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RESEARCH

Characteristics, outcomes and treatment patterns in acute myeloid leukemia patients 60 years or older in Colombia: a RENEHOC-PETHEMA study

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Abstract

There is a limited information available on the clinical characteristics, treatment patterns and outcomes on older patients diagnosed with Acute Myeloid Leukemia (AML) in Latin-America. This multicenter retrospective study analyzed 269 patients over 60 years of age diagnosed with AML in Colombia, using data from RENEHOC-PETHEMA registry, from 2009 to 2023. The median age at diagnosis was 70 years (Range:60–98), 55% were men, 61% had an ECOG < 2, and 75.5% had *de novo* AML. FLT3-ITD or NPM1 mutations were performed in 23.4% and 15.6% patients, and detected in 14.3% and 16.7% of cases, respectively. Treatment included intensive chemotherapy (IC) (36.8%), Low-Intensity Regimen Based on Low-Dose Cytarabine (LDAC-based) (12.6%), hypomethylating agents (HMAs, with/without venetoclax) (35.3%), and supportive care (15.2%). The overall survival (OS) rate was 35.2% at 1 year and 5.6% at 5 years (13.7% for IC, 9.4% for LDAC-based, and 0% for other treatments); with median OS of 8.2 months (10.6 months after IC, 8.8 months after non-IC, 8.9 months after azacitidine/decitabine, 8.2 months after azacitidine-venetoclax, and 1.9 months with supportive care). Only 1.5% of patients underwent a transplant in the first line. The Leukemia-free survival (LFS) rate was 45.8% at 1-year and 13.7% at 5-years (22.4% for IC, 9.4% and 0% for other treatments); with median LFS of 9.5 months (17.3 months after IC, 7.4 months after LDAC-based, and 10.8 months after HMA). This study provides new insights into the management of patients in Colombia, highlighting the need for a highly individualized approach in treating AML in elderly patients.

Keywords Acute myeloid leukemia · Treatment outcomes · Elderly patients · Overall survival

Introduction

Acute myeloid leukemia (AML) is a heterogeneous spectrum of hematopoietic neoplasms characterized by the clonal proliferation of myeloid progenitors with impaired differentiation into mature blood elements [1]. Notably, AML shows a higher prevalence among men and older individuals, with an average age at diagnosis of 68 years in the United States [2]. Age is a predictive factor associated with an increased likelihood of developing a disease inherently resistant to chemotherapy, attributed to unfavorable cytogenetic or molecular profiles, deteriorated functional status, and a higher burden of comorbidities [3, 4].

There is no standard therapy for patients aged 60 years or older with AML. Current first-line recommendations include "3 + 7" or similar regimens for those believed suitable for intensive chemotherapy (IC), while hypomethylating agents (HMA) are preferred for those not suitable for IC, given their lower treatment-related mortality rates (TRM). However, HMAs offer only modest benefits in terms of response and survival compared to low-dose Cytarabine (Ara-C) [5, 6]

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On the other hand, clinical trials with azacitidine (AZA) and venetoclax (VEN) combination showed improved outcomes with a composite response rate (CR/CRi) ranging between 64.0% and 73.0% and a median OS ranging between 14.7 and 17.5 months [7, 8]. These advancements are expected to yield significant improvements [9, 10]. Nevertheless, there is still a high unmet medical need among older AML patients, a it has been shown by real-world data on HMAs plus VEN regimens efficacy, with remarkably inferior results as compared with clinical trial [11]. These findings underline the relevance of epidemiological studies revealing the patterns of routine practice and outcomes in this frail population.

As there are scarce data regarding treatment patterns and outcomes of AML in latin-american population, we aimed to retrospectively analyze 294 patients over 60 years of age diagnosed with AML in Colombia. Data was extracted from the RENEHOC-PETHEMA registry (NCT02607059).

Materials and methods

Registry

Patient registration from Colombia was eased through the implementation to the Epidemiological Registry of the Cohort of Patients Diagnosed with Hematologic Neoplasias and Diseases in Colombia (RENEHOC) by the Colombian Association of Hematology and Oncology (ACHO) (https://acho.com.co/renehoc/), which includes information from twenty-four Colombian institutions; using the PLATAFOLMA (https://platafolma.org) data base, a platform of the PETHEMA group (Spanish Hematology Treatment Program), were patient data from several countries, including Colombia, are stored (NCT02607059). Both applications feature online validation and user control. We retrospectively collected key disease and patient characteristics, including age, sex, cytomorphological evaluation confirming the AML diagnosis, neoplastic diseases and cytotoxic treatments previous, cytogenetic analysis, description of the first-line treatment regimen, evaluation of disease response to treatment, and disease follow-up (relapse or death). Baseline patient and disease characteristics were documented at the time of diagnosis, prior to treatment initiation.

Eligibility

Consecutively and without selection, patients aged ≥ 60 years diagnosed with AML (according to the WHO 2008 criteria, excluding acute promyelocytic leukemia) from January 2009 to September 2023 were included in this retrospective analysis from the RENEHOC-PETHEMA epidemiological registry. This study exclusively involved Colombian institutions and received approval from the Institutional Review Board (IRB) of each participating center. Furthermore, informed consent was obtained from all participating patients in accordance with the Declaration of Helsinki.

Treatment

In Colombia, in 2017, the Ministry of Health (MinSalud) published the clinical practice guide for the detection, treatment, and monitoring of lymphoblastic and myeloid leukemias in the population over 18 years of age, providing general recommendations [12]. However, each center had autonomy in adapting specific recommendations, with the most utilized guidelines being those from NCCN, ESMO, or PETHEMA.

The therapeutic approach for patients was stratified into five distinct groups based on treatment intensity and patient tolerance: Intensive Chemotherapy (IC), non-intensive chemotherapy (non-IC): Low-Intensity Regimen Based on Low-Dose Cytarabine (LDAC-based), Non-intensive Hypometylating Agents (HMA), Non-intensive Azacitidine plus Venetoclax (AZA-VEN), and Supportive Care (SC). IC schedules included the following regimens: 3 + 7 (Idarubicin or daunorubicin and Ara-C), mitoxantrone plus Ara-C, FLAG-Ida (Fludarabine, Idarubicin and Ara-C). HMA consisted of low-dose decitabine or azacitidine. The LDAC-based group included FLUGA (fludarabine 40 mg/m²/day orally or 25 mg/m²/day intravenously on days 2–5 or 6, combined with Ara-C 75 mg/m²/day on days 2–5, and G-CSF 5 µg/kg/day on days 1 and 3) or low-dose cytarabine. The HMA incluided azacitadine or decitadine. SC included patients receiving transfusions and other supportive measures, including oral agents to control the white blood cell (WBC) counts (i.e., hydroxyurea, melphalan, mercaptopurine or thioguanine).

