



THE UNIVERSITY OF TEXAS
MD ANDERSON
CANCER CENTER

Managing Myelofibrosis (MF) in 2025

14th Joyce Niblack Memorial Conference on MPNs
Feb 15-16, 2025 | MPN Education Foundation
Phoenix, AZ

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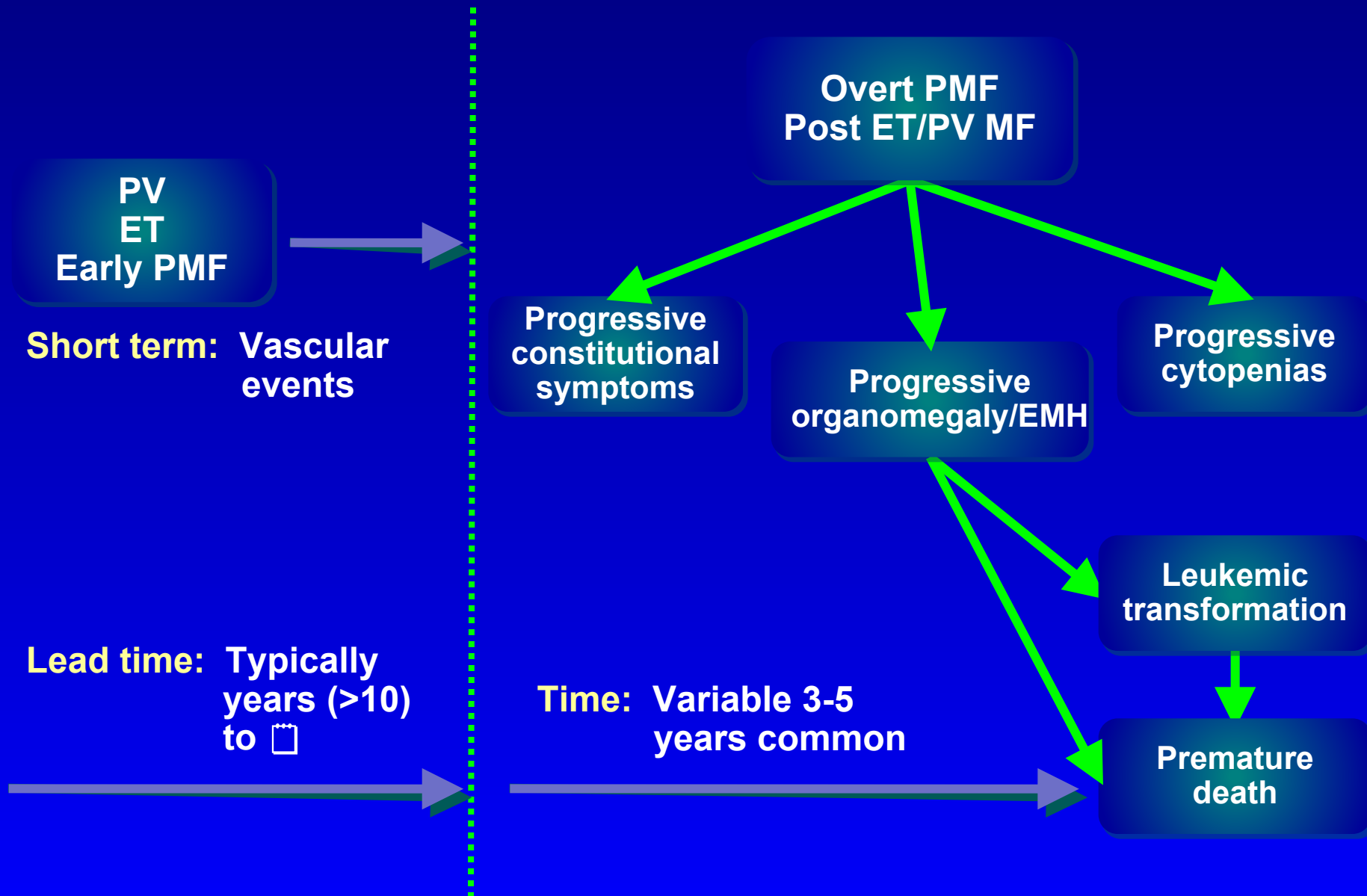
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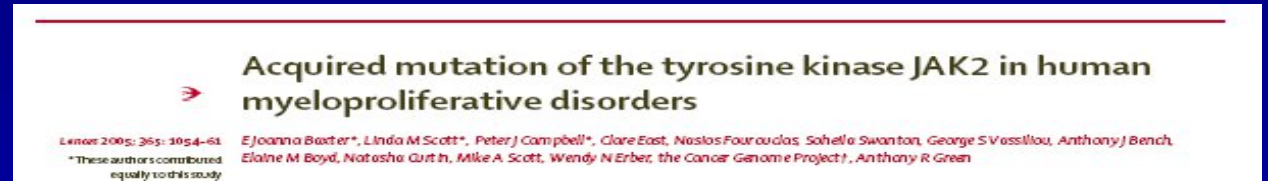
Natural History of (MPDs) MPNs

