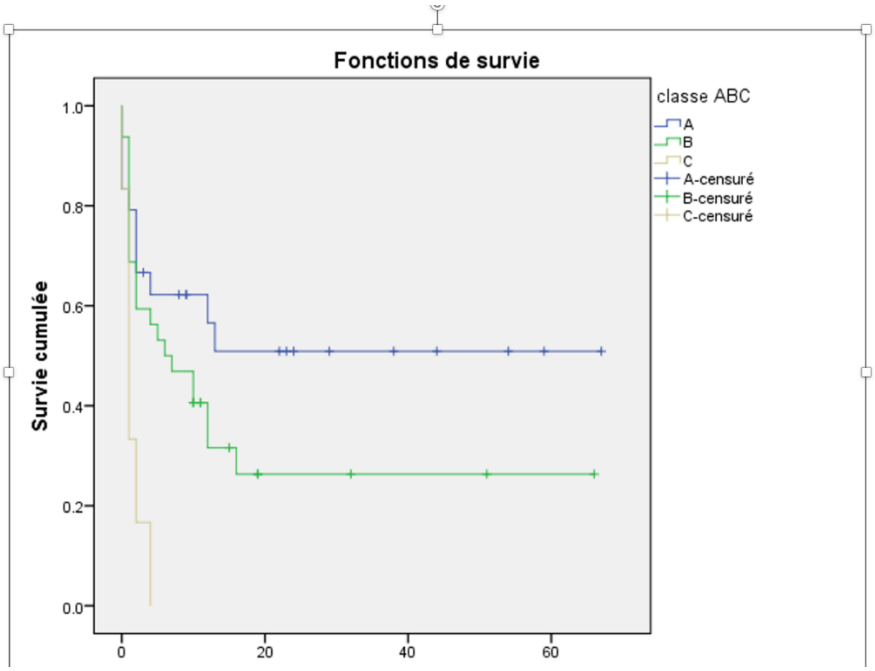

Figure 3. Overall survival curve of acute myeloblastic leukemias as a function of cytogenetic abnormalities.

In our cohort of AML patients, prognosis remained severe, with only 32 patients alive at the end of follow-up. The overall survival curve demonstrated a rapid decline in survival probability during the first months following diagnosis, reflecting significant early mortality. Median overall survival was short, estimated at approximately 2–3 months, indicating that half of the patients died during this initial period. Subsequently, the curve tended to stabilize with a plateau around 20–25% at long-term follow-up (beyond 20 months), corresponding to patients with better treatment response or more favorable prognostic factor.

4. DISCUSSION

In our study, the distribution of results by gender shows a slight female predominance (52%), with a male-to-female ratio of 0.92. This trend differs from the majority of international series consulted, which report, conversely, a male predominance. This is the case for studies conducted in Qatar (77% males) [12], at the Rabat Military Hospital (65.07%) [13], in Egypt (53.3%) [14]. Overall, in the different series compared in the literature, the sex ratio shows significant variability, ranging from 1.04 to 3.34. The median age of 49 years was lower than that reported in Western series, but close to several African and Middle Eastern series. The median age (49 years) is close to that reported by the national study (45 years) (Bekadja et al. [15]) and higher than that observed at the University of Assiut in Egypt (36.5 years) (Elnaggar et al. [14]) and that of Jeddah in Saudi Arabia (38 years) (Alsobhi et al.). [16]. In our series, the distribution according to performance status (PS) score was as follows: 54.55% of patients had a PS of 1, 29.75% a PS of 2, and 15.71% a PS ≥ 3.These results compare with international data. In Denmark [10], PS 1 was found in 41.67%, PS 2 in 16.68%, and PS ≥ 3 in 14.72%.

The clinical presentation was dominated by bone marrow failure syndromes, including anemia, hemorrhagic manifestations, and infections. Severe thrombocytopenia and significant blast infiltration were also frequently observed. The circumstances of the discovery of acute myeloid leukemia are primarily related to bone marrow failure. The initial clinical picture of our patients was marked by a clear predominance of anemia, present in 90.9% of cases.