Study definitions and endpoints

The classification of patients was performed according to the 2008 WHO criteria, with 20% or more blasts in peripheral blood or bone marrow and no prior history, in order to define de novo AML [13]. The method for counting blasts was count by morphological examination of the bone marrow aspirate. Secondary AML (sAML) was considered in patients who had evolved from a myelodysplastic syndrome (MDS), myelodysplastic or myeloproliferative neoplasms (MDS/MPN), or a blastic transformation of a myeloproliferative neoplasm (MPN), as well as those with a history of exposure to treatments such as radiotherapy or chemotherapy [13].

The achievement of Complete Response (CR) was defined as the presence of hematopoiesis of all three lines, < 5% blasts in the bone marrow sample obtained at the time of recovery of the peripheral blood count, with no circulating

blasts and extramedullary disease, and with an absolute neutrophil count > 1.0×10^9 /L and platelet count > 100×10^9 /L in peripheral blood. If patients did not reach these criteria, the response was classified as CR with incomplete hematological recovery (CRi) [9].

Partial response (PR) was defined as the presence of between 5 and 25% blasts in the bone marrow and a ≥ 50% reduction compared to baseline (hematological recovery was not needed). Patients with > 25% blasts or < 50% reduction were assessed as resistant, and those who died before response assessment were classified as induction death [10, 14]. In the context of stable disease with hematological improvement after non-IC, patients were classified as "other response". Criteria for relapse after a previous CR/CRi included reappearance of disease in the peripheral blood, ≥ 5% blasts in the bone marrow, or extramedullary disease [14].

The primary endpoint was OS, defined as time in months from the diagnosis of AML to the event of death, in all reported patients, comparing these results between different therapeutic approaches. Secondary endpoints included response to treatment and leukemia-free survival (LFS), defined as time in months from response to induction to the event of death, relapse, or secondary neoplasm.

Statistical analysis

A univariate analysis was performed for the characterization of the population, and a bivariate analysis was conducted for effect measures using Kaplan-Meier and Hazard Ratio (HR) for mortality. For all associations, a significance level $\alpha = 0.05$ was used as a reference. All statistical processes were conducted using R statistical software, version 2.2.14 (R Core Team, Vienna, Austria, http://www.R-project.org/).

Data sharing declaration

The data are the property of the Colombian Association of Hematology and Oncology of Colombia (ACHO and PETHEMA. To access PETHEMA data, contact montesinos_pau@gva.es and RENEHOC *virginia.abello@gmail.com*.

Results

Recruitment and patient profile

Overall, 294 patients aged ≥ 60 years old with newly diagnosed AML were registered. However, 25 patients were excluded due to the lack of documented therapeutic approaches.

The main characteristics of patients are shown in Table 1. This analysis encompassed a total of 269 patients aged ≥ 60 years diagnosed with AML, 55% of whom were men, median age of 70 years (range, 60–98). Among them, 61% had an ECOG < 2, comorbidities were significantly higher in the supportive care group ($p < 0.001$) and were also elevated in the non-intensive HMA group compared to those receiving venetoclax ($p = 0.001$). Cardiopathy and nephropathy were more prevalent in the supportive care group, with p-values of 0.004 and 0.019, respectively. No differences were observed in the presence of hepatopathy, diabetes, hypothyroidism, or dyslipidemia across the different treatment groups. N*ovo* AML was diagnosed in 75.5% of patients, 24.5% of cases were classified as sAML (73.5% were attributed to MDS, 23.5% to MPN, and 2.9% to MDS/MPN).

Additionally, 59 patients (21.9%) presented with a white blood cell count > 50×10^9 /L. Hemoglobin levels at diagnosis were ≤ 10 g/dL in 210 patients (79.6%), and creatinine levels > 1.3 mg/dL in 57 patients (21.2%).

Among those in whom cytogenetics were assessable ($n = 183$), 57.9% had normal results. Molecular testing revealed FLT3-ITD ($n = 63$) or NPM1 ($n = 54$) mutations in 14.3% and 16.7% of cases, respectively.

Characteristics according to therapeutic approach

Therapeutic approach data was missing in 25 (8.5%) patients. Overall, 99 (36.8%) received IC, 34 (12.6%) received LDAC-based, 70 (26%) HMA, 25 (9.3%) AZA-VEN and 41 (15.2%) SC.

The use of IC was predominant in the 60–69 years age group (82.8%), while non-IC was more common in the > 70 years group (55.0%), $p < 0.001$. Patients who received IC tended to have better ECOG performance status, with 84.1% having an ECOG index < 2 and a higher frequency of de novo AML (85.9%), and more (29.3%) had a leukocyte count > 50×10^9/L ($p = 0.064$). Among IC patients, 3 (3.0%) were successfully allo-grafted in the first CR/CRi, representing 1.1% of the overall series. No patients were allografted in the first CR/CRi following front-line non-IC treatments.

In contrast, patients who received SC were predominantly older, with 51.2% aged 80 years or older, compared to 7.3% in the 60 to 69 years group ($p < 0.001$). Additionally, 52.7% had an ECOG score > 2 ($p < 0.001$), and 12.0% had uric acid levels > 7 mg/dL. Across all treatment groups, creatinine values ≤1.3 mg/dL predominated, but more patients had abnormal renal function among SC patients ($p = 0.01$).

The most common regimen in the IC group was IDA + Ara-C (3 + 7) (26.4%), FLUGA in the LDAC-based group (8.9%), and azacitidine in the HMA group (24.5%) (Supplementary Table 1).