courtesy Dr Ruben Mesa, MD

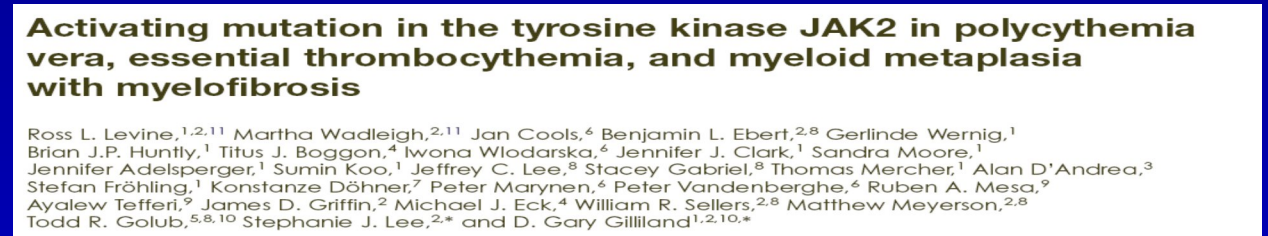


JAK2 V617F Mutation

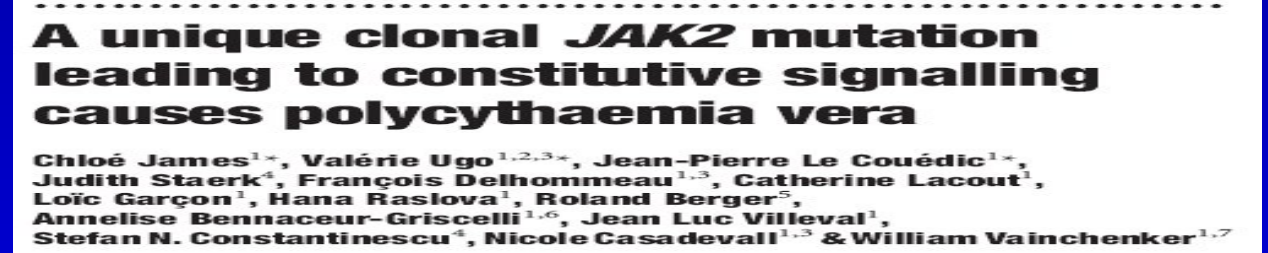
March 18th, 2005



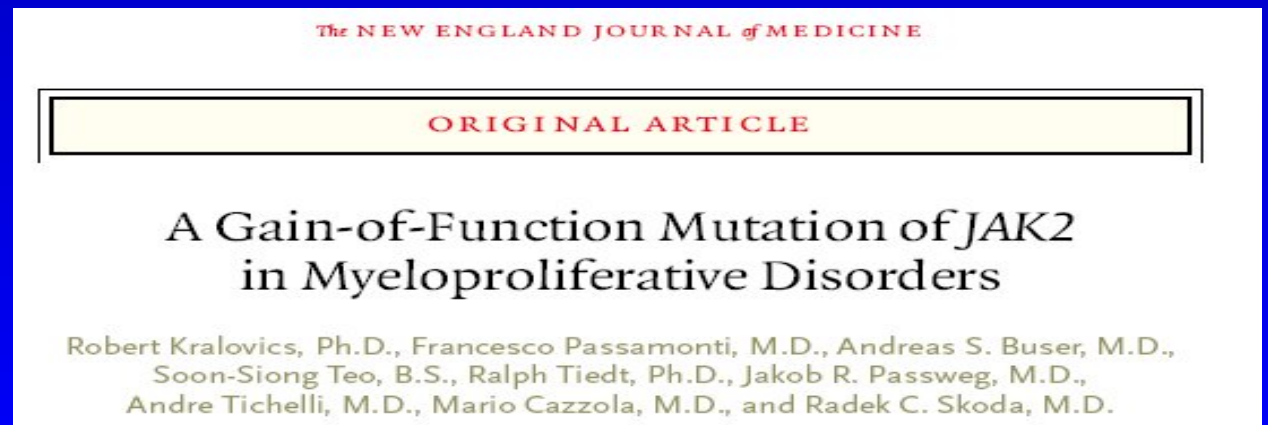
March 24th, 2005



March 27th, 2005

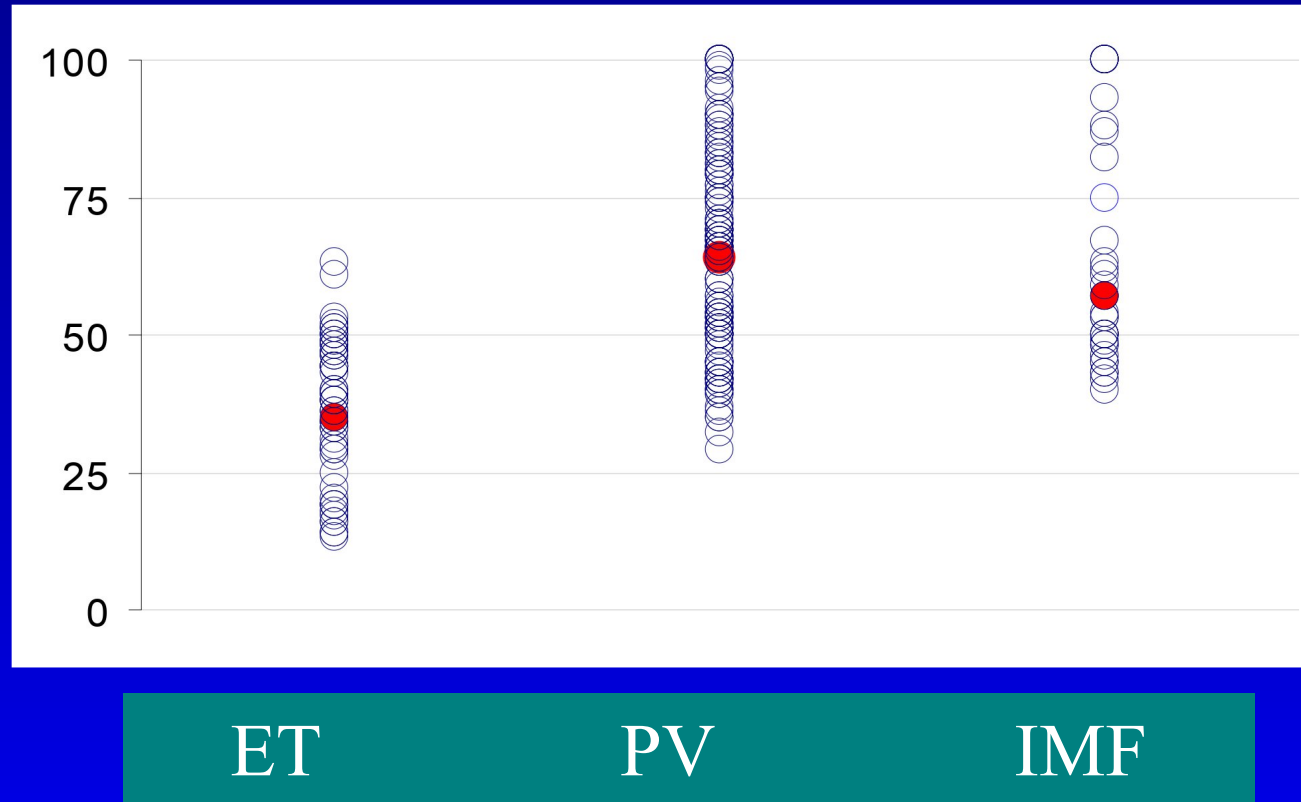


April 28th, 2005



Neutrophil JAK2 V617F allele % in MPN

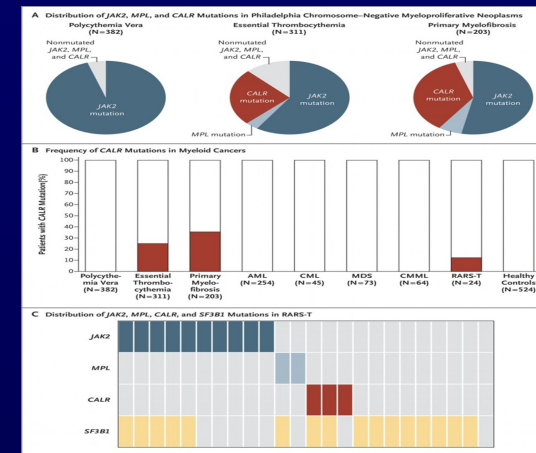
Neutrophil
JAK2V617F
allele %



Pemmaraju, Moliterno AR, Williams DM , Rogers O, Spivak JL, Leukemia 2007 Oct;21(10):2210-2
Stein BL, et al Haematologica 2010
Moliterno AR, et al Exp Hematol 2008

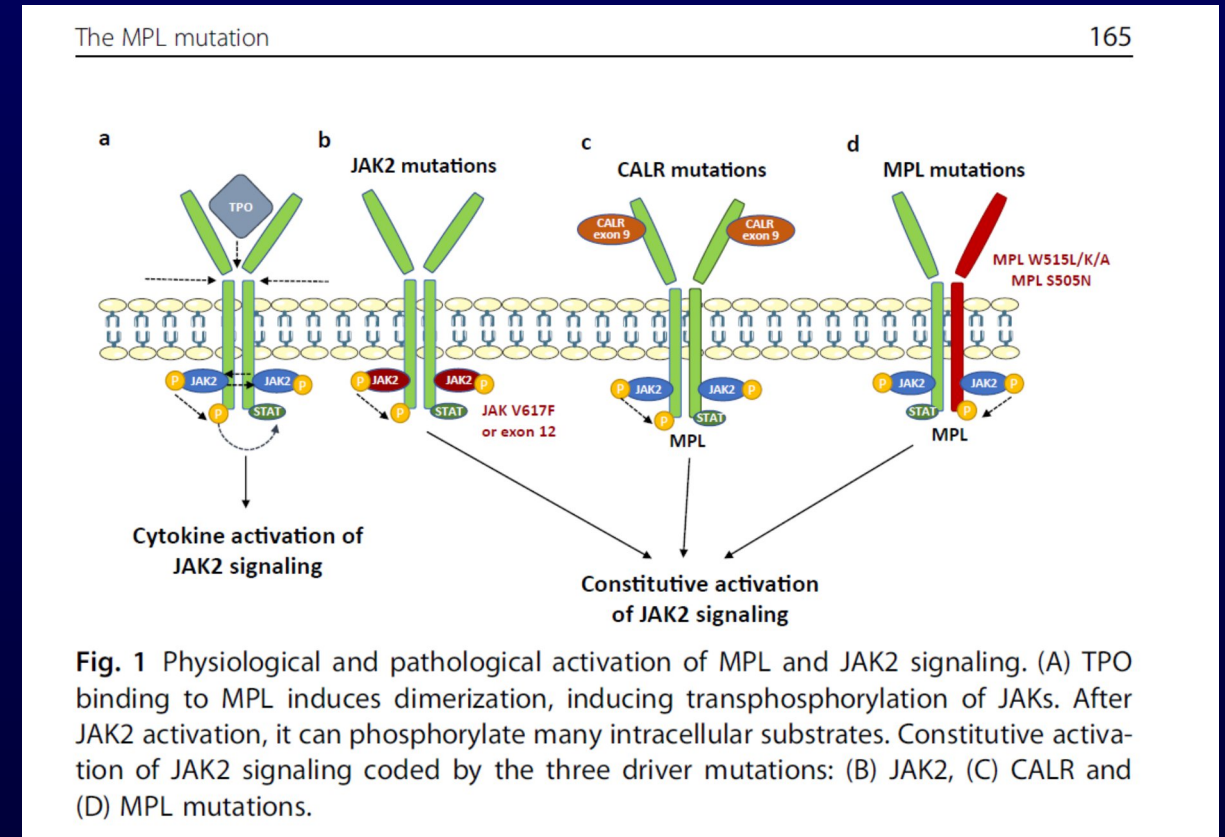
CALR Mutation

- Chromosome 19p13.3
 - Exon 9 of CALR (insertions or deletions)
- Calreticulin = protein ☾ Ca⁺⁺binding function / Endoplasmic reticulum
- Also found in nucleus; possible role transcription regulation
- Klampfel et al NEJM 2013: CALR in 25% pts with JAK2 negative ET, and in 35% in JAK2 negative MF

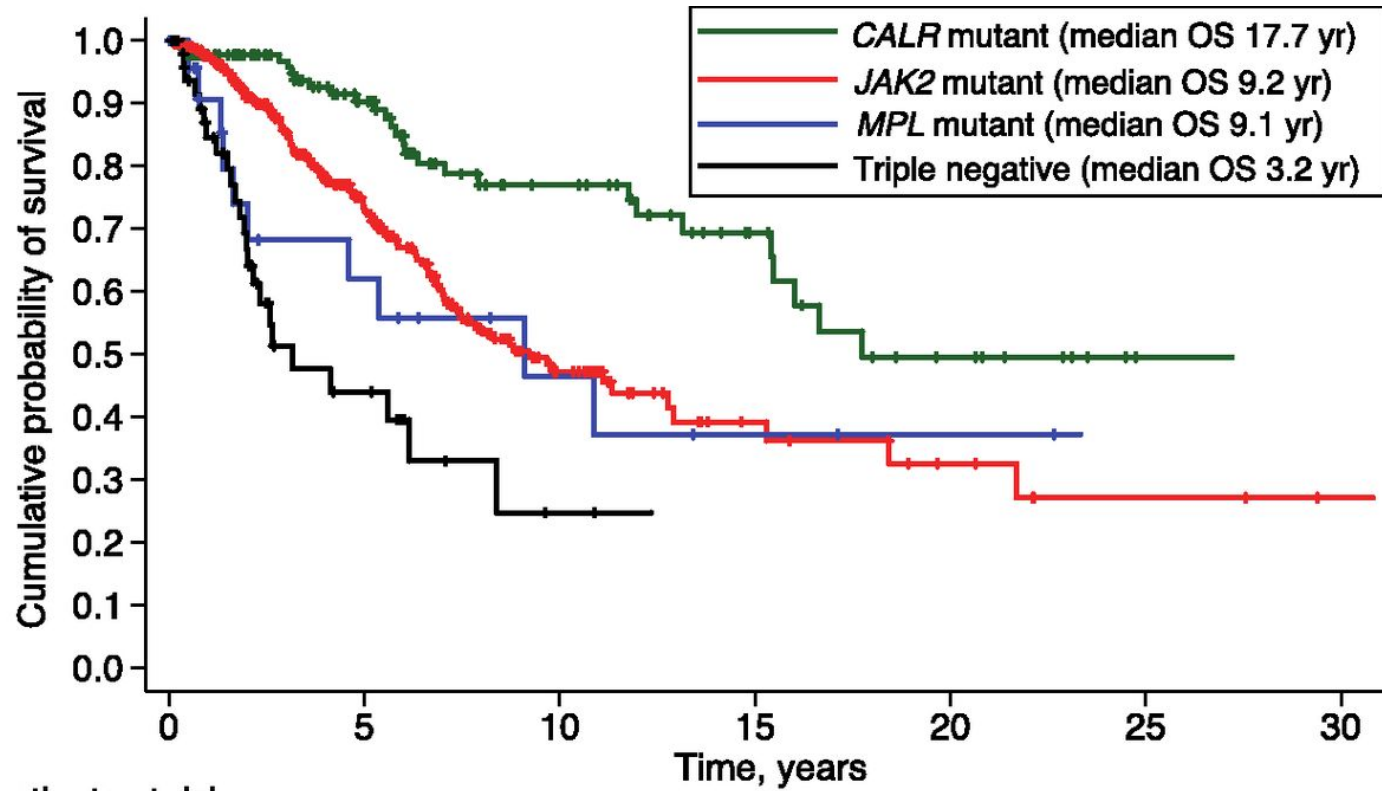


MPL Mutation: ET and MF

- MPL = proto-oncogene that encodes for TPOR (hematopoietic growth factor receptor for myeloid stem cells)
- MPL mutations ☾ dimerization of TPOR ☾ activates JAK2 and the TPO pathway



Kaplan-Meier analysis of survival of PMF patients stratified according to their driver mutation.



