A microscopic view of blood cells, showing several red blood cells (erythrocytes) in red and several white blood cells (leukocytes) in purple. The cells are scattered across the frame, with some in sharp focus and others blurred in the background.

Promising Clinical Trials and the Future Clinical Landscape of MDS

MDS Foundation Patient and Family Forum Agenda

Denver, Colorado

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UNIVERSITY OF COLORADO DIVISION OF HEMATOLOGY

Disclosures

- Research funding from Abbvie, Bristol Myers Squibb, Karyopharm and Teva
- Consultant and/or advisory board member for Karyopharm, MEI, OncoVerity, Rigel, Abbvie, Syndax, Treadwell, Bivictrix, Qihan, Bristol Myers Squibb, Sanofi, Beigene, Ryvu, Refined Science

MDS Clinical Trials Landscape

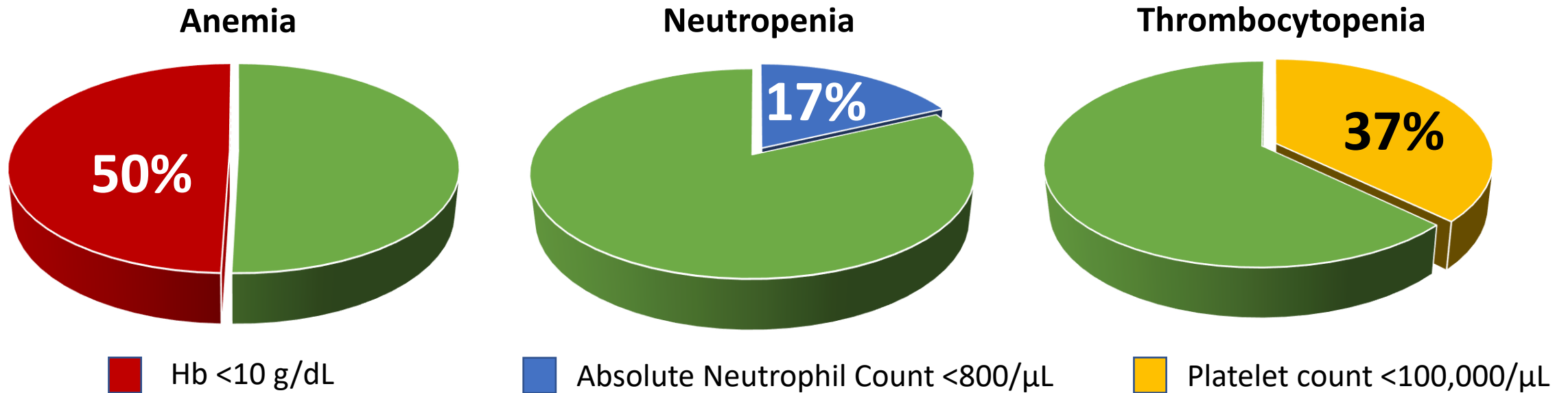
Clinical trials divided into four buckets

- Lower risk
 - Newly diagnosed
 - Previously treated
- Higher risk
 - Newly Diagnosed
 - Previously Treated

Anemia is the Hallmark of Lower Risk MDS

- Lower-risk MDS is characterized foremost by anemia¹
- 50% of MDS patients will need RBC transfusions during the course of their disease²

Frequency of cytopenias in patients with Lower-risk MDS:^{3,4}



1. Fenaux P, et al. *Br J Haematol.* 2019;189(6):1016-1027; 2. Germing U, et al. *Hemasphere.* 2019;3(6):e314;
3. Lanino L, et al. *Am J Hematol.* 2023; 10.1002/ajh.26960; 4. Santini V. *Hemato.* 2022;3(1):153-162

New Therapies in Lower Risk MDS

- Luspatercept
- Imetelstat

Luspatercept: Phase 3 Study



Patient Population

- ✓ Very-low-risk, low-risk, or intermediate-risk MDS (IPSS-R) with ring sideroblasts
- ✓ Receiving regular RBC transfusions



Most Common Grade 3–4 AEs with Luspatercept

- Fatigue (5%)
- Asthenia (3%)
- Back pain (2%)
- Nausea (1%), headache (1%), arthralgia (1%), dyspnea (1%), bronchitis (1%), UTI (1%)

FDA Approval: 04/06/2020

Luspatercept N = 153

38%



Transfusion Independence
≥ 8 Weeks (Weeks 1–24)

28%

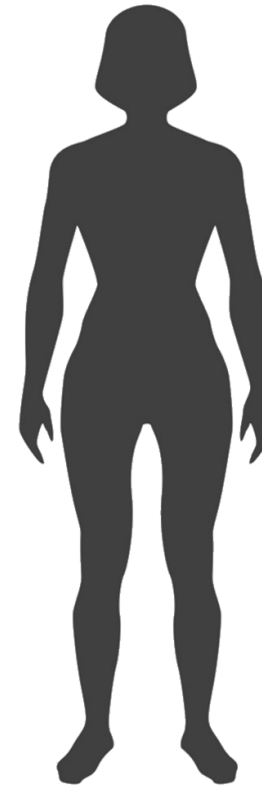


Transfusion Independence
≥ 12 Weeks (Weeks 1–24)

33%

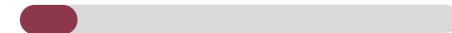


Transfusion Independence
≥ 12 Weeks (Weeks 1–48)



Placebo N = 76

13%



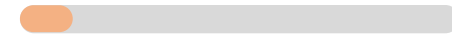
Transfusion Independence
≥ 8 Weeks (Weeks 1–24)

8%



Transfusion Independence
≥ 12 Weeks (Weeks 1–24)