A comparative analysis of the periods before and after the approval of venetoclax in Colombia (September 2021)

Table 1 Sociodemographic, clinical and laboratory characteristics of the patients according to the therapeutic approach ($n=269$)

Characteristics	All patients	Intensive Chemotherapy (IC)	Non-intensive (non-IC)							Supportive care	P^a
			Total	LDAC-based	HMA-based			P^b			
					Total	Azacitidine or decitabine	Azacitidine + venetoclax	P^c			
	n(%)	*n*(%)	*n*(%)	*n*(%)	*n*(%)	*n*(%)	*n*(%)			*n*(%)	
Global	**269 (100)**	**99 (36.8)**	**129 (48.0)**	**34 (12.6)**	**95 (35.3)**	**70 (26.0)**	**25 (9.3)**			**41 (15.2)**	
Age, years*	70 (60–98)	64 (60–83)	73 (60–98)	72.5 (60–84)	73 (60–98)	72 (60–98)	74 (64–88)	0,48	0.301	80 (64–95)	<0.001**
60–69	128 (47.6)	82 (82.8)	43 (33.3)	11 (32.4)	32 (33.7)	26 (37.1)	6 (24.0)	0.276	0.881	3 (7.3)	<0.001
70–79	104 (38.7)	16 (16.2)	71 (55.0)	20 (58.8)	51 (53.7)	34 (48.6)	17 (68.0)			17 (41.5)	
≥ 80	37 (13.7)	1 (1.01)	15 (11.7)	3 (8.8)	12 (12.6)	10 (14.3)	2 (8.0)			21 (51.2)	
Gender										41 (100)	
Hombres	148 (55.0)	53 (53.5)	70 (54.3)	19 (55.9)	51 (53.7)	40 (57.1)	11 (44.0)	0.258	0.825	25 (61.0)	0.703
Mujeres	121 (45.0)	46 (46.5)	59 (45.7)	15 (44.1)	44 (46.3)	30 (48.9)	14 (56.0)			16 (39.0)	
ECOG	246 (100)	88 (100)	120 (100)	34 (100)	86 (100)	61 (100)	25 (100)			38 (100)	
0	51 (20.7)	28 (31.8)	22 (18.4)	6 (17.6)	16 (18.6)	8 (13.1)	8 (32.0)	0.263	0.905	1 (2.6)	<0.001
1	99 (40.3)	46 (52.3)	44 (36.7)	14 (41.2)	30 (34.9)	21 (34.4)	9 (36.0)			9 (23.7)	
2	56 (22.8)	11 (12.5)	37 (30.8)	9 (26.5)	28 (32.6)	22 (36.1)	6 (24.0)			8(21.0)	
3	36 (14.6)	3 (3.4)	16 (13.3)	5 (14.7)	11 (12.8)	9 (14.8)	2 (8.0)			17 (44.8)	
4	4 (1.6)	0 (0)	1 (0.8)	0 (0)	1 (1.1)	1 (1.6)	0 (0)			3 (7.9)	
Comorbilities											
Ausent	99 (38.8)	49 (53.8)	42 (34.2)	14 (42.4)	28 (31.1)	14 (21.2)	14 (58.3)	0.001	0.241	8 (19.5)	<0.001
Presence	156 (61.2)	42 (46.2)	81 (65.8)	19 (57.6)	62 (68.9)	52 (78.8)	10 (41.7)			33 (80.5)	
Type of AML	269 (100)	99 (100)	129 (100)	34 (100)	95 (100)	70 (100)	25 (100)			41 (100)	
De novo	203 (75.5)	85 (85.9)	89 (69.0)	17 (50.0)	72 (75.8)	54 (77.1)	18 (72.0)	0.606	0.005	29 (70.7)	0.01
Secundaria	66 (24.5)	14 (14.1)	40 (31.0)	17 (50.0)	23 (24.2)	16 (22.9)	7 (28.0)			12 (29.3)	
WBC, x 10^9dl/L	5.9 (0.1–272)	6.3 (0.44–272)	4.7 (0.19–134.2)	10.5 (0.25–134.2)	4.18 (0.19–117)	3.14 (0.19–117)	16 (0.35–88)			6.5 (0.1–258)	
5 a 10	150 (55.8)	52 (52.5)	75 (58.2)	16 (47.1)	59 (62.1)	48 (68.6)	11 (44.0)	0.067	0.305	23 (56.1)	0.064
10 a 50	60 (22.3)	18 (18.2)	35 (27.1)	12 (35.3)	23 (24.2)	13 (18.6)	10 (40.0)			7 (17.1)	
> 50	59 (21.9)	29 (29.3)	19 (14.7)	6 (17.6)	13 (13.7)	9 (12.8)	4 (16.0)			11 (26.8)	
Hemoglobin, g/dL*	8.5 (3–14.3)	8.8 (3.4–14.3)	8.4 (4.1–13.7)	8.5 (4.4–11.7)	8.3 (4.1–13.7)	8.0 (4.1–13.7)	8.4 (5.4–13.3)			8.5 (3–13.4)	
≤ 10	210 (79.6)	70 (73.7)	107 (83.6)	29 (87.9)	78 (82.1)	58 (82.9)	20 (80.0)	0.481	0.318	33 (80.5)	0.194
> 10	54 (20.4)	25 (26.3)	21 (16.4)	4 (12.1)	17 (17.9)	12 (17.1)	5 (20.0)			8 (19.5)	
Platelet count x 10^9/L*	51 (2–96)	504.5 (26–93)	46.2 (22–105.5)	52 (24–118)	44 (21–105)	36 (21–75)	92 (44–118)	0.029	0.459	51 (25–74)	0.854**
BM blasts, %*	46 (26–72.9)	56 (28–78.3)	38.9 (24–65)	45 (30–70)	38 (23.6–60)	38 (24.5–58.2)	38.5 (22–38.6)	0.984	0.289	50 (35.8–73.5)	0.038**
Creatinine, mg/dL*	0.9 (0.4–3.3)	0.81 (0.4–2)	0.905 (0.48–3.3)	0.9 (0.48–3.2)	0.91 (0.5–3.3)	0.94 (0.5–2.89)	0.84 (0.55–3.3)			1.05 (0.63–2.7)	
≤ 1,3	212 (78.8)	82 (82.8)	105 (81.4)	27 (74.4)	78 (82.1)	58 (82.9)	20 (80.0)	0.749	0.729	25 (61.0)	0.01
> 1,3	57 (21.2)	17 (17.2)	24 (18.6)	7 (20.6)	17 (17.9)	12 (17.1)	5 (20.0)			16 (39.0)	

Table 1 (continued)