Anemia syndrome: Our result (90.9%) is almost identical to that reported by the Military Hospital of Rabat in Morocco (91%) [13]. However, it is significantly more frequent than in the series from the University of Assiut in Egypt (26.7%) [14] and in Tunisia (15%) [17]. Hemorrhagic syndrome: This was found in 45.5% of our patients. This frequency is quite comparable to that observed in Tunisia (46%) [17]. On the other hand, it is much higher than that of the Egyptian series (20%) [14], but remains well below that of Qatar, where 86% of patients present with hemorrhagic manifestations at diagnosis [12]. Infectious syndrome: This affected 40.5% of our cohort. This rate is significantly higher than in other reported series: 14% in Rabat [13]. Tumor syndrome, reflecting tissue infiltration by blasts, manifested primarily in our series as organomegaly (including splenomegaly and hepatomegaly) as well as lymphadenopathy. Splenomegaly: This remained the most frequent finding in our cohort, present in 20.7% of patients. This result is generally nearer than the frequencies observed in Tunisia (16%) [17]. Hepatomegaly affected 16.5% of our patients. But in Egypt, data (splenomegaly, hepatomegaly, or both) were found in 30.8% [14].

In our study of 121 cases, retinal abnormalities were dominated by retinal hemorrhage, found in 37.8% of patients, while retinal edema affected 4.9%. Retinal hemorrhages represent the most common ophthalmological manifestation in acute leukemias, particularly AML, and are usually observed at diagnosis. They are most often associated with severe thrombocytopenia and anemia, reflecting leukemic retinopathy secondary to hematological disorders (18) In our cohort, 65.83% of patients had a platelet count below 50,000/µL, while 34.17% had a count greater than or equal to 50,000/µL. These results are comparable to those of the Saudi series [16]). In our series, the median LDH level was 698.64 IU/L, significantly lower than the Saudi study (median 473 IU/L) [16] and close to the Egyptian study (median 731.5 IU/L) [14].

The majority of patients (48.9%) had an LDH level between 300 and 850 IU/L, while 30.7% had a normal LDH level (< 300 IU/L) and 20.5% had an elevated LDH level (> 850 IU/L). Our cohort is distinguished by a proportion of normal LDH levels (30.7%) [16] and very high LDH levels (>850 IU/L: 20.5) [6]. Acute promyelocytic leukemia (AML3) accounted for 7.4% of our cases. This proportion is markedly different from that reported in Tunis (15.2%) by Sayadi et al. [18] and in Jeddah, Saudi Arabia (20.7%), as reported by Alsobhi et al. [16].

Cytogenetic abnormalities remain major prognostic factors. In our series, 45.16% of patients had no detectable genetic abnormalities, while 54.84% exhibited cytogenetic alterations. These results are comparable to those reported by M.G. Elnaggar in Egypt (56.5%) with no detectable genetic abnormalities [14], suggesting a degree of consistency between the two populations. However, lower frequencies were reported in the Spanish cohort (36%) [19], the Tunisian series by Gmidene A et al. (37.1%) [20], and the Moroccan study (44%) [21].

The t(15;17) translocation was identified in 14.5% of our patients, a frequency comparable to that reported by Srivastava et al. (16.7%) [23] and slightly higher than that observed by Elnaggar et al. (9.2%) [14]. However, it was lower than the prevalence reported by Thao et al. (19.6%) [24] and markedly higher than that found in the Moroccan cohort of Kaltoum et al. (3.9%) [21]. These variations may be explained by differences in study populations, inclusion criteria, and the proportion of acute promyelocytic leukemia cases within AML cohorts.

The t(8;21) translocation was detected in 16.1% of our patients, representing the highest frequency among the compared studies. This prevalence was substantially higher than those reported in Egypt [14] (7.5%), Vietnam [24] (10.1%), Morocco [21] (8.4%), and India [23] (7.2%). The relatively high occurrence of t(8;21) in our cohort may partly explain the increased proportion of patients classified within the favorable-risk group. As t(8;21) is a recurrent cytogenetic abnormality associated with favorable outcomes, its higher frequency may reflect geographic and population-based differences in the distribution of AML cytogenetic subtypes.