No. of patients at risk:

| | | | | | | |
|--------------------|-----|-----|----|----|---|---|
| <i>CALR</i> mutant | 140 | 72 | 37 | 19 | 9 | 1 |
| <i>JAK2</i> mutant | 396 | 135 | 39 | 13 | 7 | 3 |
| <i>MPL</i> mutant | 25 | 10 | 5 | 3 | 2 | 0 |
| Triple negative | 53 | 11 | 2 | 0 | 0 | 0 |

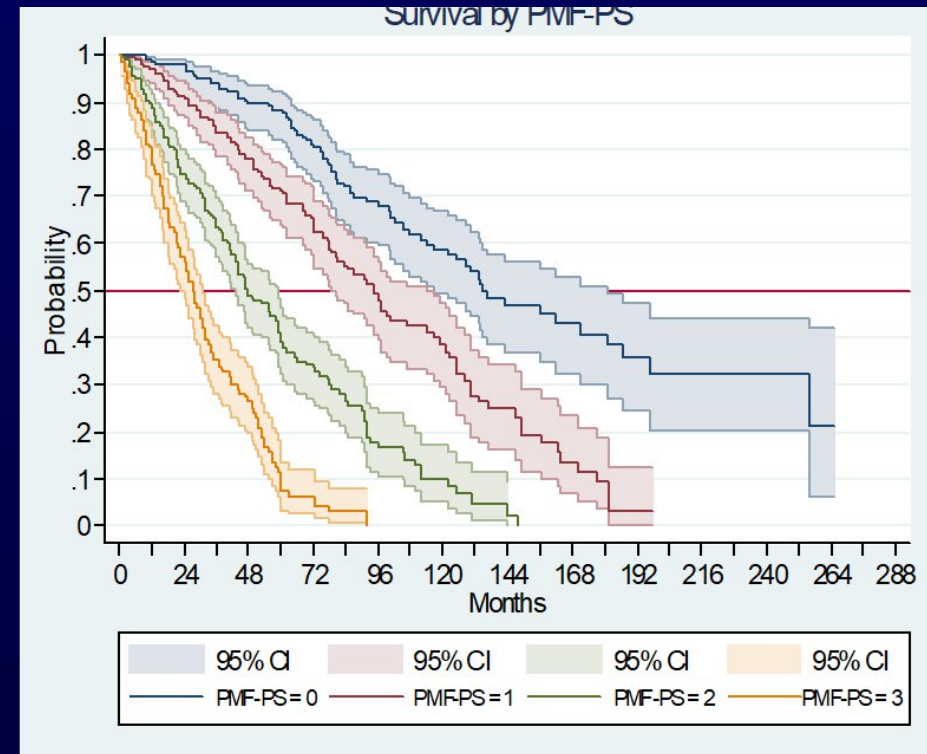
Elisa Rumi et al. Blood 2014;124:1062-1069

Myelofibrosis MF: WHO 2016

- **Major criteria:**
- 1. Presence of megakaryocytic proliferation and atypia, accompanied by either reticulin and/or collagen fibrosis grades 2 or 3*
- 2. Not meeting WHO criteria for ET, PV, BCR-ABL1+ CML, myelodysplastic syndromes, or other myeloid neoplasms
- 3. Presence of JAK2, CALR or MPL mutation or in the absence of these mutations, presence of another clonal marker ** or absence of reactive myelofibrosis ***
- **Minor criteria: Presence of at least 1 of the following, confirmed in two consecutive determinations:**
- a. Anemia not attributed to a comorbid condition
- b. Leukocytosis $>11 \times 10^9 /L$
- c. Palpable splenomegaly
- d. LDH increased to above upper normal limit of institutional reference range
- e. Leukoerythroblastosis “tear drop” cells
- **Diagnosis of overt PMF requires meeting all three major criteria, and at least one minor criterion** * see Table 8 ** in the absence of any of the 3 major clonal mutations, the search for the most frequent accompanying mutations (e.g.ASXL1, EZH2, TET2, IDH1/IDH2, SRSF2, SF3B1) are of help in determining the clonal nature of the disease
- ***BM fibrosis secondary to infection, autoimmune disorder or other chronic inflammatory conditions, hairy cell leukemia or other lymphoid neoplasm, metastatic malignancy, or toxic (chronic) myelopathies

MF: Treatment based on Risk Stratification- Proposal: IPSS, DIPSS, MIPSS

- Low risk: supportive care, transfusions, close surveillance, clinical trials
- Intermediate risk: standard treatment, JAK2 inhibitors, clinical trials, consider allo-SCT
- High risk: JAK2 inhibitors, clinical trials, allo-SCT



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JOURNAL OF CLINICAL ONCOLOGY

RAPID COMMUNICATION

MIPSS70: Mutation-Enhanced International Prognostic Score System for Transplantation-Age Patients With Primary Myelofibrosis

Paola Guglielmelli, Terra L. Lasho, Giada Rotunno, Mythri Mudireddy, Carmela Mannarelli, Maura Nicolosi, Annalisa Pacilli, Animesh Pardhanani, Elisa Rumi, Vittorio Rosti, Curtis A. Hanson, Francesco Mannelli, Rhett P. Ketterling, Nascema Gangat, Alessandro Rambaldi, Francesco Passamonti, Giovanni Barosi, Tiziano Barbui, Mario Cazzola, Alessandro M. Vannucchi, and Ayalew Tefferi

MF: Further scoring systems

- **DIPSS (dynamic)—Mayo (Blood 2010;115)**
 - Modified IPSS to be able to calculate over time: all 1 pt except Hb (2 points)
 - Age >65
 - WBC >25K
 - Hb <10: 2 points
 - Circulating blasts greater than or equal to 1%
 - Constitutional sxs
- **DIPSS Plus—adds 3 new factors, each 1 point (Mayo, 2011 JCO)**
 - Unfavorable karyotype
 - Plt count <100K
 - Transfusion need
- **MIPSS /MIPSS-PLUS**
 - BM fibrosis
 - Molecular : CALR ; HR molecular mutations

JAK Inhibitors for Myelofibrosis: 4 Approved Agents

Ruxolitinib (JAK1/2)

- Approved for intermediate-/high-risk MF based in part on COMFORT trials¹

Fedratinib (JAK2/FLT3)

- Approved for INT-2/high-risk MF; validated by JAKARTA and long-term safety evidence (where no cases of WE were reported)^{2,3}

Pacritinib (JAK2/FLT3/IRAK1)

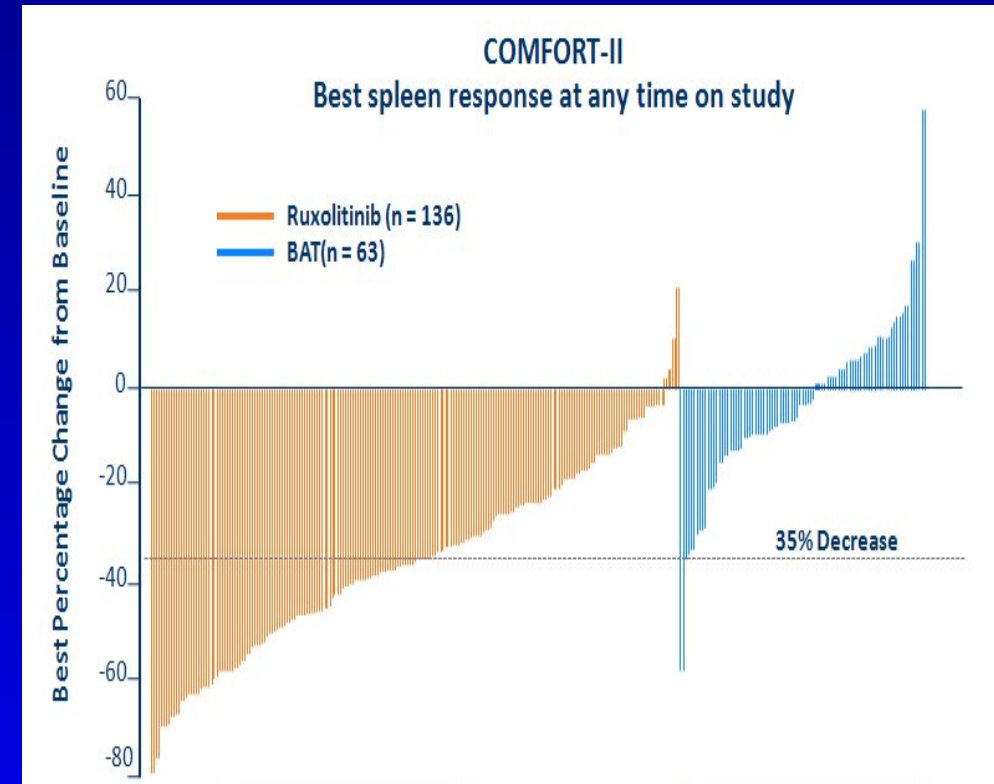
- Approved for adults with intermediate- or high-risk MF with platelets $<50 \times 10^9/L$
- Validated by PERSIST trials⁴

Momelotinib (JAK1/JAK2/ACVR1)

- Approved for intermediate- or high-risk MF patients with anemia
- Validated by MOMENTUM study⁵ and subpopulation from the SIMPLIFY-1 trial⁶

Ruxolitinib - First-in-Class JAK1/JAK2 inhibitor

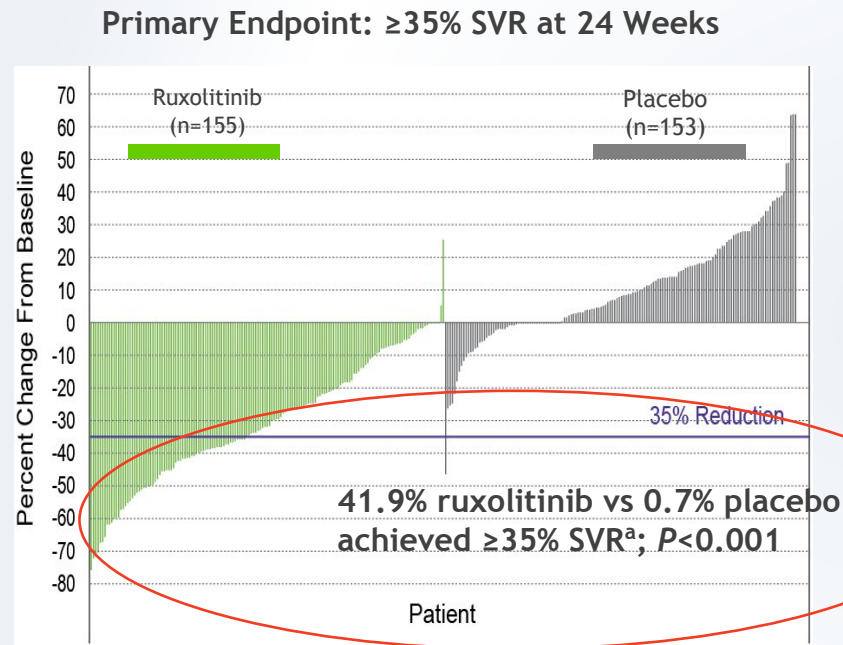
- In 2012, Ruxolitinib became first FDA approved drug for MF
- Reduction in spleen size and improvement in symptom burden-based on Ruben Mesa MPN TSS- Total Symptom Burden scale



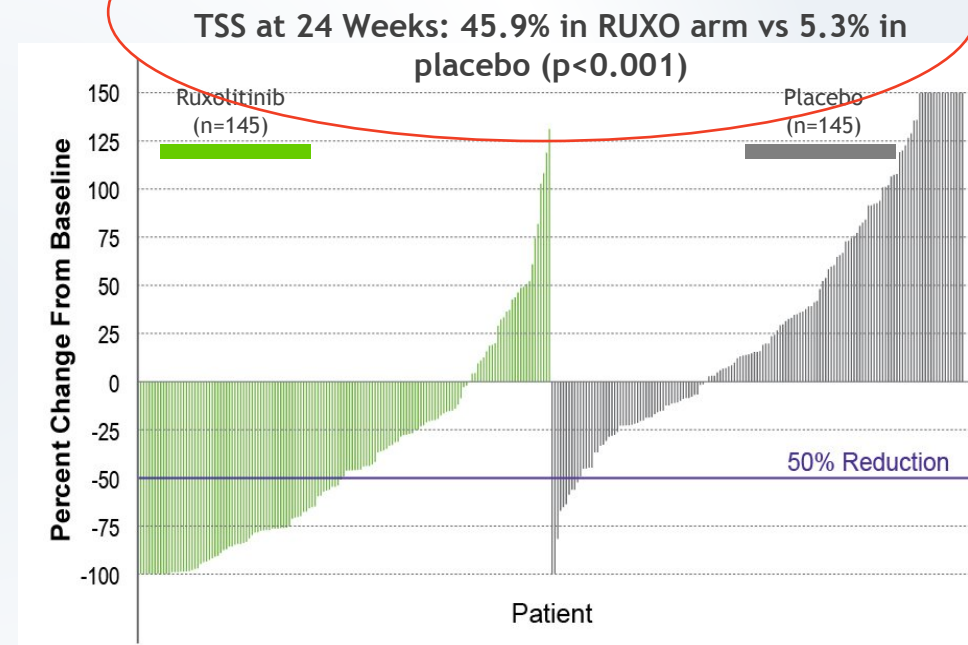
Harrison, C et al NEJM 2012;366:787-798
Verstovsek, S et al NEJM 2012;366:799-807