Characteristics	All patients	Intensive Chemotherapy (IC)	Non-intensive (non-IC)							Supportive care	P^a
			Total	LDAC-based	HMA-based			P^c	P^b		
					Total	Azacitidine or decitabine	Azacitidine + venetoclax				
	n(%)	*n*(%)	*n*(%)	*n*(%)	*n*(%)	*n*(%)	*n*(%)			*n*(%)	
Uric acid, mg/dL	171 (100)	63 (100)	83 (100)	19 (100)	64 (100)	42 (100)	22 (100)			25 (100)	
≤7	136 (79.5)	50 (79.4)	64 (77.1)	12 (63.2)	52 (81.2)	33 (63.5)	19 (86.4)	0.521	0.099	22 (88.0)	0.496
>7	35 (20.5)	13 (20.6)	19 (22.9)	7 (36.8)	12 (18.8)	9 (21.4)	3 (13.6)			3 (12.0)	
Bilirubin, mg/dL	211 (100)	77 (100)	102 (100)	24 (100)	78 (100)	57 (100)	21 (100)			32 (100)	
≤1,2	171 (81.0)	62 (80.5)	86 (84.3)	18 (75.0)	68 (87.2)	49 (86.0)	19 (90.5)	0.597	0.151	23 (71.9)	0.290
>1,2	40 (19.0)	15 (19.5)	16 (15.7)	6 (25.0)	10 (12.8)	8 (14.0)	2 (9.5)			9 (28.1)	
Albumin, g/dL	153 (100)	55 (100)	74 (100)	18 (100)	56 (100)	41 (100)	15 (100)			24 (100)	
≤3,5	100 (65.4)	34 (61.8)	51 (68.9)	11 (61.1)	40 (71.4)	30 (73.2)	10 (66.7)	0.633	0.411	15 (62.5)	0.669
>3,5	53 (34.6)	21 (38.2)	23 (31.1)	7 (38.9)	16 (28.6)	11 (26.8)	5 (33.3)			9 (37.5)	
LDH, U/L	210 (100)	75 (100)	106 (100)	26 (100)	80 (100)	58 (100)	22 (100)			29 (100)	
≤600	154 (73.3)	54 (72.0)	81 (76.4)	16(61.5)	65 (81.2)	47 (81.0)	18 (81.8)	0.936	0.061	19 (65.5)	0.475
>600	56 (26.7)	21 (28.0)	25 (23.6)	10 (38.4)	15 (18.8)	11 (19.0)	4 (18.2)			10 (34.5)	
Cytogenetics	183 (100)	73 (100)	91 (100)	23 (100)	68 (100)	45 (100)	23 (100)			19 (100)	
Normal	106 (57.9)	49 (67.1)	50 (54.9)	11 (47.8)	39 (57.3)	28 (62.2)	11 (47.8)	0.50	0.613	7 (36.8)	0.069
Anormal	65 (35.5)	18 (24.7)	36 (39.6)	10 (43.5)	26 (72.2)	15 (33.3)	11 (47.8)			11 (57.9)	
No metaphases	12 (6.6)	6 (8.2)	5 (5.5)	2 (8.7)	3 (4.4)	2 (4.5)	1 (4.4)			1 (5.3)	
FLT3-ITD	63 (100)	32 (100)	29 (100)	3 (100)	26 (100)	13 (100)	13 (100)			2 (100)	
Positive	9 (14.3)	4 (12.5)	4 (13.8)	1 (33.3)	3 (11.5)	0 (0)	3 (23.1)	0.220	0.3	1 (50)	0.378
Negative	54 (85.7)	28 (87.5)	25 (86.2)	2 (66.7)	23 (88.5)	13 (100)	10 (76.9)			1 (50)	
NPM1	42 (100)	19 (100)	22 (100)	4 (100)	18 (100)	7 (100)	11 (100)			1 (100)	
Positive	7 (16,7)	3 (15.8)	3 (13.6)	1 (25.0)	2 (11.1)	0 (0)	2 (18.2)	0.231	0.470	1 (100)	0.250
Negative	35 (83.3)	16 (84.2)	19 (86.4)	3 (75.0)	16 (88.9)	7 (100.0)	9 (81.8)			0 (0)	

*Result in Median (range). **P compare continuous variables. P^a; compare therapeutic approaches, P^b; compare semiintensive vs. HMA, P^{cc}; compare monotherapy vs. azacitidine-venetoclax. *ECOG* Eastern Cooperative Oncology Group, *AML* acute myeloid leukemia, *WBC* white blood cells, *LDH* lactate dehydrogenase, *FLT3* FMS-like tyrosine kinase 3, *ITD* internal tandem duplication, *NPM1* Nucleophosmin1

demonstrated significant changes in treatment indications. After this approval, a reduction was observed in the indication for IC (40.5% vs. 20.4%) and SC (16.8% vs. 8.2%), along with an increase in the use of non-IC therapies (42.7% vs. 71.4%), $p = 0.001$ (Table 2).

Response to front-line therapy

Of 187 evaluable patients for response, 84 (44.9%) achieved CR/CRi, 21 (11.2%) achieved PR, 32 (17.1%) exhibited resistance, 5 (2.7%) demonstrated another response, and 45 (24.1%) died during induction. The CR/CRi rate was lower in those who received non-IC compared to those who received IC, with rates of 39.4% and 53.6%, respectively. Among the five groups, the highest CR/CRi rate was observed in the intensive chemotherapy (IC) group, with a rate of 53.6%. Within the non-intensive groups, however, the CR/CRi rate was notably higher in those who received AZA-VEN achieving 69.5% (16 out of 23 patients) (Table 3).

Long-term outcomes

Overall survival

The median OS was 8.2 months (95%CI 6.4–9.5), with 1-year and 5-year OS rates of 35.2% (95%CI 29.2–41.2) and 5.6% (95%CI 2.5–10.6), respectively. Median OS was 10.6 months in patients who received IC, 8.8 months in those treated with non-IC, LDAC-based 8.9 months (95%CI 6.6–14.4), HMA 8.9 months (95%CI 5.9–14.3), AZA-VEN 8.2 months (95%CI 4.5–8.2) and 1.9 months in patients who received SC. At 5 years of follow-up, patients who received IC had an OS of 13.7% (95% CI 6.1–24.5) (Table 3; Fig. 1). Median OS between HMA and AZA-VEN did not show statistical significance was ($p = 0.53$).

Leukemia-free survival (LFS)

LFS rates were 45.8% at 1 year and 13.7% at 5 years across all patients. Among those who received IC, the 5-year LFS was 22.4% (Table 3; Fig. 2). The median LFS for the overall patient population was 9.5 months (95%CI: 6.6–15.1), whereas in the IC-treated group, the median LFS increased to 17.3 months (95%CI: 7.7–29.1), for LDAC-based patients was 7.4 months (95%CI: 4.6–10), while for those receiving HMA it was 10.8 months (95%CI: 5.3–15.1).