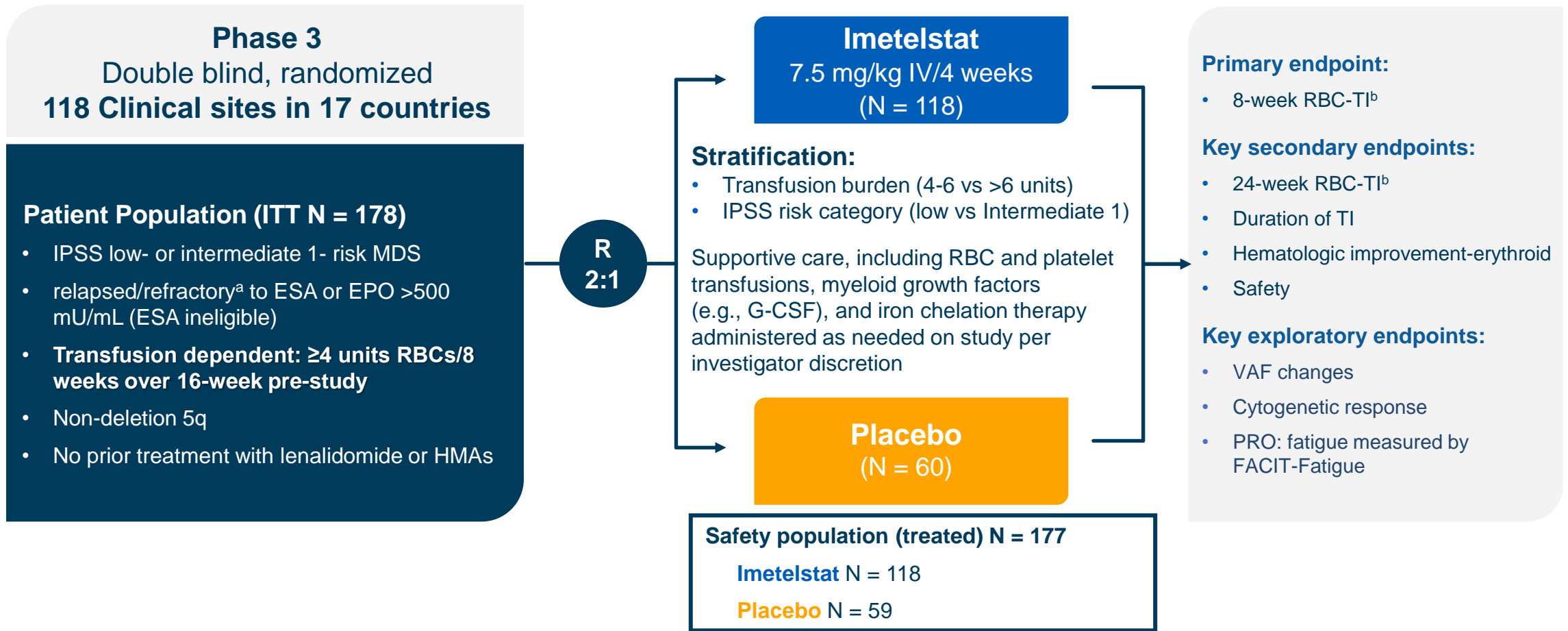
12%



Transfusion Independence
≥ 12 Weeks (Weeks 1–48)

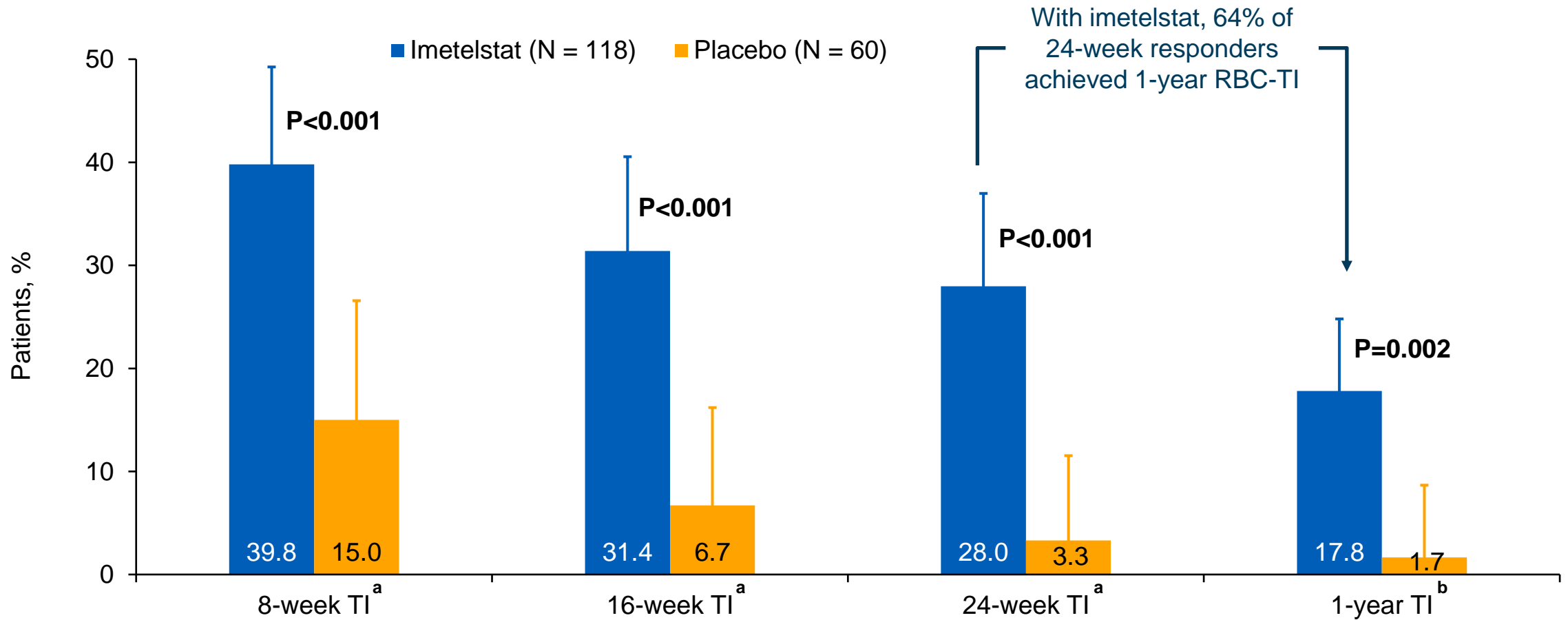
$P < .001$
For All Comparisons

IMerge Phase 3 Trial Design (MDS3001; NCT02598661)



^aReceived ≥8 weeks of ESA treatment (epoetin alfa ≥40,000 units, epoetin beta ≥30,000 units or darbepoetin alfa 150 µg or equivalent per week) without Hgb rise ≥1.5 g/dL or decreased RBC transfusion requirement ≥4 units/8 weeks or transfusion dependence or reduction in Hgb by ≥1.5 g/dL after hematologic improvement from ≥8 weeks of ESA treatment. ^bProportion of patients without any RBC transfusion for ≥8 consecutive weeks since entry to the trial (8-week TI); proportion of patients without any RBC transfusion for ≥24 consecutive weeks since entry to the trial (24-week TI)
EPO, erythropoietin; ESA, erythropoiesis stimulating agent; G-CSF, granulocyte colony-stimulating factor; Hgb, hemoglobin; HMA, hypomethylating agent; IPSS, International Prognostic Scoring System; ITT, intent-to-treat; IV, intravenous; MDS, myelodysplastic syndromes; R, randomization; RBC, red blood cell; TI, transfusion independence, VAF, variant allele frequency.

Higher Rates of Longer-Term Duration of RBC TI Observed With Imetelstat vs Placebo, Including 1-year RBC TI With Additional 3 Month Follow-up



^aData cutoff: October 13, 2022. ^bData cutoff: January 13, 2023.

P-values were determined by the Cochran-Mantel-Haenszel test, with stratification for prior RBC transfusion burden (≥ 4 to ≤ 6 vs. >6 RBC units/8-weeks during a 16-week period prior to randomization) and baseline International Prognostic Scoring System risk category (low vs. intermediate-1) applied to randomization. RBC, red blood cell; TI, transfusion independence.

Recent Disappointments in the Newly Diagnosed, Higher Risk Category

- Pevonidostat (NEDD8 inhibitor)
 - Failed to meet primary endpoint of event free survival
- APR-246 (Targeted therapy for TP53 mutations)
 - Failed to meet primary endpoint of complete response rate