COMFORT-I: Key Efficacy Endpoints

SVR responses were seen with ruxolitinib in JAK2^{V617F}-positive patients and JAK2^{V617F}-negative patients, relative to placebo



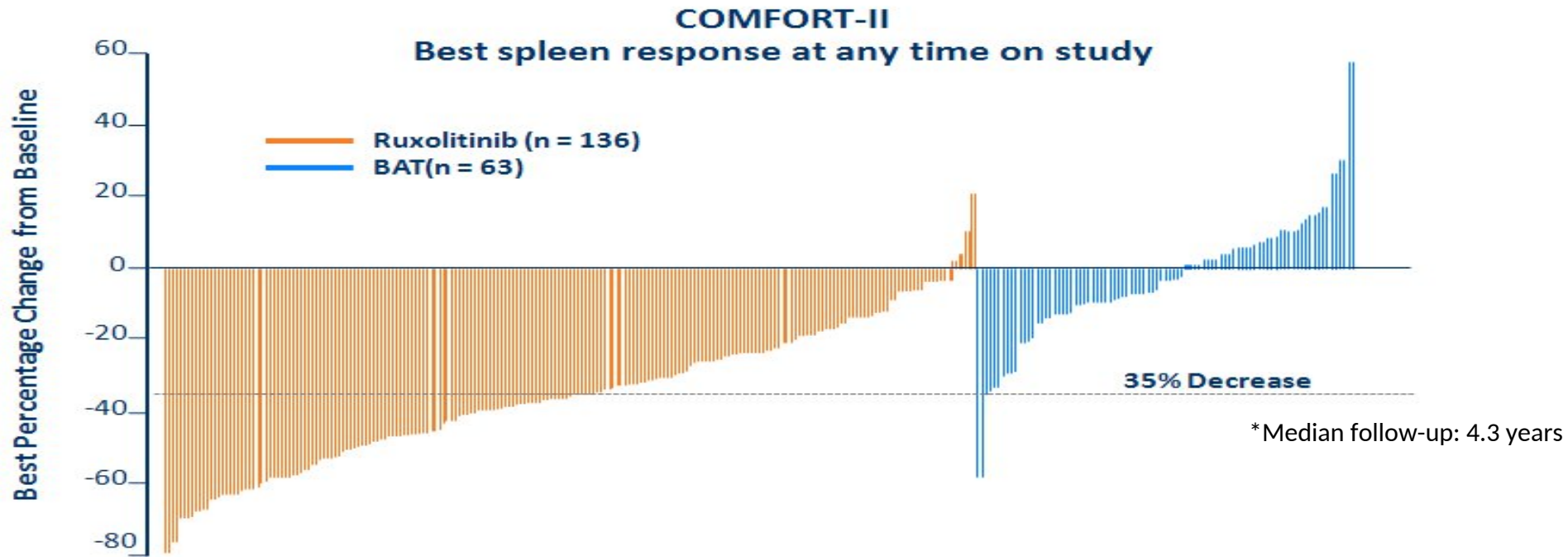
OR, 134.4 (95% CI: 18.0, 1004.9); $P < 0.001$



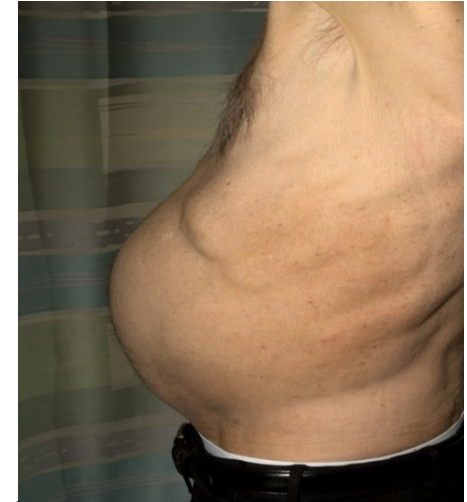
OR, 15.3 (95% CI: 6.9-33.7); $P < 0.001$

^a Changes in palpable spleen length in the ruxolitinib and placebo groups mirrored the changes in spleen volume. SVR, spleen volume reduction; TSS, total symptom score. Verstovsek S, et al. *N Engl J Med.* 2012;366:799-807.

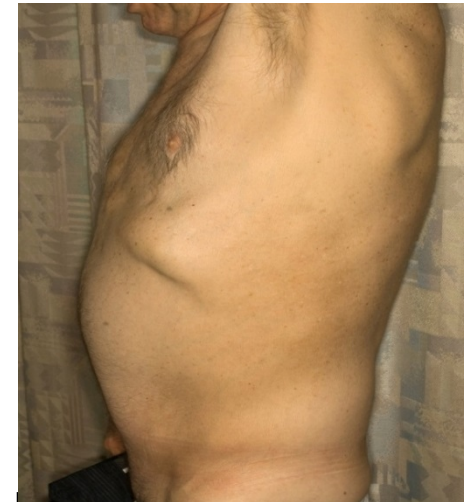
Spleen Volume Response: Ruxolitinib vs. BAT



- Dosed based on platelet number (not recommended for platelets <50K)
- It can cause anemia and thrombocytopenia
- Long-term ruxolitinib therapy prolongs survival (earlier intervention and better the spleen response, longer the survival)

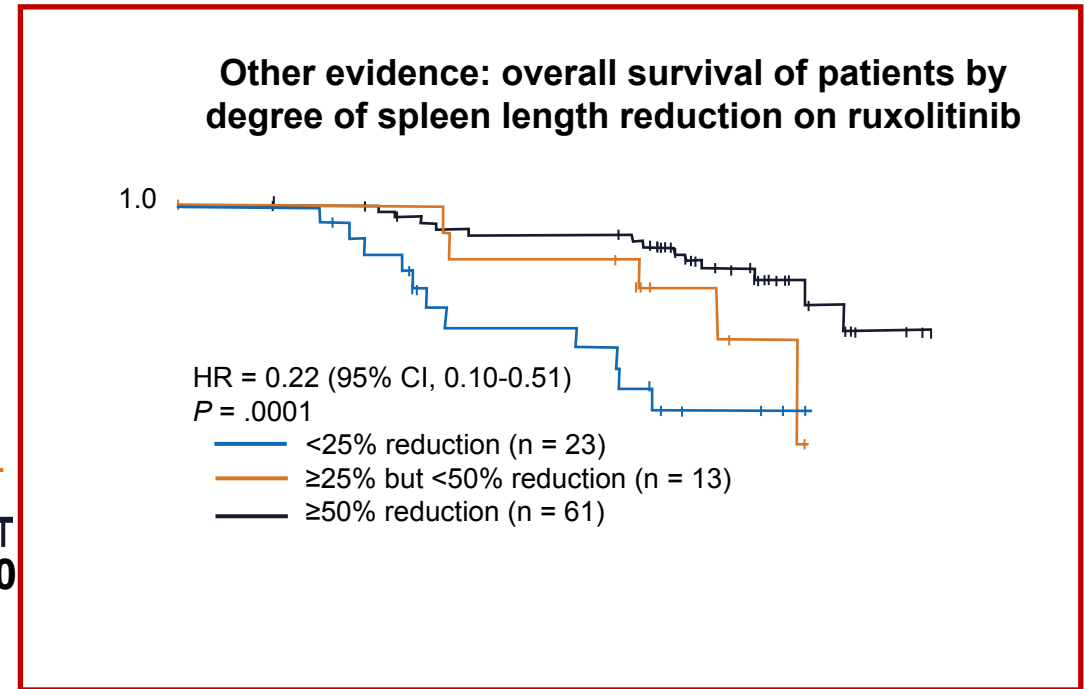
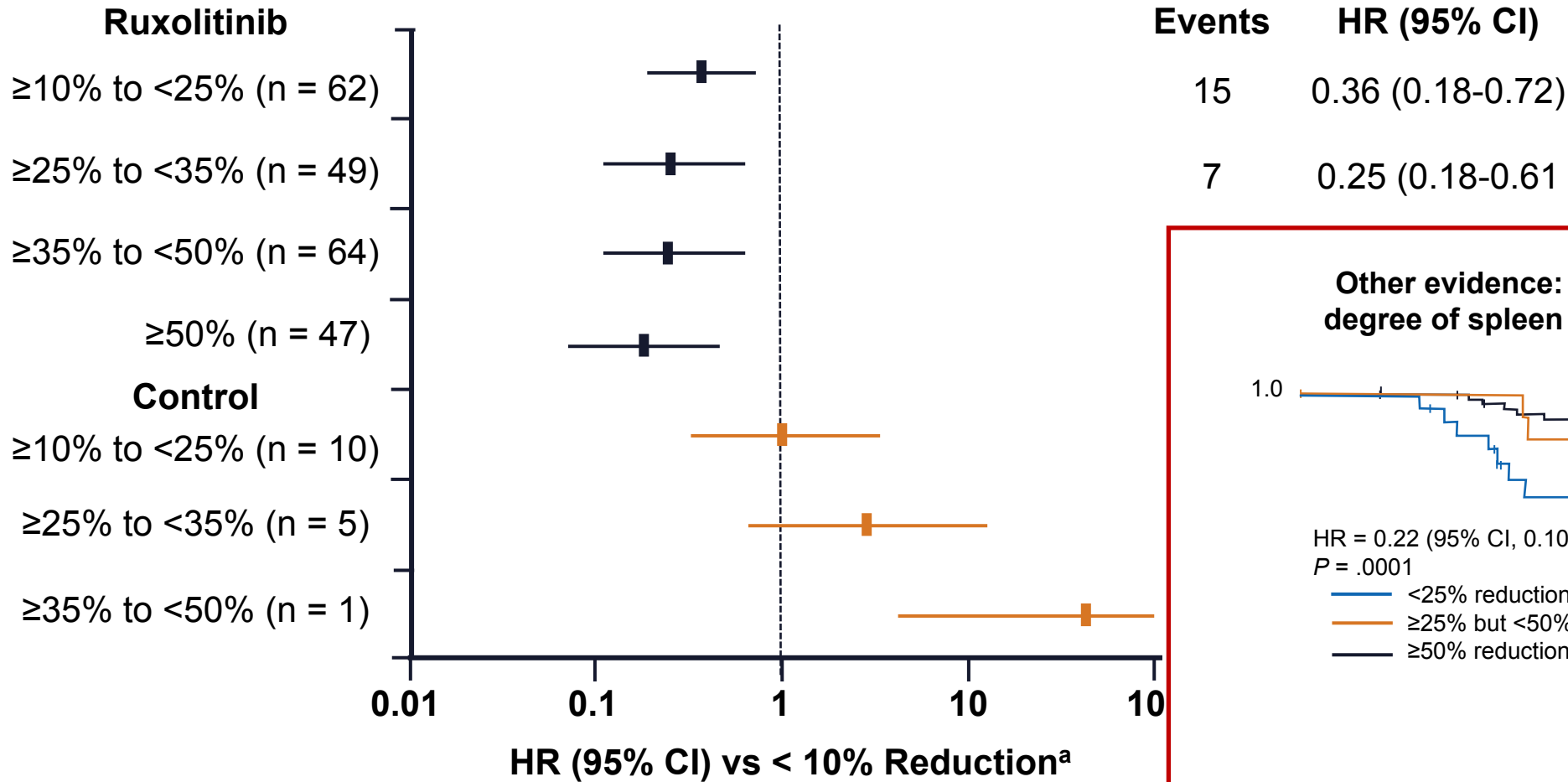