Discussion

This study provides real-world evidence on treatment patterns and outcomes in patients ≥ 60 years with AML in Colombia, a middle-income country. This analysis of the multicenter RENEHOC-PETHEMA registry included 269 patients aged 60 years or older, with a median age of 70 years, which is somewhat lower than the findings of studies focused on older patients in Spain and Mexico [14–16]. One could argue that the relatively younger median age of our patients compared to the Spanish study may be related to a lower life expectancy: 77.2 years in Colombia versus 83.2 years in Spain [17]. Our findings, in comparison with other studies, indicate consistency in the higher incidence in men [18, 19], poorer functional status [14, 20, 21], and a proportion of secondary AML concordant with the Spanish population [14] and higher than that in Mexico [16].

Cytogenetic analysis plays a vital role in managing AML in the elderly, influencing prognosis, treatment decisions, and risk [22]. This emphasizes the importance of karyotype as a critical and independent prognostic factor in older AML patients, potentially informing stratified treatment approaches [23]. Unfortunately, there was a 32% loss of karyotype data in this study, coupled with an additional 6.6% with non-assessable karyotypes, rendered it unsuitable as a marker for initial therapy selection in many cases, further hindered by the inability to obtain results within the ELN 2017 recommended from an international expert panel (9). Similar limitations affected molecular testing results. Only 63 patients (23.4%) underwent FLT3-ITD testing, with only 9 positive results (14.3%). Despite limited data, these findings were comparable to those of the VILMA study [14] with 209 patients (14%) being FLT3-ITD positive. NPM1 testing was performed in only 42 patients, resulting in 16.7% NPM1 mutations, while the Spanish VILMA study reported positivity in 26% of tested subjects. Our limited data are in agreement with a study on patients from Latin American countries (Colombia, Panama, and Peru), where 89% lacked FLT3 or NPM1 testing, highlighting a regional shortcoming [14, 24].

Table 2 Proportion of therapeutic approach according to availability of venetoclax in Colombia

Time frame	Overall *n* (%)		Intensive chemotherapy *n* (%)		Non-intensive *n* (%)		Supportive care *n* (%)		*P*
Until september 2021	220	(81.8)	89	(40.5)	94	(42.7)	37	(16.8)	0.001
Later september 2021	49	(18.2)	10	(20.4)	35	(71.4)	4	(8.2)	

Table 3 Main clinical outcomes according to therapeutic approach

Variable	All patients	Therapeutic approach									P^a
		Intensive chemotherapy	Non-intensive							Supportive care	
			Total	LDAC-based	HMA-based				P^b		
					Total	Azacitidine o decitabine	Azacitidine – venetoclax	P^c			
Response, n (%)	**187 (100)**	**84 (100)**	**99 (100)**	**29 (100)**	**70 (100)**	**47 (100)**	**23 (100)**			**4 (100)**	
ORR (CR + CRi)	84 (44.9)	45 (53.6)	39 (39.4)	13 (44.8)	26 (37.1)	10 (21.3)	16 (69.5)				
CR	66 (35.3)	39 (46.4)	27 (27.3)	7 (24.1)	20 (28.6)	7 (14.9)	13(56.5)	<0.01	<0.01	–	0.054
CRi	18 (9.6)	6 (7.2)	12(12.1)	6 (20.7)	6 (8.5)	3 (6.4)	3 (13.0)			–	
PR	21 (11.2)	8 (9.5)	13 (13.1)	3 (10.3)	10 (14.3)	8 (17.0)	2 (8.7)			–	
Resistance	32 (17.1)	12 (14.3)	19 (19.2)	6 (20.8)	13 (18.6)	13 (27.7)	0			1 (25.0)	
Induction death	45 (24.1)	18 (21.4)	25 (25.3)	7 (24.1)	18 (25.7)	14 (29.8)	4 (17.4)			2 (50.0)	
Other	5 (2.7)	1 (1.2)	3 (3.0)	0	3 (4.3)	2 (4.3)	1 (4.4)			1 (25.0)	
Overall Survival, n (%)	**263 (100)**	**94 (35.8)**	**129 (49.0)**	**34 (12.9)**	**95 (36.1)**	**70 (26.6)**	**25 (9.5)**			**40 (15.2)**	
Median (95%CI), months	8.2 (6.4–9.5)	10.6 (8.3–21.5)	8.8 (6.6–10.4)	8.9 (6.6–14.4)	7.1 (4.0–10.1)	8.9 (5.9–14.3)	8.2 (4.5–8.2)			1.9 (1.0–5.0)	
1 year (95%CI)	35.2 (29.2–41.2)	47.9 (36.7–58.3)	37.9 (28.7–47.1)	26.3 (12.6–42.2)	43.2 (31.8–54.0)	42.5 (29.8–54.6)	47.2 (22.4–68.6)			10.3 (3.3–22.1)	
5 yearS (95%CI)	5.6 (2.5–10.6)	13.7 (6.1–24.5)	-	9.4 (1.9–24.6)	2.9 (0.2–12.3)	-	-			-	
Time since Diagnosis (months)	5.1 (0– 146.5)	6.6 (0–146.5)	5.9 (0 –54.5)	7.1 (3.1–11.9)	5.9 (1.8–14.4)	6.2 (1.8–14.9)	4.6 (2.1–8.2)			1.8 (0–35.4)	<0.01
Hazard ratio		1.63 (1.17–2.28)	1.46 (0.9–2.3)		0.8 (0.4–1.6)			0.537	0.098	0.31 (0.21–0.48)	<0.01
Leukemia-Free Survival, n (%)	**84 (100)**	**44 (52.4)**	**40 (47.6)**	**13 (15.5)**	**27 (32.1)**	**11 (13.1)**	**16 (19.0)**				
Median (95%CI), months	9.5 (6.6–15.1)	17.3 (7.7–29.1)	8 (4.9–10)	7.4 (4.6–10)	8 (3.9–14.7)	10.8 (5.3–15.1)	4.9 (1.4–4.9)			–	
1 year (95%CI)	45.8 (34–56.8)	60.7 (44.0–63.8)	26.3 (12.3–42.6)	17.9 (2.9–43.4)	32.1 (13.1–53.0)	40.4 (12.5–67.4)	30.1 (7.5–57.2)			–	
5 years (95%CI)	13.7 (5.9–24.6)	22.4 (9.7–38.4)	–	–	–	–	–			–	
Time since Diagnosis (months)	7.5 (0–142)	12.4 (0–142)	5.9 (0–32)	6 (4–24)	5.2 (0–32)	8.2 (3–32)	2.3 (0–22)			–	
Hazard ratio			2.2 (1.3–3.4)		1.1 (0.5–2.4)		1.8 (0.6–4.8)	0.239	0.799	–	0.004