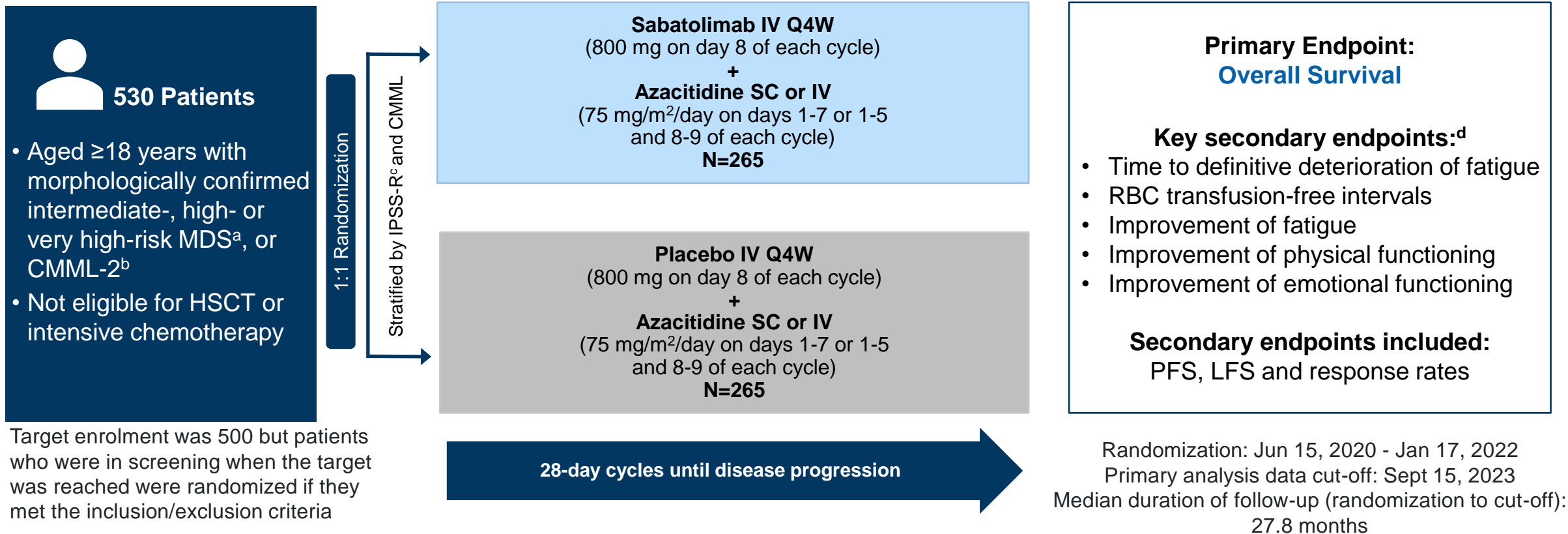
Two more recent large randomized studies reported this spring...

Sabatolimab

- Targets TIM-3, immunotherapy/stem cell target
- Randomized phase 2 study showed trend toward improved progression-free survival
- Improved duration of complete remission (18 vs 9.2 months)
- Definitive phase 3 study with overall survival as primary endpoint conducted

STIMULUS-MDS2 design

Randomized, double-blind, placebo-controlled, multi-centered Phase III study



Target enrolment was 500 but patients who were in screening when the target was reached were randomized if they met the inclusion/exclusion criteria

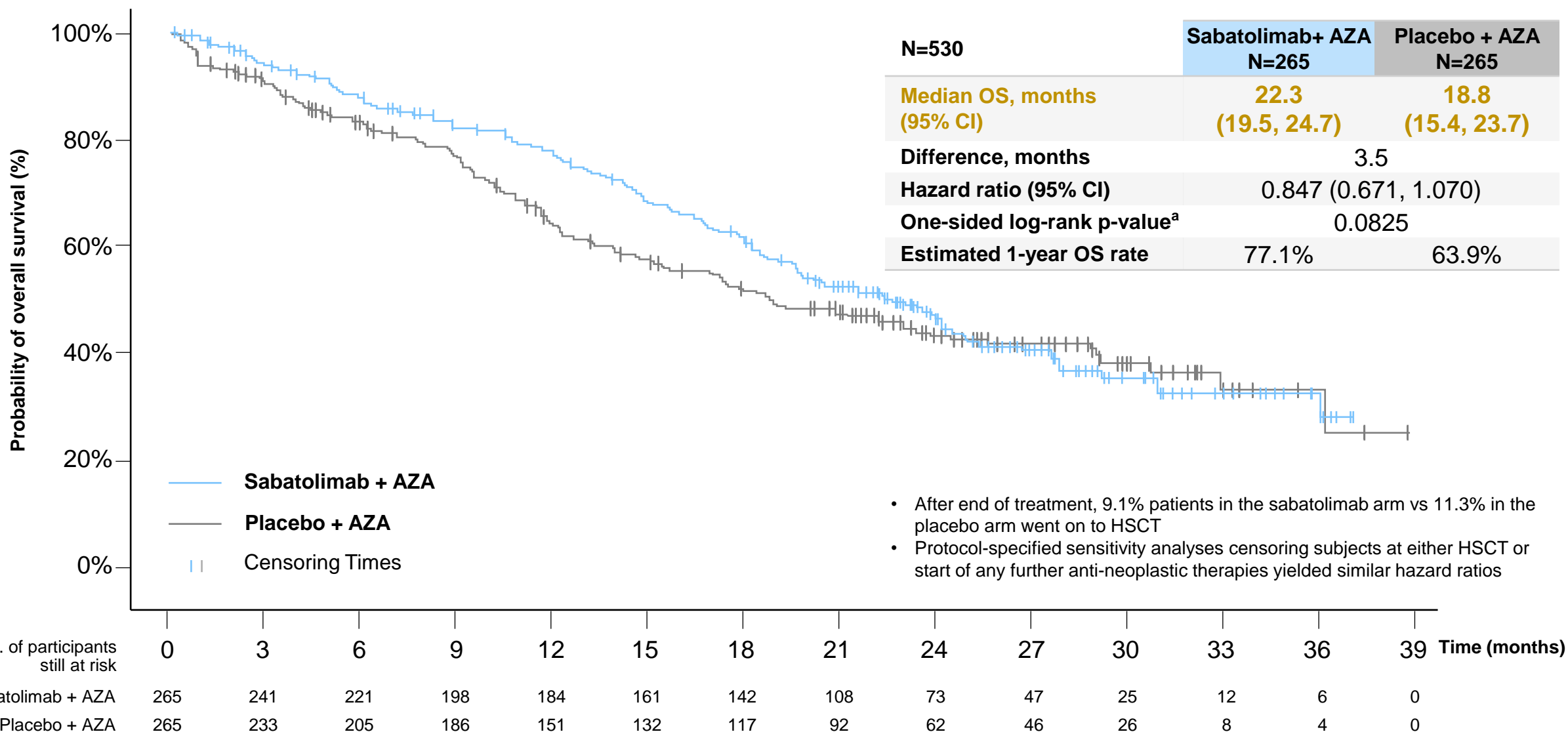
 36 countries  151 study centers

NCT04266301. CMML-2, chronic myelomonocytic leukemia 2; CR, complete response; HSCT, hematopoietic stem cell transplantation; IPSS-R, Revised International Prognostic Scoring System; IV, intravenous; LFS, leukemia-free survival; MDS, myelodysplastic syndromes; OS, overall survival; PFS, progression-free survival; Q4W, every 4 weeks; RBC, red blood cell; SC, subcutaneous; WBC, white blood cell.

^aDefined according to the IPSS-R criteria: very high risk (>6 points), high risk (>4.5 – ≤ 6 points), or intermediate risk (>3 – ≤ 4.5 points). ^bWBC $<13 \times 10^9/L$ at time of initial diagnosis. ^cIPSS-R prognostic risk score (intermediate, high, very high). ^dIf the primary endpoint was significant at the primary analysis, the first two key secondary endpoints were tested and if at least one of the first two key secondary endpoints was statistically

^e endpoints were tested in a sequence.