MF Patient Pre-Ruxolitinib Therapy



After 2 Months of Therapy

Better Spleen Response to Ruxolitinib, Better Outcome

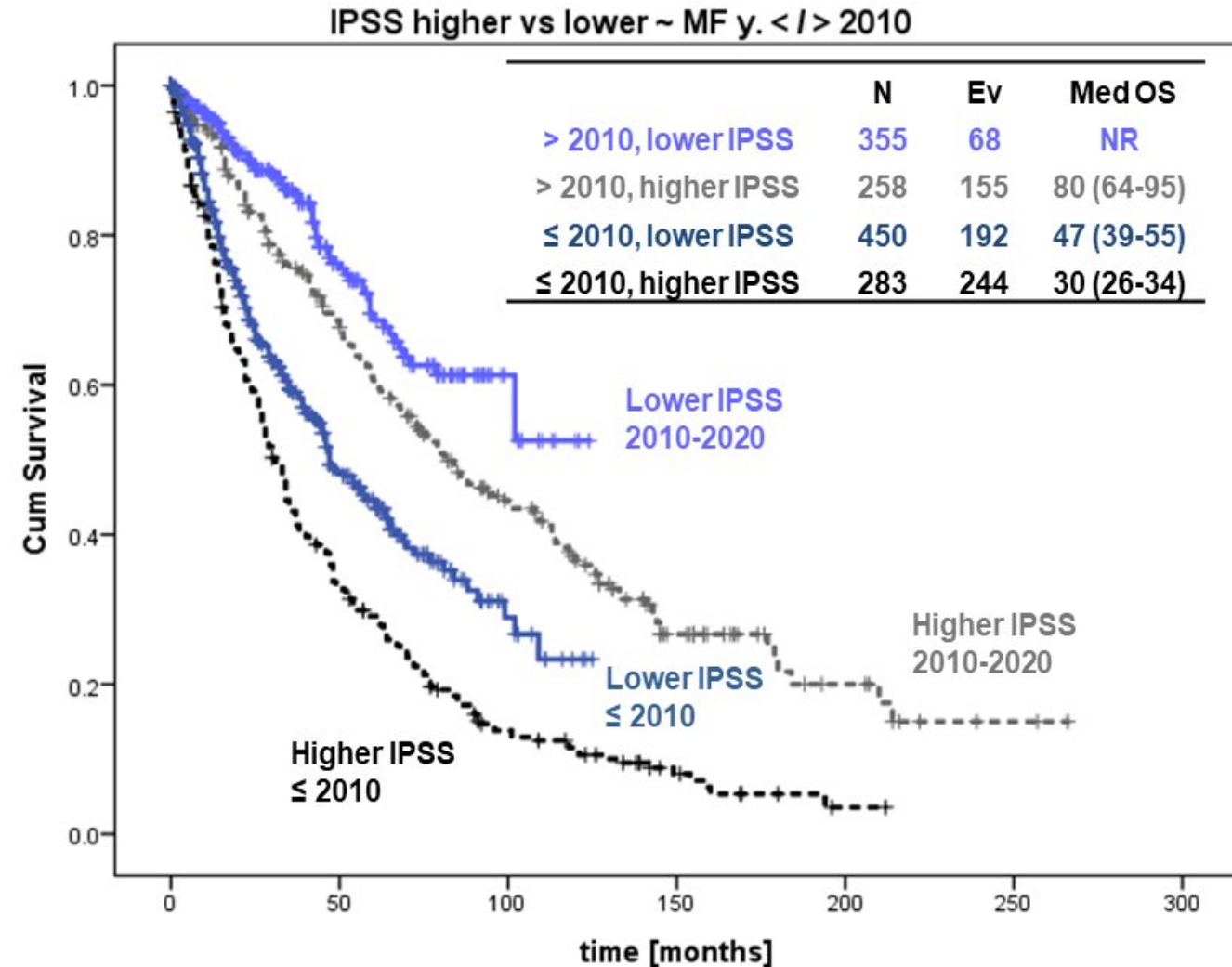
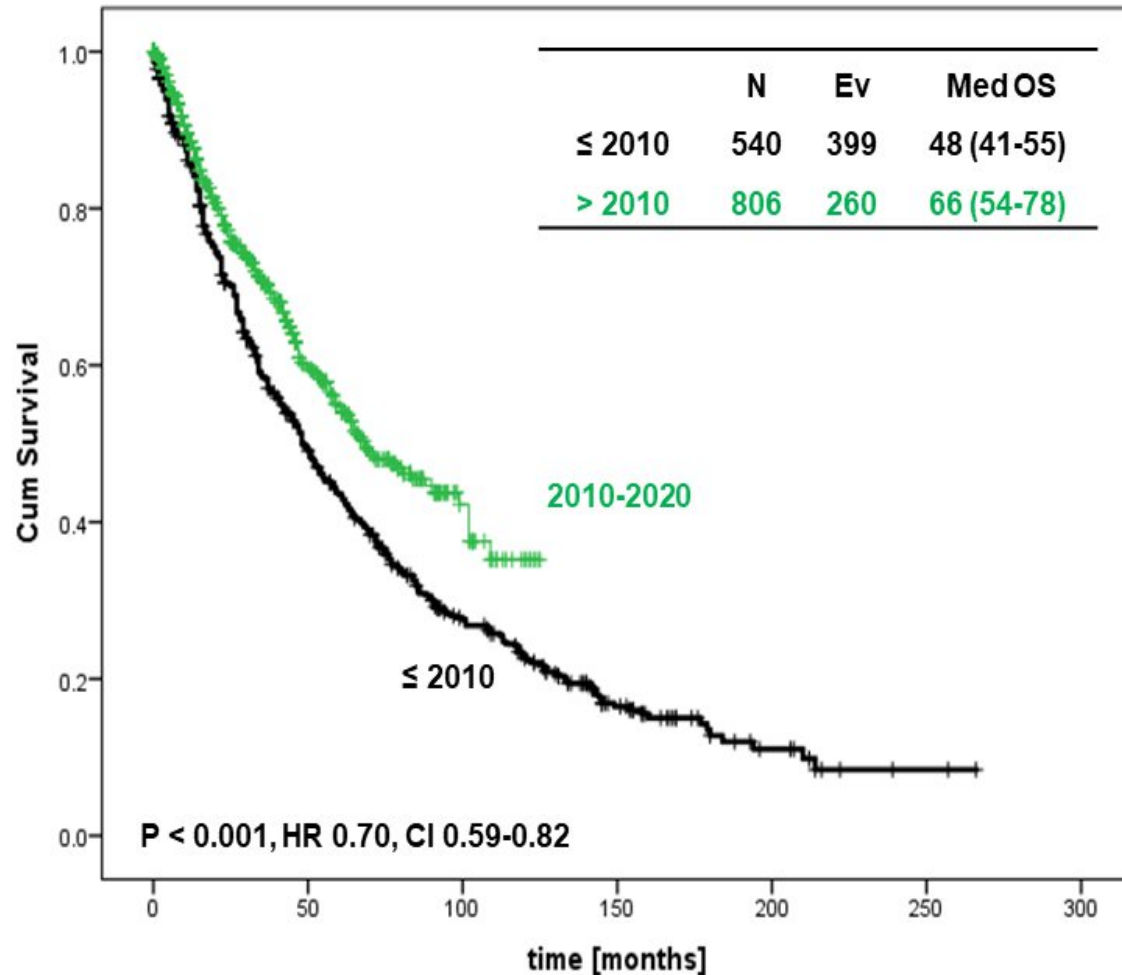


^aCategory includes patients with a <10% reduction from baseline in spleen volume at week 24 or no assessment (ruxolitinib, n=64; control, n=189); among these patients, there were 26 deaths (events) in the pooled ruxolitinib group and 63 deaths in the control group.

1. Vannucchi AM et al. *Haematologica*. 2015;100:1139-1145.

Improved Survival of Patients with Myelofibrosis in the Last Decade

Lucia Masarova, Prithviraj Bose, Naveen Pemmaraju, Lingha Zhou, Sherry Pierce, Zeev Estrov, Hagop Kantarjian, Srdan Verstovsek



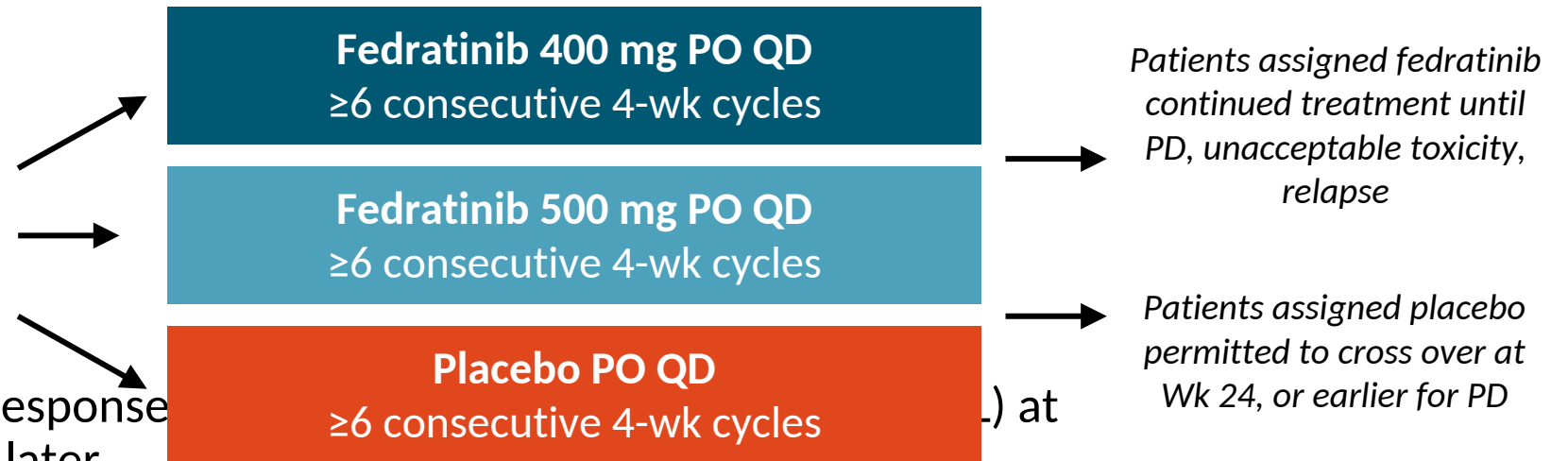
JAKARTA: Fedratinib for Primary or Secondary MF

- International, double-blind, randomized phase III trial
 - Fedratinib**: highly selective, potent inhibitor of wild-type and mutant JAK2; also inhibits FLT3

Adults with primary, post-PV, or post-ET MF; int-2-risk or high-risk status; platelet count $\geq 50 \times 10^3/\mu\text{L}$; splenomegaly; ECOG PS 0-2; life expectancy ≥ 6 mo