P^a; compare therapeutic approaches, P^b; compare semiintensive vs. HMA, P^c; compare monotherapy vs. azacitidine-venetoclax

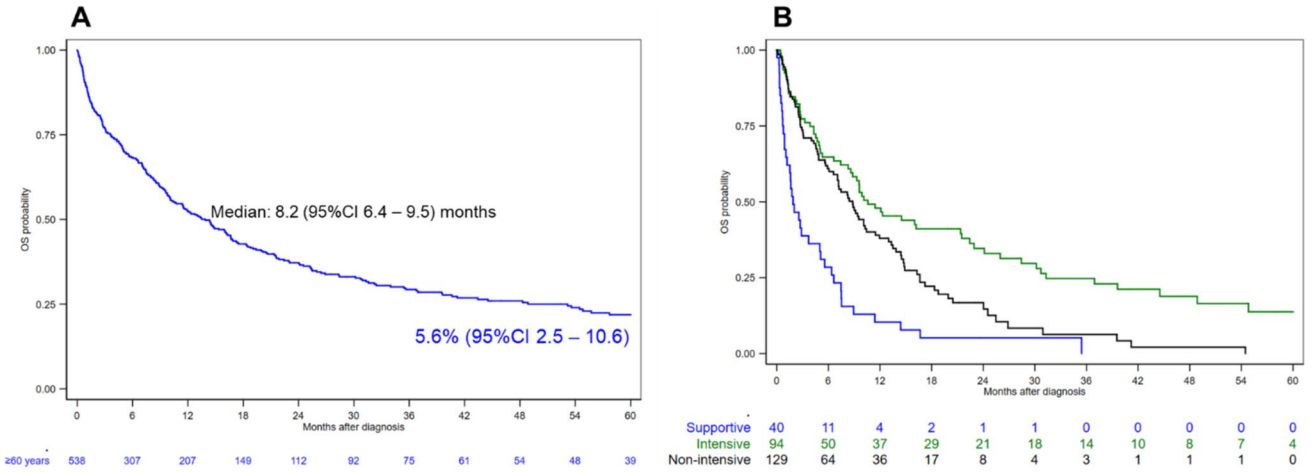

Fig. 1 Overall survival (OS) in elderly AML patients. **a.** Global OS; **b**. OS according to therapeutic approach

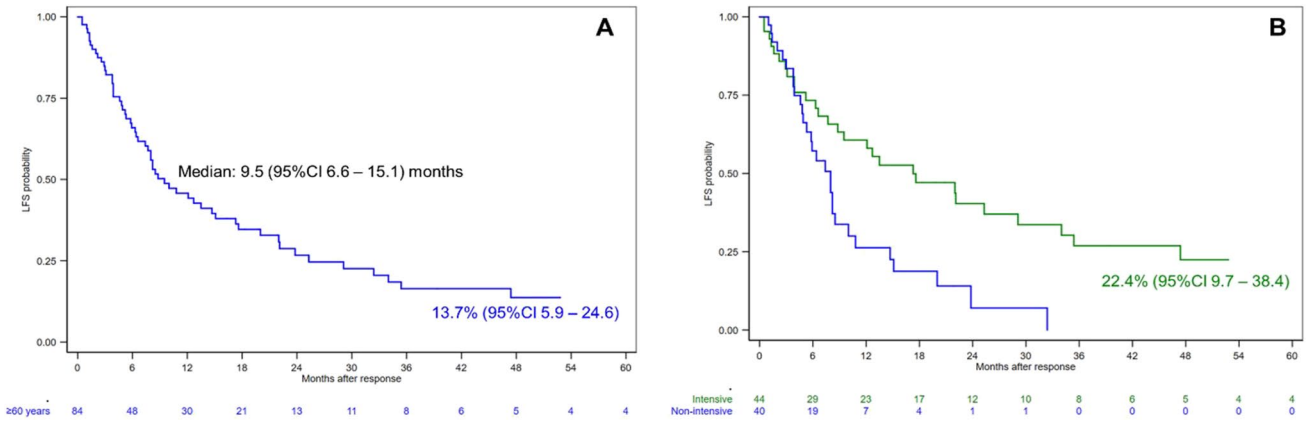

Fig. 2 Leukemia-Free Survival (LFS) in elderly AML patients. **a**. Global LFS; **b**. LFS according to therapeutic approach

Among 228 patients (84.7%) actively treated, roughly half received non-IC. Talati et al. [19] reported in a cohort of 980 patients aged 70 or older a lower frequency non-IC approach (35.3%), including 255 (26%) patients receiving hypomethylating and 91 (9.3%) receiving other low-intensity regimens. Notably, the VILMA study and a study conducted with patients from a single Colombian also institution, both showed a predominance of IC use [14, 25]. Within the IC group, idarubicin was the most used anthracycline, while azacitidine was favored over decitabine as hypomethylating agent, like a study by the PETHEMA group analyzing outcomes with HMAs [26]. Patients receiving IC were younger, with a median age of 64 years, compared to 72.5 years in the LDAC-based, 72 years in the HMA group, 74 years in the AZA-VEN group and 80 years in the SC group.

ECOG performance status 0–1 was more frequent in patients receiving IC compared to SC (84% vs. 55%), a trend also observed in the VILMA study [14] where ECOG status 0–1 was seen in 75%, 68%, and 42% of patients in the IC, non-IC, and SC groups, respectively.

Furthermore, approximately one-third of patients receiving IC had white blood cell counts exceeding 50×10^9/L ($p = 0.01$), which could be related to more leukocytes among younger patients and/or a need for more intensive cytoreduction among hyperleukocytic AML patients.

Evaluation of the overall response to treatment revealed significant differences based on the treatment received. Patients who received IC exhibited higher CR/CRi rates (53.6%), in line with European or North-American countries studies [14, 19]. For patients who received non-IC, the CR/CRi rate was 39.4%, inferior to those reported by Wei et al., who evaluated 211 adult AML patient's ineligible for conventional intensive chemotherapy and received venetoclax combined with low-dose Ara-C, where the overall response rate was 48% [27]. However, our CR/CRi rate for AZA-VEN was higher (69.5%) than with other non-IC options in our

cohort (21.3% and 44.8%), and comparable to that reported in the VIALE study.