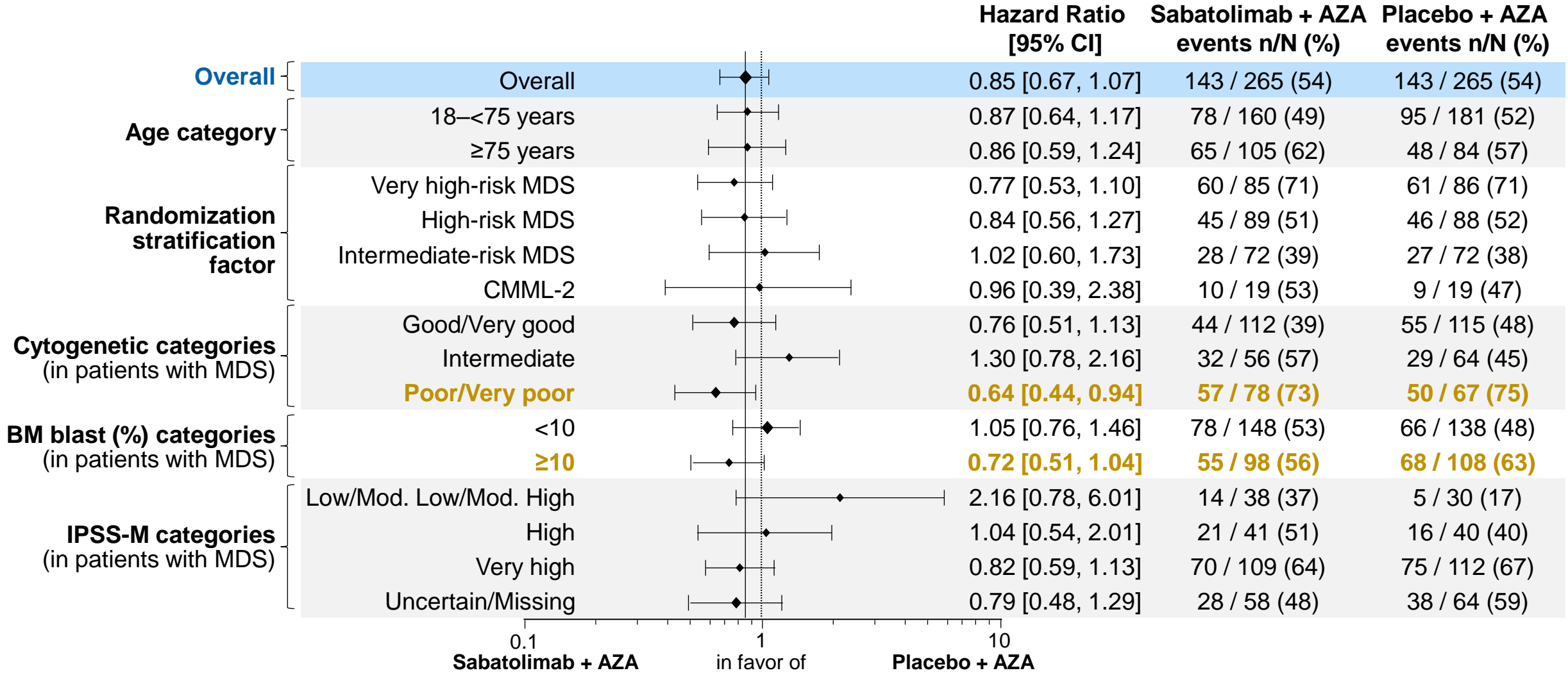
Overall survival (primary endpoint) (N=530)



- After end of treatment, 9.1% patients in the sabatolimab arm vs 11.3% in the placebo arm went on to HSCT
- Protocol-specified sensitivity analyses censoring subjects at either HSCT or start of any further anti-neoplastic therapies yielded similar hazard ratios

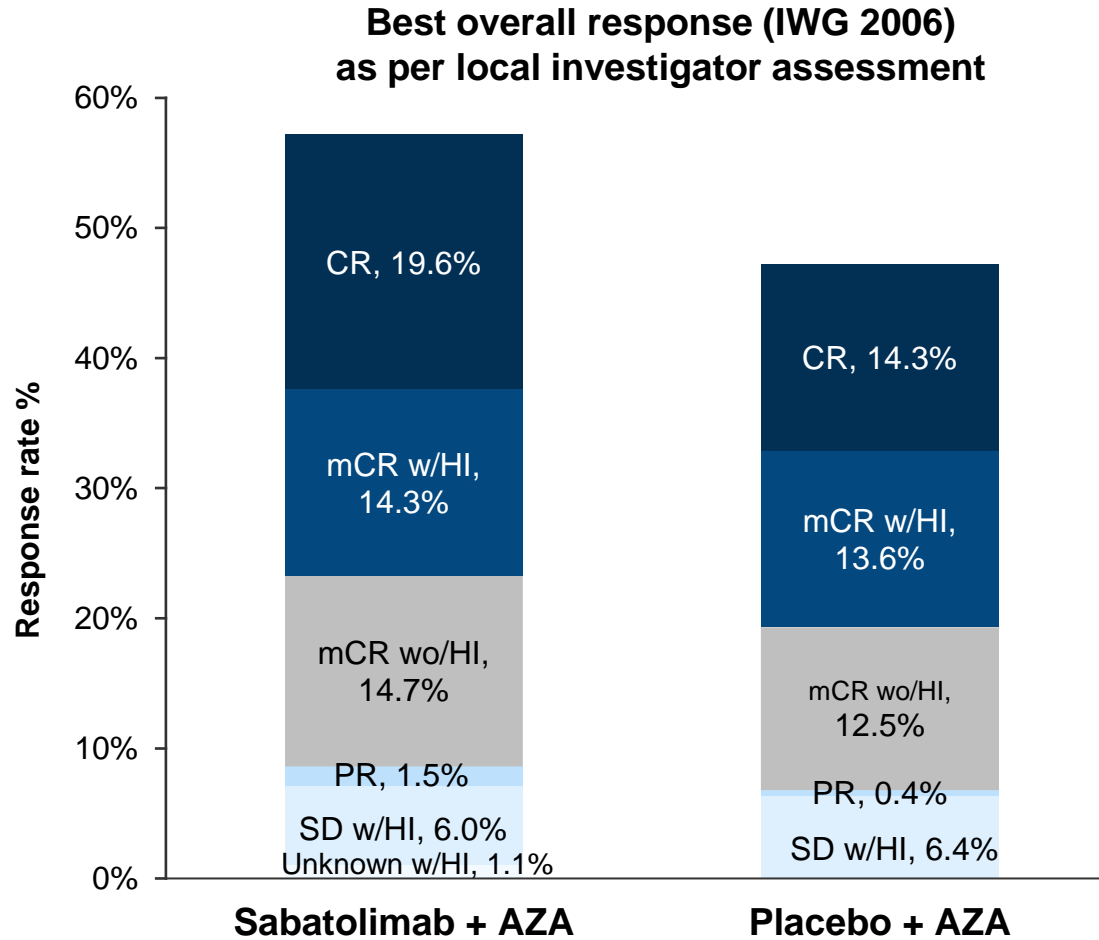
AZA, azacitidine; CI, confidence interval; CMML-2, chronic myelomonocytic leukemia 2; HSCT, hematopoietic stem cell transplantation; IPSS-R, Revised International Prognostic Scoring System; MDS, myelodysplastic syndromes; OS, overall survival. Full analysis set. Cox-model are stratified by randomization stratification factor (Intermediate-risk MDS, High-risk MDS, Very high-risk MDS, CMML-2) as per interactive stratified by the randomization stratification factor (IPSS-R very high, IPSS-R high, IPSS-R intermediate, CMML-2) with critical alpha level 0.0246.

Overall survival by subgroups



AZA, azacitidine; BM, bone marrow; CI, confidence interval; CMML-2, chronic myelomonocytic leukemia; IPSS-M, Molecular International Prognostic Scoring System; MDS, myelodysplastic syndromes; OS, overall survival. Full analysis set. Dotted line shows no effect point. Bold line shows overall treatment effect point (for all patients). Hazard ratio of sabatolimab versus placebo is calculated by using unstratified cox model except for 'Overall'. Hazard Ratio of sabatolimab versus placebo for 'Overall' is obtained from Cox model stratified by randomization stratification factor (Intermediate-risk MDS, High-risk MDS, Very high-risk MDS, CMML-2) as per interactive response technology. Only subgroup categories having at least one patient with OS event in sabatolimab and placebo are displayed. Cytogenetic categories, BM blast (%) categories and IPSS-M categories are shown for MDS only. Please note this forest plot was included in the published abstract with errors in cytogenetic and IPSS-M categories, which have been corrected here.