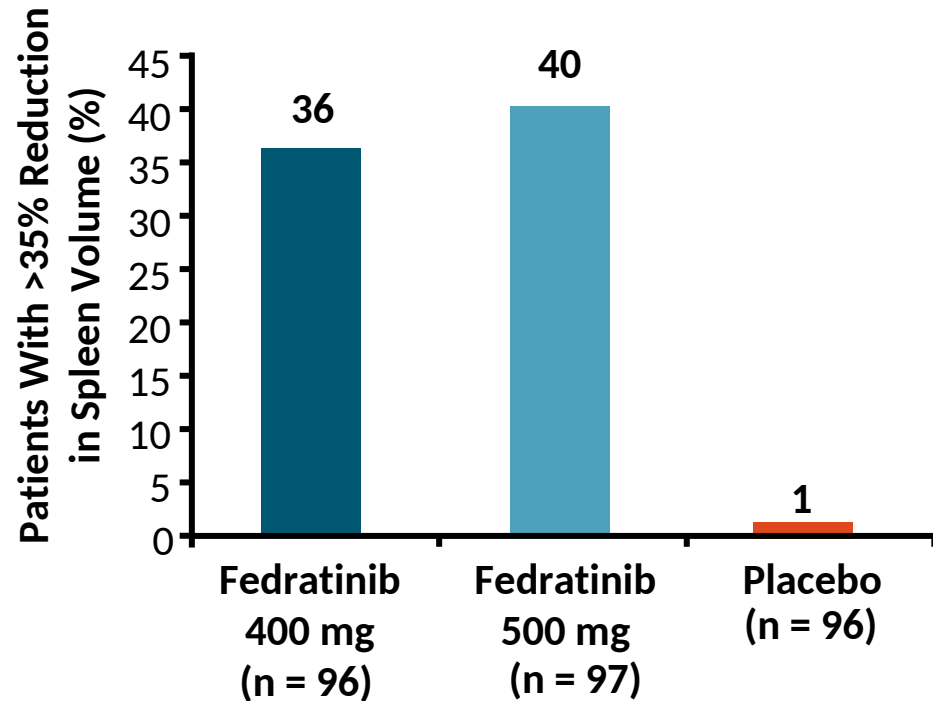
- Primary endpoint:** spleen response Wk 24 and confirmed 4 wk later

- Secondary endpoints:** symptom response ($\geq 50\%$ reduction in TSS), safety

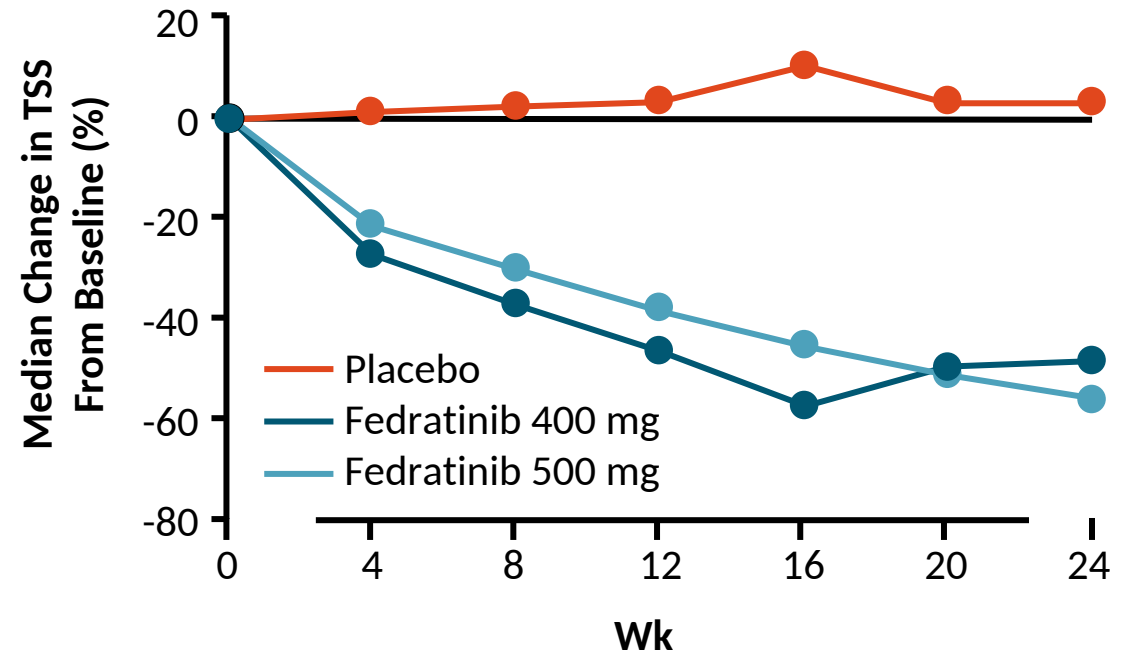


JAKARTA: Efficacy

Spleen Response (Primary Endpoint)



Change in Total Symptom Score



- FDA approved for patients with intermediate-2-risk or high-risk MF who have platelet counts $\geq 50 \times 10^9/L$

Review of Encephalopathy Cases

- Across nine fedratinib trials enrolling 670 MPN or solid tumor patients
- Five potential WE patients
- One subject had malnutrition related to protracted nausea and vomiting, as well as clinical signs and MRI findings consistent with WE
- Two subjects likely experienced WE, both of which recovered without a dose interruption, suggesting fedratinib does not inhibit thiamine absorption
- Two subjects inconclusive or not supportive of WE

No clear link between WE and fedratinib

- 1. Fedratinib does not appear to increase risk for thiamine deficiency beyond its potential to exacerbate malnutrition through poor management of preventable GI events**
- 2. Proper management of GI is an important component of care for patients on fedratinib**

Phase 3 PERSIST-1 and PERSIST-2: Study Design

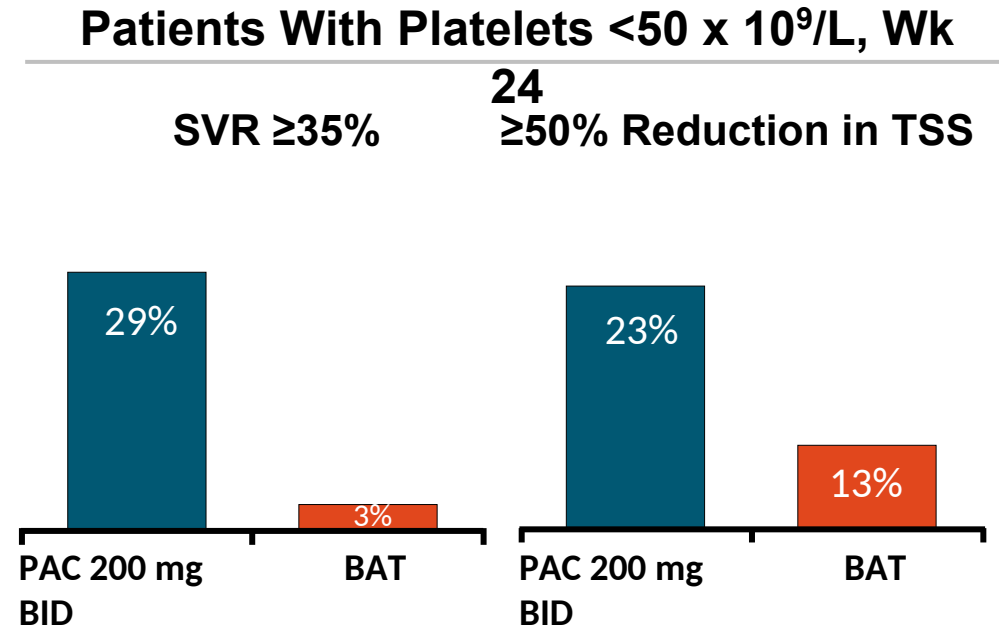
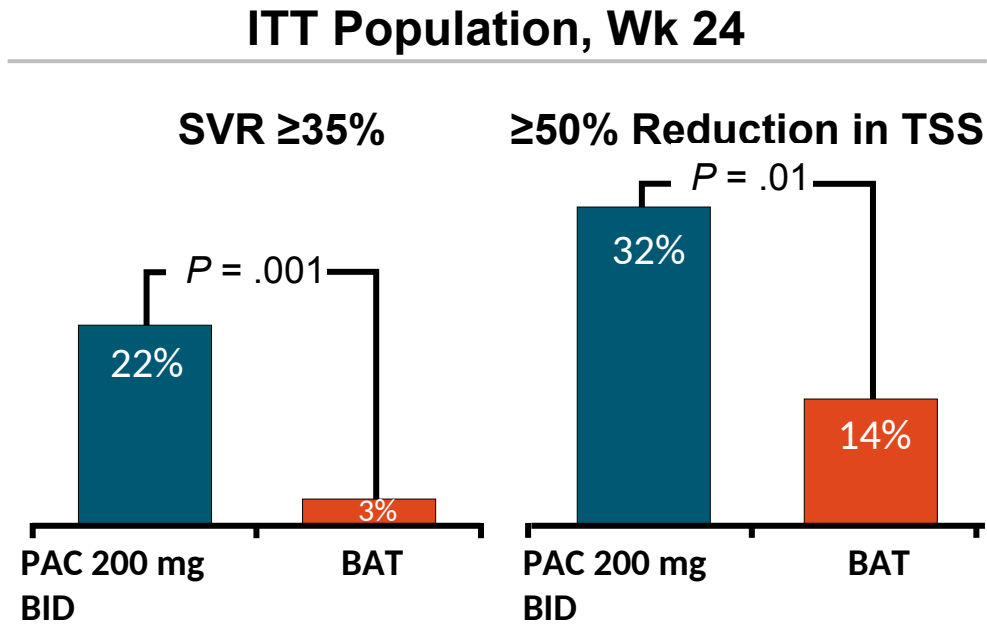
PERSIST-1 1L therapy



PERSIST-2 Thrombocytopenia 1L & 2L therapy



PERSIST-2: Spleen/Symptom Response at 200 mg bid

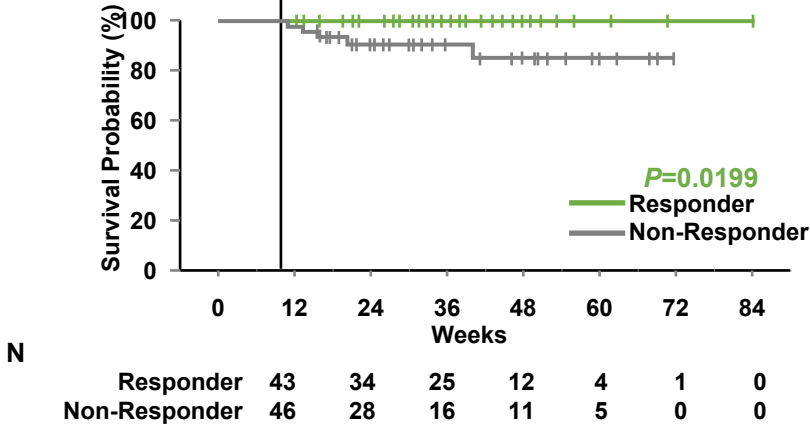


- Rarely myelosuppressive; can cause GI side effects
- **Pacritinib received accelerated FDA approval as therapy for patients with intermediate/high-risk MF with platelets <50 x 10⁹/L**