Furthermore, patients treated with IC achieved a median OS of 10.6 months, compared to 8.8 months for those receiving HMA. Our findings are consistent with previous reports, including those from Récher et al. who observed a median OS of 10.9 months in patients receiving IC compared to 9.2 months for those treated with non-intensive therapies [18]. Similarly, Bell et al. reported a median OS of 14.7 months vs. 4.3 months for patients treated with IC and non-IC, respectively [15]. These findings are also similar to those of the VILMA study, which reported a median OS of 8.6 months for the IC group and 7.8 months for the non-IC group 13). Furthermore, patients who exclusively received SC had a median OS of 1.9 month, consistent with the findings of a similar Latin American AML study and the VILMA study (1.38 months; 1.2 months) [14, 24].

Our data suggest that, consistent with observations from the VILMA study, the choice of treatment regimen was not solely based on factors such as age, ECOG, and certain abnormalities in laboratory tests related to comorbidities (e.g., elevated creatinine levels), which were more frequently observed in patients who received SC. Disease characteristics, such as elevated white blood cell counts and the presence of secondary AML, also influenced the choice of TA [14].

Although the results of this study suggest that AZA-VEN achieves similar OS compared with HMA monotherapy, we confirm that it was able to induce a higher proportion of CR/CRi. However, larger analyses are needed to confirm whether the potential benefit attributed to AZA-VEN.

While our study offers valuable real-world data, it is constrained by the limited number of AML cases aged 60 years or older selected from the RENEHOC-PETHEMA registry (2003–2023) across 13 Colombian hospitals, which only yielded a total of 560 AML cases nationwide. This figure represents less than half of the 1,400 prevalent cases reported by the Cuenta de Alto Costo of Colombia in 2021, indicating potential selection bias [28]. In fact, as our treatment outcomes were in general comparable to European and North-Amercian countries, we could hypothesize that our series was enriched by AML patients from referral institutions in Colombia. In fact, there was a stringent selection process for participating centers, including the requirement for a hematologist researcher, membership in ACHO, and approval from ethics committees. All these criteria ensured robust data collection and high-quality information for each registered AML case.

Our findings should encourage latin-american medical community to improve patient selection for new therapeutic options for AML. Additionally, these data may influence payers to recognize the need for therapies that improve outcomes in older patients with this disease, as well as the need of full genetic AML characterization, and access to curative approaches with IC with or without allogeneic stem cell transplant. Furthermore, this study exemplifies successful collaboration between established cooperative groups, such as PETHEMA and emerging groups like RENEHOC, establishing a network of hematology professionals in a middle-income country.

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Author contributions Conceptualization, methodology, investigation, and validation of the study performed by Claudia Sossa-Melo, Virginia Abello Polo, Luis A. Salazar, Angela M. Peña, María Luna-González, Diana Cuervo-Lozada, Guillermo E. Quintero-Vega, Jorge Daza, Olga Paola Omaña-Orduz, William Mantilla, Iván Perdomo, Kenny Galvez, Laura María Díaz Correa, Paola Andrea Guerrero-Burbano, Juan Manuel Herrera, Henry Idrobo, LM Gaviria, Mario Ernesto Correa Correa, José Lobatón, Carlos Daniel Bermúdez, Julian Eduardo Pedraza Morales, Juan Carlos Serrano Casas, Francisco Jaramillo, Rigoberto Gómez, Carmen Rosales, María Helena Solano, Carlos Varón, David Martínez-Cuadrón, and Pau Montesinos. Formal analysis and writing original draft were performed by Claudia Sossa-Melo, Pau Montesinos, María Luna-González, and David Martínez-Cuadrón. Writing review and editing were Claudia Sossa-Melo, Virginia Abello Polo, Luis A. Salazar, Angela M. Peña, María Luna-González, Diana Cuervo-Lozada, Guillermo E. Quintero-Vega, Jorge Daza, Olga Paola Omaña-Orduz, William Mantilla, Iván Perdomo, Kenny Galvez, Laura María Díaz Correa, Paola Andrea Guerrero-Burbano, Juan Manuel Herrera, Henry Idrobo, LM Gaviria, Mario Ernesto Correa Correa, José Lobatón, Carlos Daniel Bermúdez, Julian Eduardo Pedraza Morales, Juan Carlos Serrano Casas, Francisco Jaramillo, Rigoberto Gómez, Carmen Rosales, María Helena Solano, Carlos Varón, Rebeca Rodríguez Veiga, David Martínez-Cuadrón, and Pau Montesinos

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Data availability No datasets were generated or analysed during the current study.

Declarations

Ethics approval General approval was obtained for the RENEHOC registry, and specific approval was granted by the Institutional Review Boards of each participating center. All procedures adhered to the ethical principles outlined in the Declaration of Helsinki.

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

Competing interests The authors declare no competing interests.