Best overall response



	Sabatolimab + AZA N=265	Placebo + AZA N=265
CR^a, % (95% CI)	19.6 (15.0, 24.9)	14.3 (10.4, 19.1)
CR+PR+HI^b, % (95% CI)	42.6 (36.6, 48.8)	34.7 (29.0, 40.8)

AZA, azacitidine; CI, confidence interval; CR, complete remission; (w/wo) HI, (with/without) hematological improvement; IWG, International Working Group; mCR, marrow CR; PD, progressive disease; PR, partial remission; SD, stable disease; w/wo, with/without. Full analysis set. ^aCR bone marrow assessments were performed less frequently than in the STIMULUS-MDS1 study and therefore CRs are not directly comparable: first assessment performed after 6 cycles. ^bHI must be concurrent with best overall response.

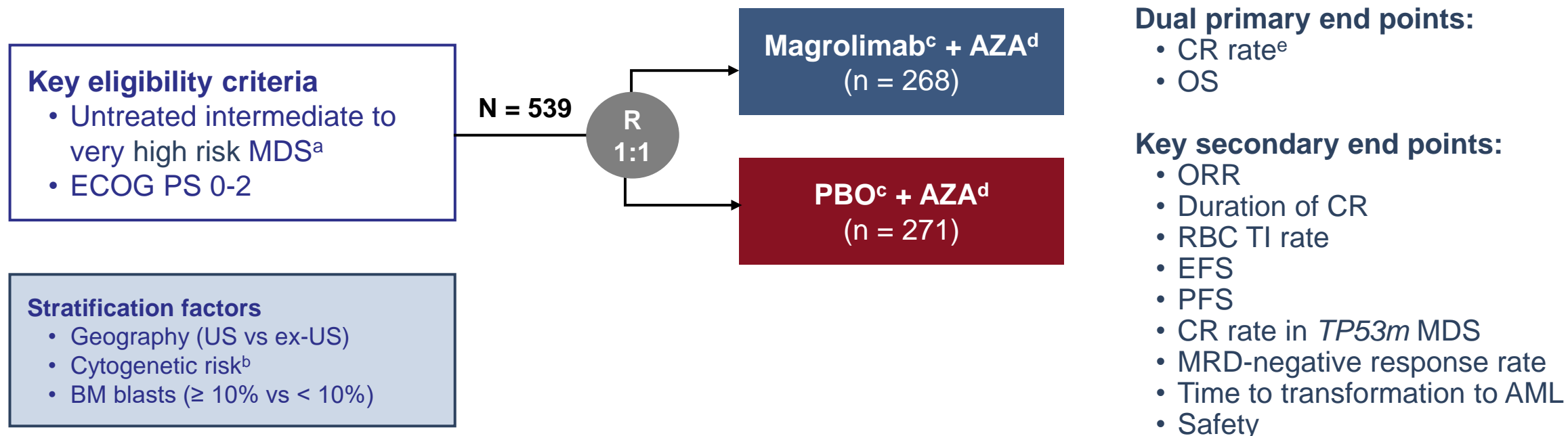
Sabatolimab Conclusions

- Did not improve overall survival, the primary endpoint

Magrolimab

- CD47 antibody
- Promising early phase data
- Potential activity in those with TP53 mutations

ENHANCE: Randomized, Double-Blind, Phase 3 Study



- Study stopped early at prespecified interim analysis due to futility

^aPer IPSS-R¹: intermediate, > 3-4.5; high, > 4.5-6; very high, > 6. ^bPer IPSS-R¹: very good/good/intermediate vs poor/very poor vs unknown. ^cMagrolimab priming doses given at 1 mg/kg IV on days 1 and 4, 15 mg/kg on day 8, and 30 mg/kg on days 11 and 15, then weekly for 5 doses, and then maintenance doses of 30 mg/kg every 2 weeks beginning 1 week after the fifth weekly dose. PBO mirrored the magrolimab dosing schedule. ^dAll patients received subcutaneous or IV AZA 75 mg/m² on Days 1-7 or Days 1-5, 8, and 9 every 28-day cycle (6-cycle minimum). One cycle was 28 days. ^ePrimary analysis of CR rate was conducted 8 months after 348 participants had been randomized.

AML, acute myeloid leukemia; **AZA**, azacitidine; **BM**, bone marrow; **CR**, complete remission; **ECOG PS**, Eastern Cooperative Oncology Group performance score; **EFS**, event-free survival; **HR**, high risk; **IPSS-R**, Revised International Prognostic Scoring System; **IV**, intravenous; **MDS**, myelodysplastic syndrome; **MRD**, minimal residual disease; **ORR**, objective response rate; **OS**, overall survival; **PBO**, placebo; **PFS**, progression-free survival; **R**, randomization; **RBC**, red blood cell; **SCT**, stem cell transplant; **TI**, transfusion independence; **TP53m**, TP53-mutated; **US**, United States.