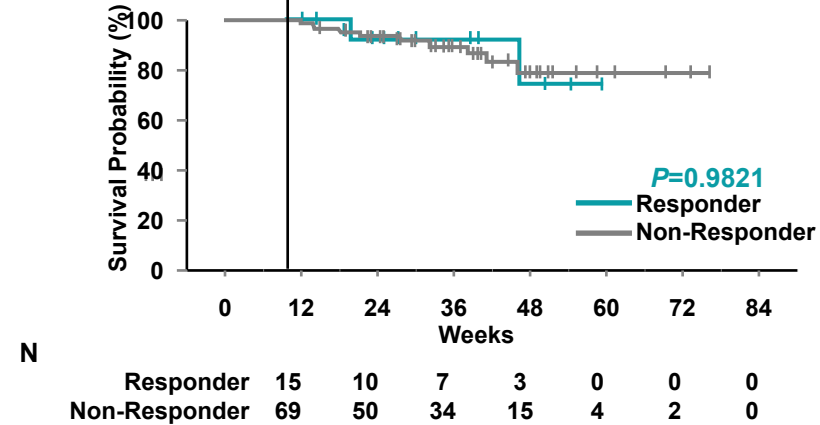
SVR Predicts Survival In MF Patients On Pacritinib But Not Best Available Therapy: Persist-2 Landmark Overall Survival Analysis

Pacritinib

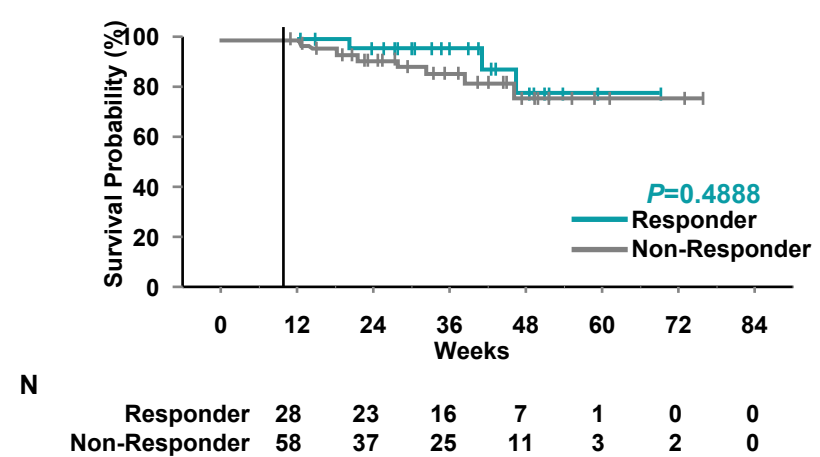
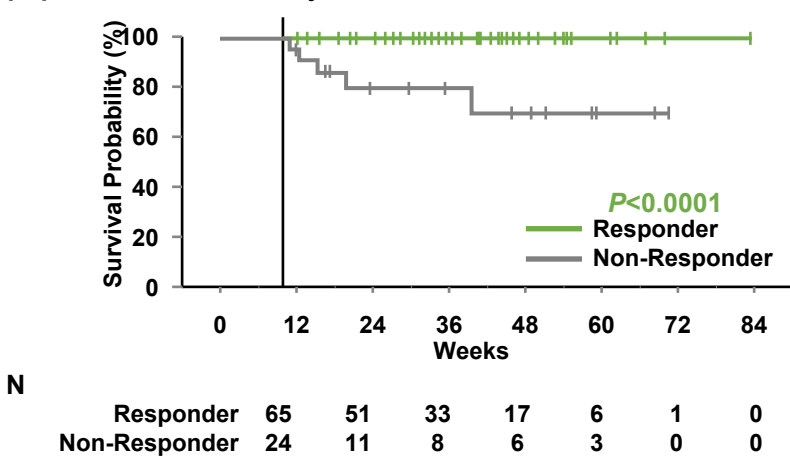
(B) OS Stratified by $\geq 20\%$ SVR



BAT (including RUX)



(C) OS Stratified by $\geq 10\%$ SVR



Risk-adjusted safety analysis of the oral JAK2/IRAK1 inhibitor pacritinib in patients with myelofibrosis

Naveen Pemmaraju¹ | Claire Harrison² | Vikas Gupta³ | Srdan Verstovsek¹ |
Bart Scott⁴ | Stephen T. Oh⁵ | Francesca Palandri⁶ | Haifa Kathrin Al-Ali⁷ |
Marta Sobas⁸ | Mary Frances McMullin⁹ | Ruben Mesa¹⁰ | Sarah Buckley¹¹ |
Karisse Roman-Torres¹¹ | Alessandro Vannucchi¹² | Abdulraheem Yacoub¹³

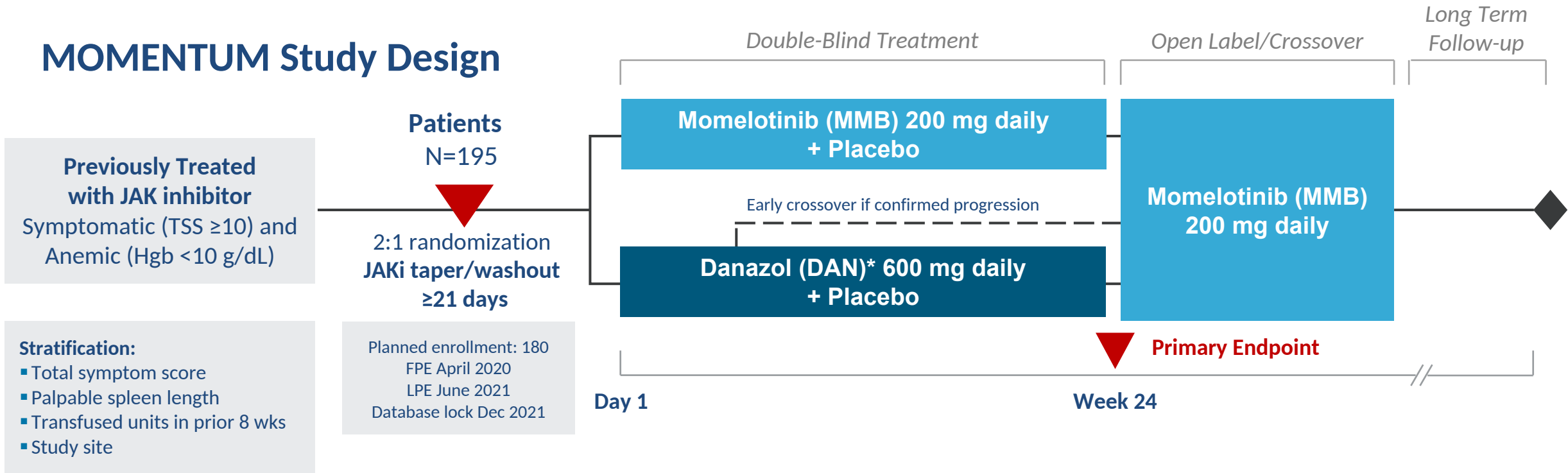
Abstract

The safety profile of the novel oral JAK2/IRAK1 inhibitor pacritinib in patients with cytopenic myelofibrosis was described in the Phase 2 PAC203 and Phase 3 PERSIST-2 studies. To account for longer treatment durations on the pacritinib arms compared to best available therapy (BAT), we present a risk-adjusted safety analysis of event rates accounting for different time on treatment. While the rate of overall events was higher on pacritinib compared to BAT, the rate of fatal events was lower, and there was no excess in bleeding, cardiac events, secondary malignancy, or thrombosis on pacritinib, including in patients with severe thrombocytopenia.

TABLE 1 Baseline patient and disease characteristics

| Characteristic | PAC203 | PERSIST-2 | | Pooled Analysis | |
|--|-----------------------------|------------------------------|---------------|---------------------|---------------------------|
| | PAC 200 mg BID n = 54 | PAC 200 mg BID n = 106 | BAT n = 98 | BAT = RUX n = 44 | PAC 200 mg BID n = 160 |
| Age (years), median (range) | 69 (37, 85) | 67 (39, 85) | 68 (32, 83) | 68 (42, 83) | 68 (37, 85) |
| Female gender, n (%) | 22 (41%) | 44 (42%) | 45 (46%) | 15 (34%) | 66 (41%) |
| ECOG PS ≥ 2 , n (%) | 8 (15%) | 12 (11%) | 18 (18%) | 10 (23%) | 20 (13%) |
| PLT ($\times 10^9/L$), median (IQR) ¹ | 59 (29, 91) | 55 (36, 93) | 57 (29, 81) | 61 (35, 91) | 57 (33, 93) |
| PLT $< 50 \times 10^9/L$, n (%) ¹ | 24 (44%) | 47 (44%) | 42 (43%) | 17 (39%) | 71 (44%) |
| HB < 10 g/dl, n (%) | 41 (76%) | 62 (59%) | 54 (55%) | 23 (52%) | 103 (64%) |
| Receives RBC transfusions, n (%) ² | 34 (63%) | 49 (46%) | 47 (48%) | 19 (43%) | 83 (52%) |
| Peripheral blasts $\geq 1\%$, n (%) | 32 (59%) | 48 (45%) | 46 (47%) | 27 (61%) | 80 (50%) |
| Primary MF, n (%) | 37 (69%) | 82 (77%) | 60 (61%) | 22 (50%) | 119 (74%) |
| DIPSS high risk, n (%) | 14 (26%) | 29 (27%) | 26 (27%) | 12 (27%) | 43 (27%) |
| Prior JAKi exposure, n | 54 (100%) | 51 (48%) | 52 (53%) | 32 (73%) | 105 (66%) |

MOMENTUM Study Design



Primary Endpoint

- Total symptom score (TSS) response rate at Week 24

Key Secondary Endpoints

- Transfusion independence (TI) rate at Week 24
- Splenic response rate (SRR) at Week 24

ClinicalTrials.gov: [NCT04173494](https://clinicaltrials.gov/ct2/show/study/NCT04173494)