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References

1. Arber DA, Orazi A, Hasserjian R, Thiele J, Borowitz MJ, Le Beau MM et al (2016) The revision to the World Health Organization classification of myeloid neoplasms and acute leukemia. Blood 127(20):2391–405. [Internet]. 2016 May 19 [cited 2023 Sep 25]; https://doi.org/10.1182/blood-2016-03-643544
2. American Cancer Society Leucemia Mieloide Aguda (LMA) [Internet]. 2023 [cited 2023 Sep 16]. https://www.cancer.org/es/cancer/tipos/leucemia-mieloide-aguda/acerca/que-es-leucemia-mieloide-aguda.html
3. Podoltsev NA, Stahl M, Zeidan AM, Gore SD (2017) Selecting initial treatment of acute myeloid leukaemia in older adults. Blood Rev 31(2):43–62
4. Appelbaum FR, Gundacker H, Head DR, Slovak ML, Willman CL, Godwin JE et al (2006) Age and acute myeloid leukemia. Blood. [cited 2023 Sep 19];107(9):3481–5. https://doi.org/10.1182/blood-2005-09-3724
5. Alsouqi A, Geramita E, Im A (2023) Treatment of acute myeloid leukemia in older adults. Cancers 15(22):5409. https://doi.org/10.3390/cancers15225409
6. Dombret H, Seymour JF, Butrym A, Wierzbowska A, Selleslag D, Jang JH et al (2015) Clinical trials and observations: international phase 3 study of azacitidine vs conventional care regimens in older patients with newly diagnosed AML with > 30% blasts. Blood [Internet]. [cited 2023 Oct 11];126(3):291. Available from: /pmc/articles/PMC4504945/
7. DiNardo CD, Pratz K, Pullarkat V, Jonas BA, Arellano M, Becker PS et al (2019) Venetoclax combined with decitabine or azacitidine in treatment-naive, elderly patients with acute myeloid leukemia. Blood 133(1):7–17
8. DiNardo CD, Tiong IS, Quaglieri A, MacRaild S, Loghavi S, Brown FC et al (2020) Molecular patterns of response and treatment failure after frontline venetoclax combinations in older patients with AML. Blood 135(11):791–803
9. Döhner H, Estey E, Grimwade D, Amadori S, Appelbaum FR, Büchner T et al (2017) Diagnosis and management of AML in adults: 2017 ELN recommendations from an international expert panel. Blood. [cited 2022 Apr 19];129(4):424–47. https://doi.org/10.1182/blood-2016-08-733196
10. Pollyea DA, Altman JK, Chair V, Bixby D, Fathi AT, Foran JM et al (2023) NCCN Guidelines Versión 3.2023 Leucemia mieloide aguda (Edad ≥ 18 años) [Internet]. [cited 2023 Sep 25]. https://www.nccn.org/home/
11. Solana-Altabella A, Rodríguez-Veiga R, Martínez-Cuadrón D, Montesinos P (2024) A systematic review of venetoclax for the treatment of unfit AML patients in real-world: is all that glitters gold? Annals of hematology. https://doi.org/10.1007/s00277-024-05891-w
12. Ministerio de Salud y Protección Social (2017) Guía de práctica clínica para la detección, tratamiento y seguimiento de leucemias linfoblástica y mieloide en la población mayor de 18 años, 1st edn. Bogotá, Colombia
13. Vardiman JW, Thiele J, Arber DA, Brunning RD, Borowitz MJ, Porwit A et al (2009) The 2008 revision of the World Health Organization (WHO) classification of myeloid neoplasms and acute leukemia: Rationale and important changes. Blood J Am Soc Hematol 114: 937–951
14. Martínez-Cuadrón D, Serrano J, Gil C, Tormo M, Martínez-Sánchez P, Pérez-Simón JA et al (2021) Evolving treatment patterns and outcomes in older patients (≥ 60 years) with AML: changing everything to change nothing? Leukemia. [cited 2023 Sep 25];35(6):1571–85. https://doi.org/10.1038/s41375-020-01058-4
15. Bell JA, Galaznik A, Farrelly E, Blazer M, Murty S, Ogbonnaya A et al (2019) A retrospective study evaluating treatment patterns and survival outcomes in elderly patients with acute myeloid leukemia treated in the United States with either 7 + 3 or a hypomethylating agent. Leuk Res 78:45–51
16. Jaime-Pérez JC, Ramos-Dávila EM, Picón-Galindo E, Jiménez-Castillo RA, De León AG, Gómez-Almaguer D (2023) Outcomes and survival predictors of Latin American older adults with acute myeloid leukemia: data from a single center. Hematol Transfus Cell Ther 45:S43–50
17. Banco Mundial Datos de libre acceso del Banco Mundial [Internet]. 2022. https://datos.bancomundial.org/. Accessed 11 Oct 2023
18. Récher C, Röllig C, Bérard E, Bertoli S, Dumas PY, Tavitian S et al (2022) Long-term survival after intensive chemotherapy or hypomethylating agents in AML patients aged 70 years and older: a large patient data set study from European registries. Leukemia 36(4):913–922
19. Talati C, Dhulipala VC, Extermann M, Al Ali N, Kim J, Komrokji R et al (2020) Comparisons of commonly used front-line regimens on sur vival outcomes in patients aged 70 years and older with acute myeloid leukemia. Haematologica 105(2):398–406
20. Juliusson G, Antunovic P, Derolf Å, Lehmann S, Möllgård L, Stockelberg D et al (2009) Age and acute myeloid leukemia: real world data on decision to treat and outcomes from the Swedish Acute Leukemia Registry. Blood 113(18):4179–4187
21. Nagel G, Weber D, Fromm E, Erhardt S, Lübbert M, Fiedler W et al (2017) Epidemiological, genetic, and clinical characterization by age of newly diagnosed acute myeloid leukemia based on an academic population-based registry study (AMLSG BiO). Ann Hematol 96(12):1993–2003. https://doi.org/10.1007/s00277-017-3150-3
22. Estey EH (2018) Acute myeloid leukemia: 2019 update on risk-stratification and management. Am J Hematol 93(10):1267–1291
23. Grimwade D, Walker H, Harrison G, Oliver F, Chatters S, Harrison CJ et al (2001) The predictive value of hierarchical cytogenetic classification in older adults with acute myeloid leukemia (AML): analysis of 1065 patients entered into the United Kingdom Medical Research Council AML11 trial. Blood 98(5):1312–1320
24. Gálvez-Cárdenas KM, Enciso-Olivera LJ, Samanez-Figari CA, Quintana-Truyenque S, Castillo-Ríos BA, Quintero-Vega GE et al (2023) Treatment patterns and clinical outcomes in acute myeloid leukemia patients who are not eligible for intensive induction chemotherapy: a real-world study from Latin-America. Med Y Laboratorio 27(4):315–332

25. Mendoza-Urbano DM, Tello-Cajiao ME, Rosales J, Ahumada FE, Parra-Lara LG, Arrieta E (2023) Survival in elderly patients diagnosed with acute myeloid leukemia: a hospital-based study. J Hematol 12(1):7–15
26. Labrador J, de la Fuente A, Martínez-Cuadrón D, Rodríguez-Veiga R, Serrano J, Tormo M et al (2021) Long-term subgroup analyses from azacitidine vs. decitabine in unfit newly diagnosed Acute myeloid leukemia patients: results from the Pethema registry. Blood 138(Supplement 1):1256–1256
27. Wei AH, Montesinos P, Ivanov V, DiNardo CD, Novak J, Laribi K et al Venetoclax plus LDAC for newly diagnosed AML ineligible for intensive chemotherapy: a phase 3 randomized placebo-controlled trial. Blood 135(24):2137. [Internet]. 2020 Jun 6 [cited 2023 Sep 28]; https://doi.org/10.1182/blood.2020004856
28. Fondo Colombiano de Enfermedades de Alto Costo, Cuenta de Alto Costo (CAC) (2023) Situación del cáncer en la población adulta atendida en el SGSSS de Colombia 2022; Bogotá, D.C. https://cuentadealtocosto.org/publicaciones/situacion-del-cancer-en-la-poblacion-adulta-atendida-en-el-sgsss-decolombia-2022/

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