Response and Other Selected Efficacy Outcomes

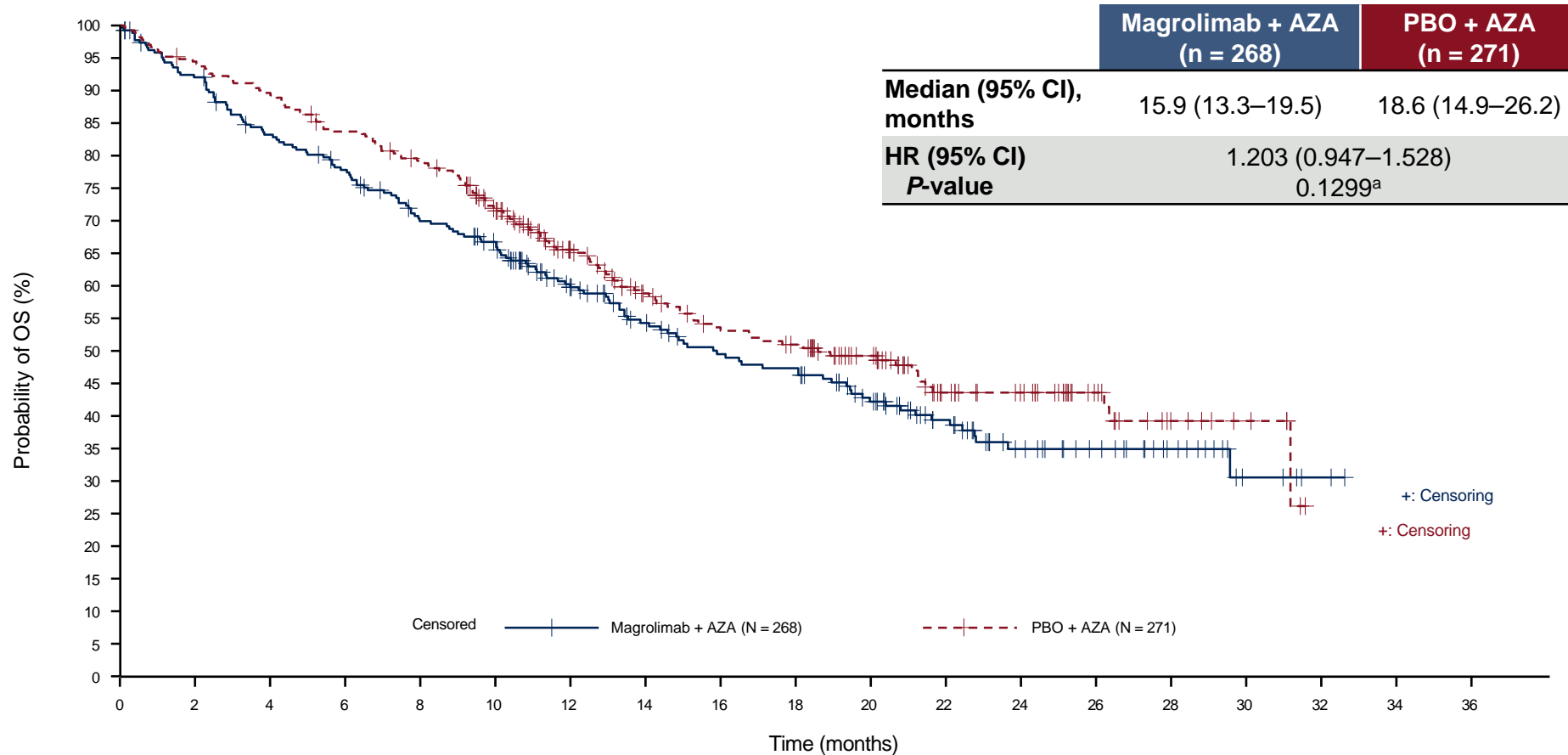
Outcome	Magrolimab + AZA (n = 268) ^a	PBO + AZA (n = 271) ^a
Best response of CR at primary analysis (n = 348),^b % (95% CI)	20.5 (14.8–27.2)	25.0 (18.7–32.2)
Odds ratio (95% CI),^c P-value	0.779 (0.471–1.288)	
Final analysis (ITT)		
Best response of CR, % (95% CI)	21.3 (16.5–26.7)	23.6 (18.7–29.1)
Median ^d duration of CR (95% CI), ^{b,e} months	10.9 (8.9–16.7)	11.1 (8.1–NE)
ORR, ^f % (95% CI)	53.7 (47.6–59.8)	58.7 (52.6–64.6)
CR rate in <i>TP53m</i> population, % (95% CI) ^g	17.7 (10.0–27.9)	32.8 (21.6–45.7)
TI rate, % (95% CI) ^h	27.9 (20.6–36.1)	35.2 (26.9–44.2)
Median ^d duration of TI (95% CI), ⁱ months	11.8 (6.1–17.2)	8.2 (4.9–10.4)
MRD-negative status, % (95% CI) ^j	21.6 (16.9–27.1)	22.5 (17.7–28.0)
Transformed to AML, n (%)	34 (12.7)	43 (15.9)
Median ^d time to transformation (95% CI), ^k months	NE (21.2–NE)	25.5 (25.5–NE)
SCT rate, ^l % (95% CI)	20.9 (16.2–26.3)	35.4 (29.7–41.4)
Median ^d time to SCT (range), months	6.05 (2.66–16.85)	5.85 (2.76–19.12)

- There was no significant difference in CR rate or ORR between treatments
- The CR rate in the *TP53m* population was lower with magrolimab + AZA
- Fewer patients in the magrolimab + AZA arm proceeded to SCT ($P = 0.0001$)

^aITT. ^bPatients who discontinued study treatment and received SCT and patients who achieved a response and then proceeded to SCT were not censored at the time of SCT, but followed until disease progression, transformation to AML, or start of new anticancer therapy. ^cStratified Cochran-Mantel-Haenszel test. ^dKaplan-Meier estimate. ^eCalculated based on patients who achieved CR. ^fInvestigator-assessed best response of CR, PR, marrow CR, or any hematologic improvement prior to initiation of any new anticancer therapy for MDS per IWG 2006. ^g*TP53m* testing results available in 64.0% of patients at time of report; 41.4% were *TP53m*. Denominator for CR rate in *TP53m* population was the number of patients who were *TP53m*. ^hDenominator of post-baseline TI rate was the number of patients who were transfusion dependent at baseline. ⁱCalculated on the basis of patients who achieved TI. ^jDenominator for MRD-negativity rate was the ITT. ^kCalculated on the basis of patients who transformed to AML. ^lTwo-sided P -value between treatment arms was 0.0001.

idine; CR, complete remission; ITT, intent-to-treat; IWG, International Working Group; MRD, minimal residual disease; NE, not estimable; ORR, objective response rate; TI, transfusion independence; *TP53m*, *TP53*-mutant.

OS at Final Analysis



N at risk (events)

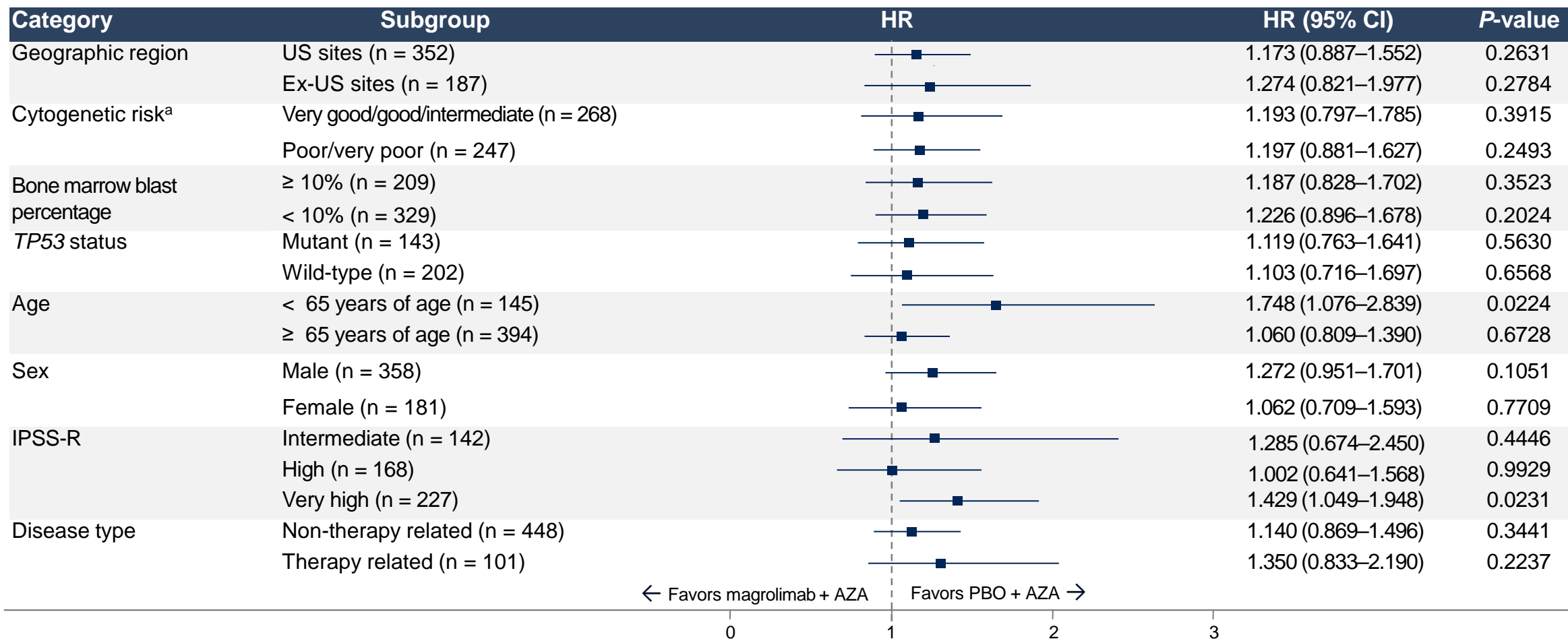
	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
Magrolimab + AZA	288 (0)	242 (21)	216 (44)	200 (58)	176 (78)	163 (86)	126 (102)	105 (113)	92 (122)	88 (126)	70 (135)	50 (139)	32 (144)	21 (144)	15 (144)	5 (145)	2 (145)	0 (145)	
PBO + AZA	271 (0)	255 (15)	242 (28)	224 (44)	210 (56)	179 (76)	141 (90)	115 (104)	101 (115)	94 (119)	74 (122)	46 (149)	38 (129)	22 (129)	11 (131)	6 (131)	0 (132)		

Median follow-up for OS: magrolimab + AZA, 11.37 months; PBO + AZA, 12.52 months.