Regarding prognostic stratification, favorable-risk patients accounted for 35.4% of our cohort, a proportion comparable to that reported in Vietnam [24] (36%) and higher than those observed in Egypt [14] (24.2%), Morocco [21] (17%), and India [23] (25.6%). Conversely, the intermediate-risk group represented 54.6% of cases, a frequency similar to those reported in Vietnam [24] (53.6%) and India [23] (53.5%), while remaining lower than those observed in Egypt [14] (65%) and Morocco [21] (65.4%). These findings indicate a relatively favorable cytogenetic profile in our population, likely driven by the higher prevalence of favorable-risk abnormalities, particularly t(8;21) and t(15;17).

For the unfavorable prognostic group, the rate in our series is 10%, identical to the Egyptian study [14] and the Vietnamese study [24]. These results compare with data from the literature, as summarized in Table 2.

Overall Survival According to Genetic Abnormalities

Survival at 24 months for the favorable prognostic group (Class A) is estimated at 50%, reflecting a relatively favorable prognosis, while it decreases to 41% for the intermediate prognostic group (Class B), suggesting a more unfavorable outcome. In contrast, the unfavorable prognostic group (Class C) is characterized by an extremely poor prognosis, with no survival beyond the sixth month. The poor survival observed in the adverse-risk group is mainly related to the intrinsic biological aggressiveness of these cytogenetic

abnormalities rather than differences in therapeutic management, as patients received standard-of-care treatment in our center.These results are consistent with those in the literature [25] and clearly demonstrate that cytogenetic classification is an important prognostic factor in acute myeloid leukemia, allowing patients to be stratified into distinct risk groups and guiding therapeutic management.

Table 2. Comparative table of prognostic group frequencies across studies.

Parameters	Our study (N=62)	M.G. Elnaggar (2021, Egypt) N=120 [14]	Thao L.T.T (2023, Vietnam) N=336 [24]	Kaltoum ABO (2021, Morocco) N=927 [21]	Srivastava V.M (2023, India) N=1791 [23]
Normal karyotype	54.84%	56.5%	38.1%	44%	36.1%
t(15;17)	14.5%	9.2%	19.6%	3.9%	16.7%
t(8;21)	16.1%	7.5%	10.1%	8.4%	7.2%
Favorable risk	35.4%	24.2%	36%	17%	25.6%
Intermediate risk	54.6%	65%	53.6%	65.4%	53.5%

Limitations of the Study

This study has several limitations. First, it is a retrospective single-center study, making it susceptible to selection bias. In addition, the relatively small sample size may reduce statistical power and limit the generalizability of the findings to the broader AML population.

A major limitation of this study is the lack of routine molecular testing. Due to technical and resource constraints, prognostic stratification according to the ELN 2022 classification relied exclusively on conventional cytogenetic analysis (karyotyping). Consequently, several molecular abnormalities with established prognostic significance, such as mutations in NPM1, FLT3, CEBPA, TP53, RUNX1, and ASXL1, could not be assessed. The absence of these molecular data may have resulted in the misclassification of some patients and may have influenced the distribution of prognostic groups as well as survival analyses.

Furthermore, not all cytogenetic abnormalities recommended by ELN 2022 could be fully investigated in all patients because of technical and availability constraints. Patient follow-up was also heterogeneous, which may have affected overall survival estimates and the assessment of prognostic factors.

Finally, the absence of multivariate analysis limits the identification of independent prognostic factors. Prospective multicenter studies incorporating comprehensive molecular profiling are needed to provide a more accurate risk stratification and a better understanding of AML outcomes in our setting.

5. CONCLUSION

Acute myeloid leukemia remains a hematologic malignancy with a poor prognosis in our setting. Our results confirm the major prognostic value of cytogenetic classification in AML. The integration of molecular markers into routine cytogenetic investigations is now essential for more precise patient stratification according to ELN 2022 recommendations. Strengthening diagnostic platforms, together with improving access to innovative and targeted therapies, should be considered a priority to enhance treatment outcomes and overall survival.

Perspectives

Prospective multicenter studies including larger patient cohorts are needed to confirm our findings and improve their representativeness. Systematic integration of molecular analyses according to ELN 2022 recommendations would allow better prognostic stratification of AML patients. Improving access to molecular biology techniques and innovative therapies could also optimize therapeutic management and patient survival. Finally, a more detailed evaluation of clinical, biological, and cytogenetic prognostic factors may contribute to the development of predictive models adapted to our local context.

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