HRs and corresponding 95% CIs; log-rank test 2-sided *P*-values presented. Medians estimated by Kaplan-Meier method. Overall survival; PBO, placebo.

OS in Key Subgroups

- OS results in key subgroups were consistent with those in the overall population



^aarm and 9 patients in the PBO + AZA arm had unknown cytogenetic risk status.
[†]Revised International Prognostic Scoring System; OS, overall survival; PBO, placebo; US, United States.

Magrolimab Conclusions

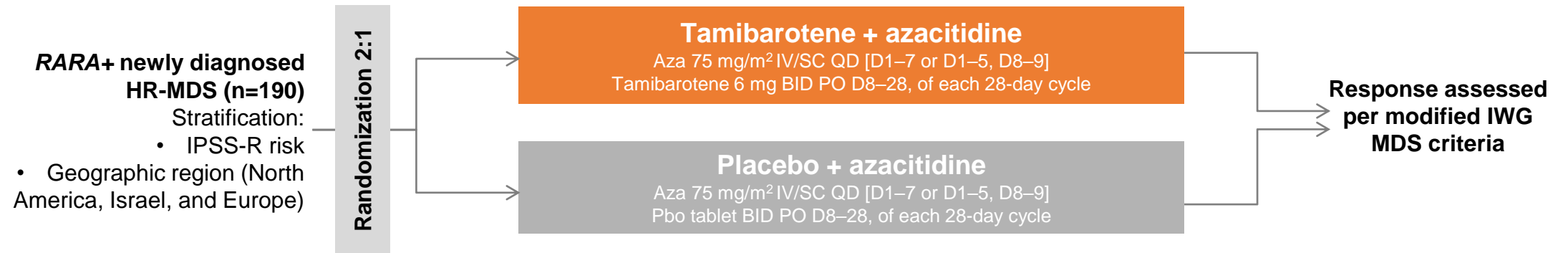
- Did not meet primary end points of CR and OS
- Trend toward worse OS in the magrolimab arm
- Resulted in more adverse events

Ongoing Studies

- Tamibarotene
- Venetoclax

Tamibarotene + Aza vs Pbo+Aza

Phase 3, double-blind, randomized trial in patients with *RARA*+ newly diagnosed HR-MDS



Key inclusion criteria

- Adults ≥18 years old
- *RARA*+ based on the investigational biomarker test
- Newly diagnosed with HR-MDS by 2016 WHO classification and classified by IPSS-R as very high, high, or intermediate risk
- Blast count >5% at study entry

Key exclusion criteria

- Patients suitable for transplant at the time of screening

Primary endpoint

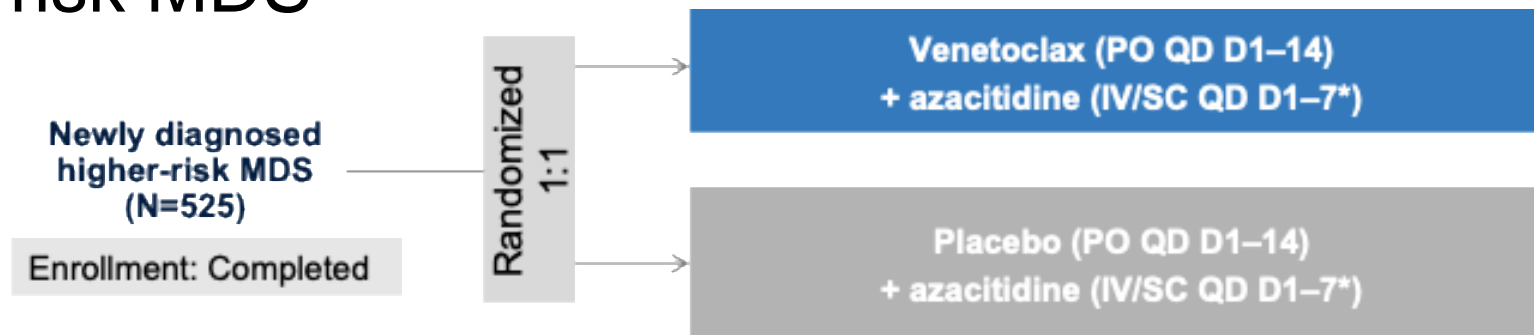
- Proportion of participants with CR [Timeframe: up to 5 years]

Key secondary endpoints

- ORR
- EFS, OS
- Transfusion independence

Venetoclax

- BCL-2 inhibitor, revolutionized AML
- Subject of a registrational phase 3 study in newly diagnosed higher risk MDS



Key inclusion criteria

- ≥18 years old with newly diagnosed MDS according to 2016 WHO classification
- <20% BM blasts
- ECOG PS 0-2
- IPSS-R score of >3 (Intermediate, high, very high)
- No planned HSCT at the time of C1D1

Primary endpoints

- CR
- OS

Secondary endpoints

- Modified overall response (mOR)
- Transfusion independence (TI)
- ORR
- QoL

Higher Risk, Previously Treated

- No large phase 3 studies
- Frequently use venetoclax-based regimens off label if patients have increased blasts

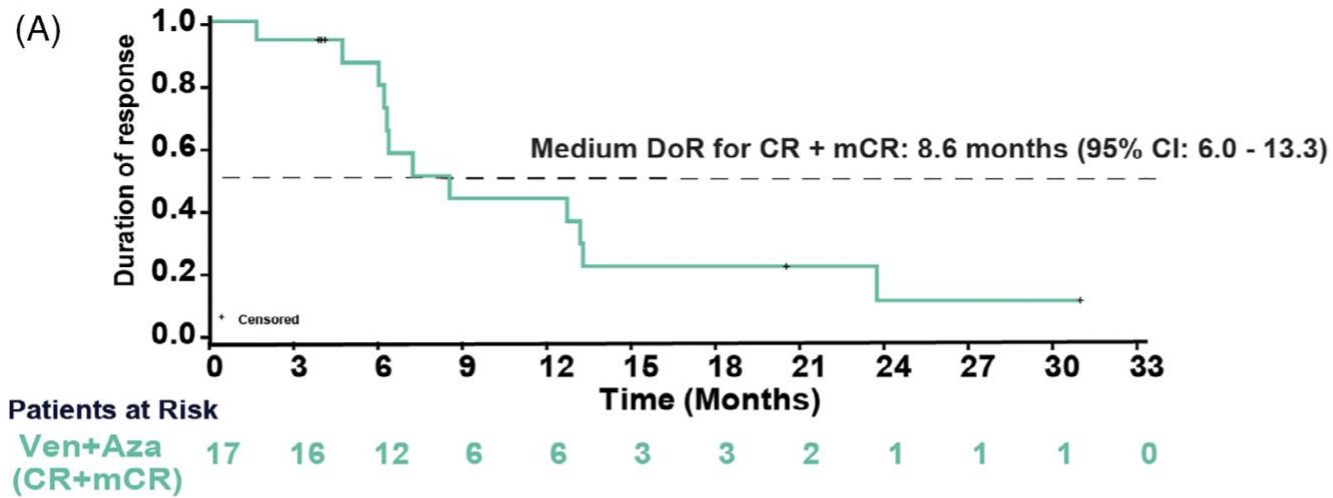
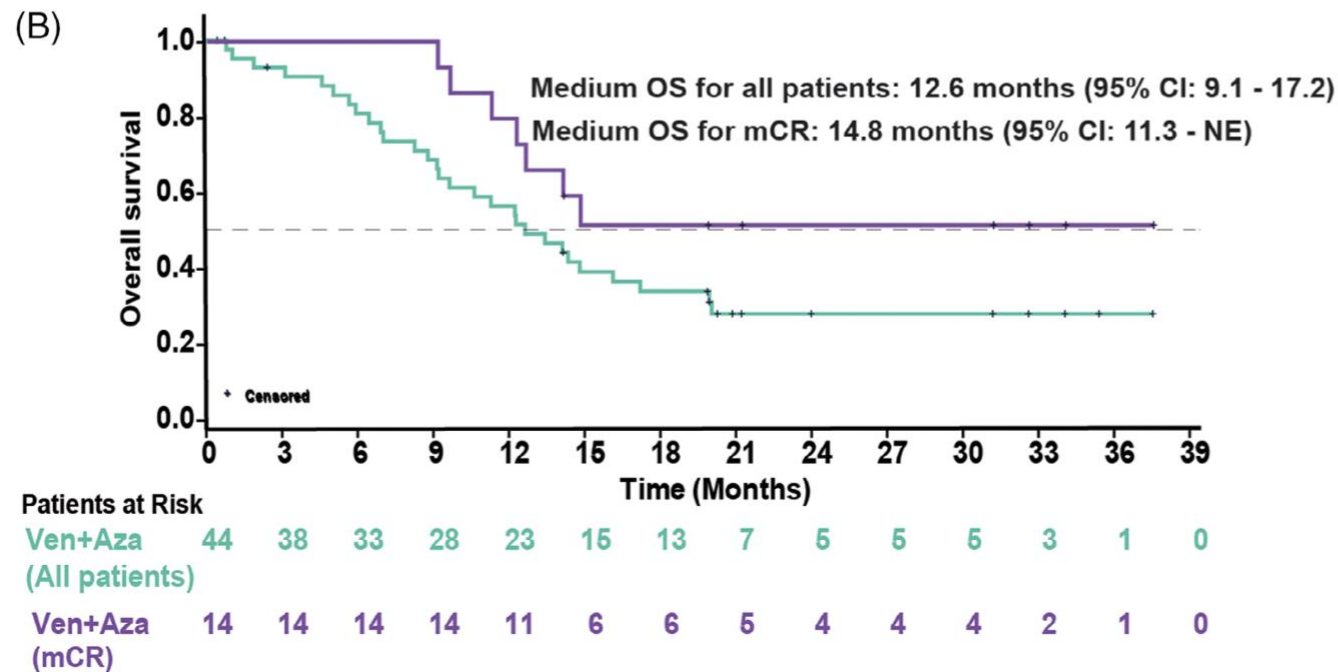


FIGURE 1 (A) Duration of response (DoR). (B) Overall survival (OS) in patients treated with venetoclax (Ven) and azacitidine (Aza). [Color figure can be viewed at wileyonlinelibrary.com]

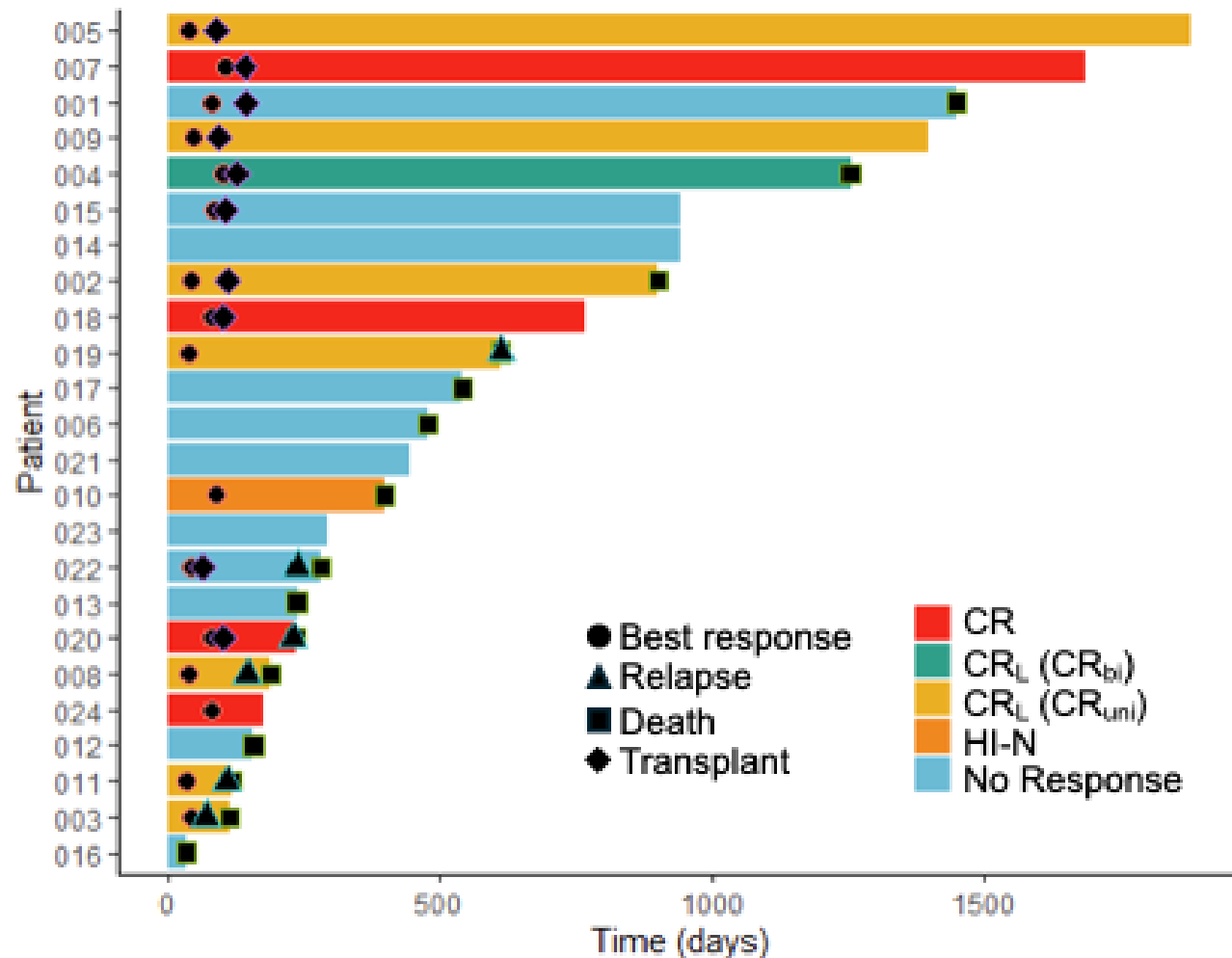


Another Approach

- Can we target the root cause of MDS, the stem cell population?
- Omacetaxine with azacitidine for newly diagnosed high-risk MDS patients
- University of Colorado clinical trial

Trial Results

- 24 patients
- 54% response rate
- Median OS of 541 days



Conclusions

- Lower risk MDS has some new therapies but may not modify the disease
- Higher risk MDS sorely in need of new/improved therapies
- Near future holds promise



Alpenglow
Maroon Bells
Western Colorado