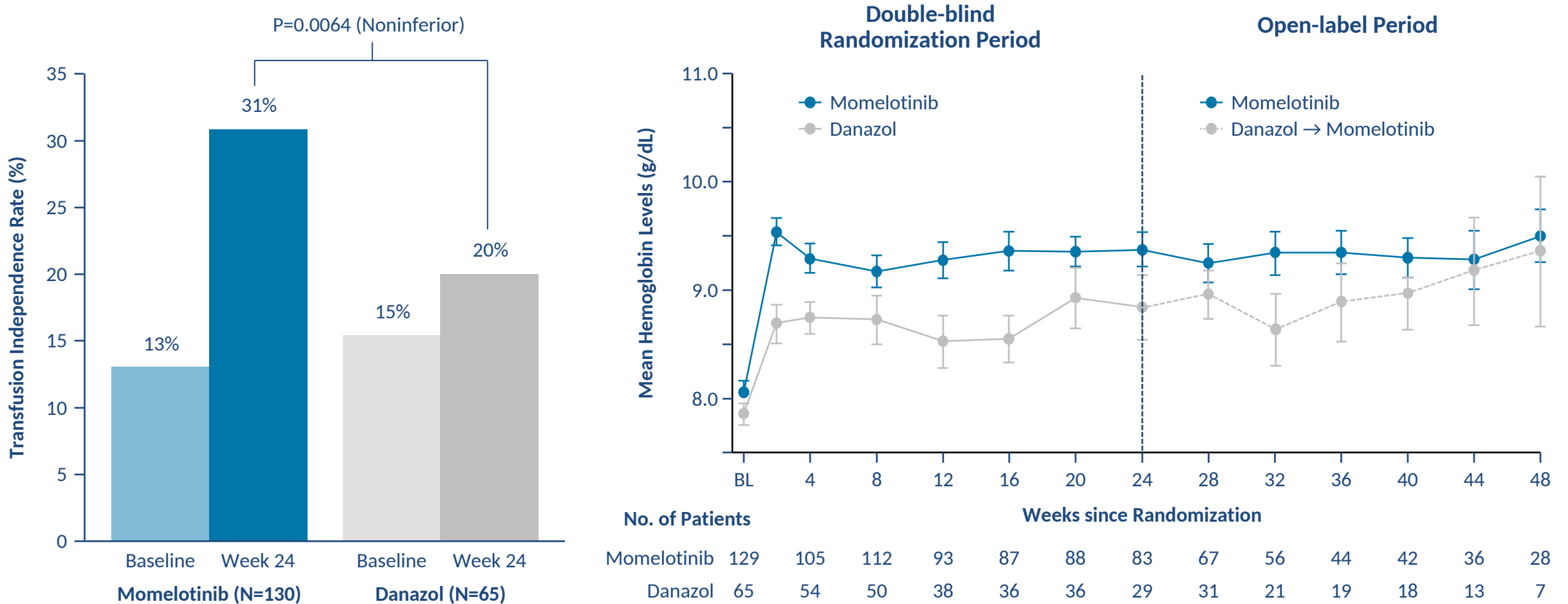
*Danazol was selected as an appropriate comparator given its use to ameliorate anemia in MF patients, as recommended by NCCN, ESMO guidelines.

TSS response defined as achieving ≥50% reduction in TSS over the 28 days immediately prior to the end of week 24 compared to baseline.

TI defined as not requiring red blood cell transfusion in the last 12 weeks of the 24-week randomized period, with all hemoglobin levels during the 12-week interval of ≥8 g/dL.

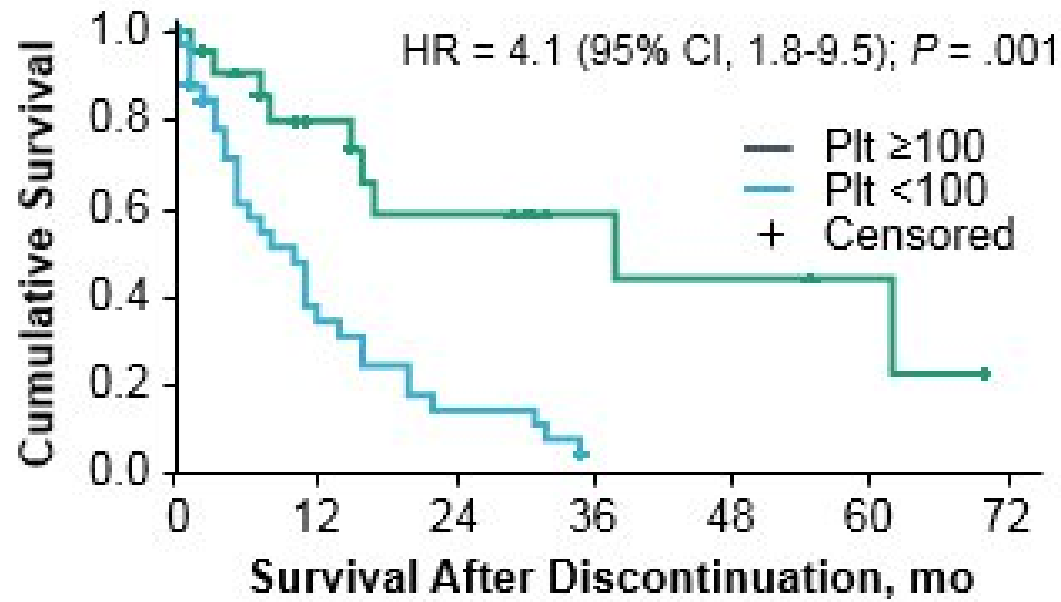
SRR defined as achieving a ≥25% or ≥35% reduction in spleen volume from baseline.

Transfusion Independence* Rate at W24 and Mean Hemoglobin Over Time



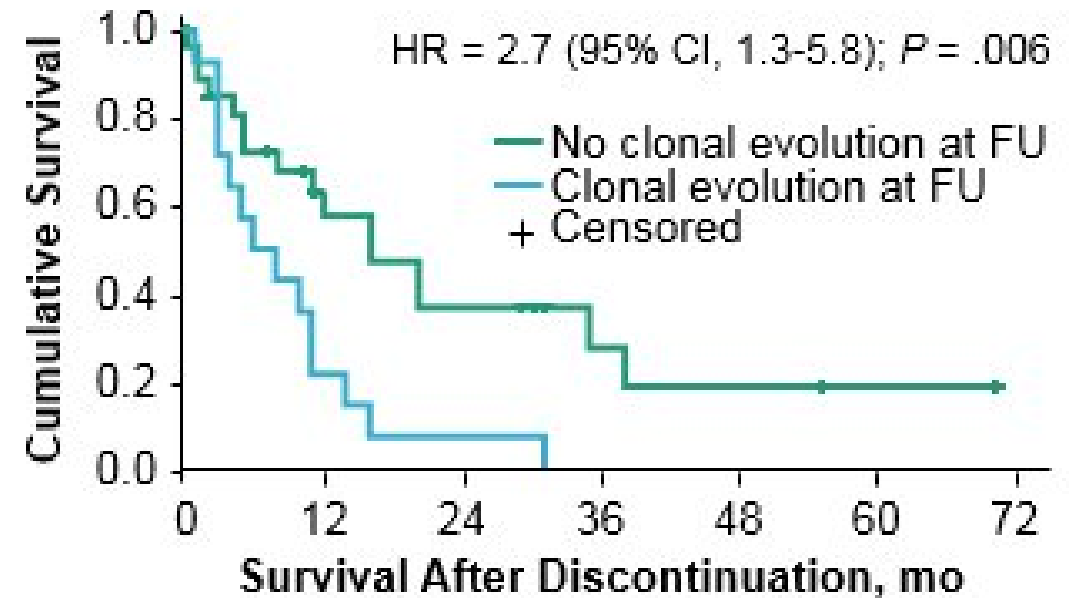
*Defined as not requiring red blood cell transfusion in the terminal 12 weeks of the 24-week randomized period, with all hemoglobin levels during the 12-week interval of ≥ 8 g/dL.

Prognosis After Ruxolitinib Discontinuation



Plts < 100 median survival 11/12

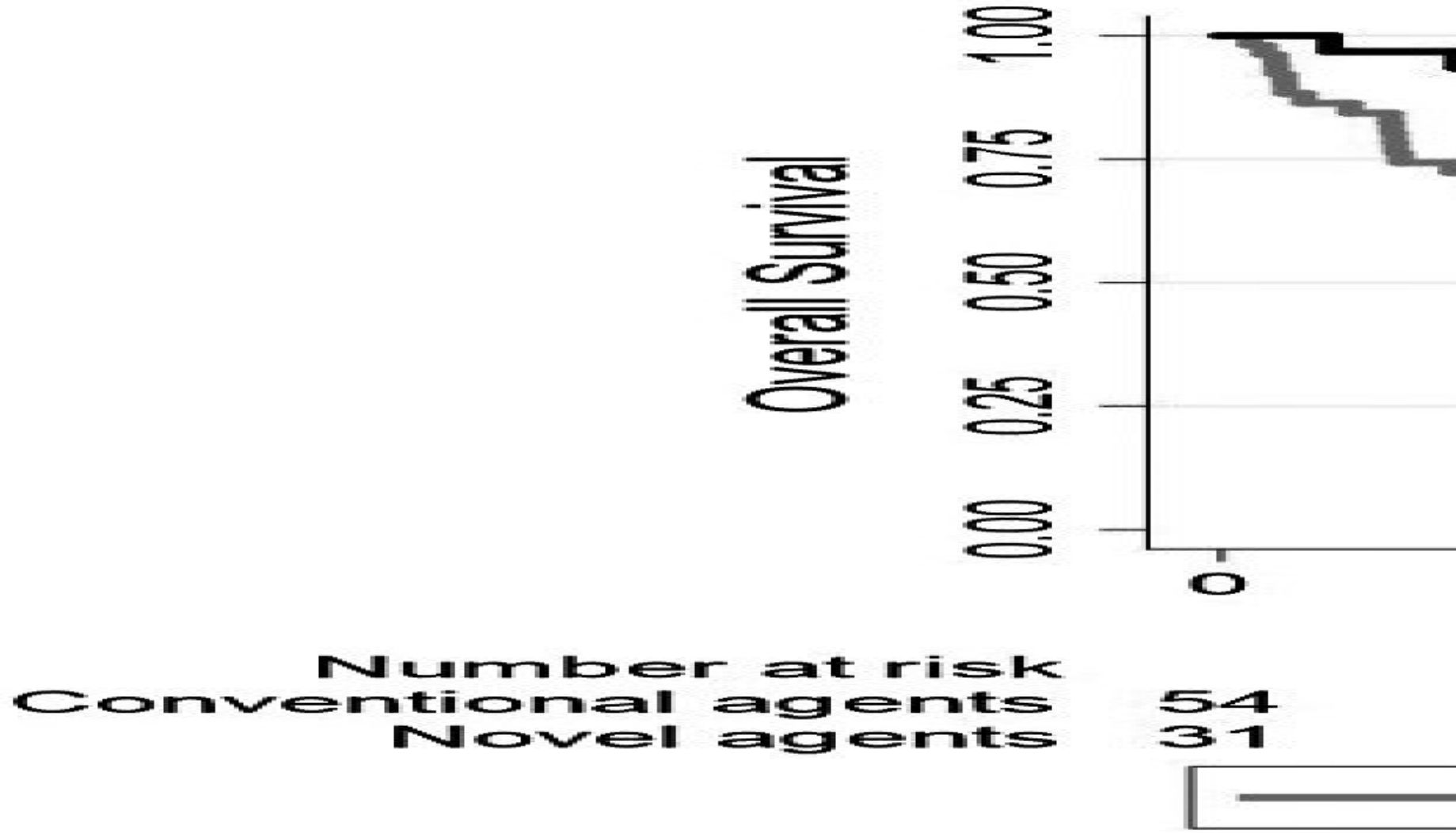
| No. at risk | 0 | 12 | 24 | 36 | 48 | 60 | 72 |
|----------------|----|----|----|----|----|----|----|
| Plt ≥ 100 | 23 | 12 | 7 | 4 | 3 | 1 | 0 |
| Plt < 100 | 33 | 10 | 4 | 0 | | | |



Clonal evolution median survival 6/12

| No. at risk | 0 | 12 | 24 | 36 | 48 | 60 | 72 |
|-------------|----|----|----|----|----|----|----|
| No CE | 28 | 16 | 4 | 4 | 2 | 1 | 0 |
| CE | 14 | 3 | 3 | 1 | 0 | | |

Life after ruxolitinib: Reasons for discontinuation, impact of disease phase, and outcomes in 218 patients with myelofibrosis



- At 3 years, 41% of patients stopped taking RUXO
- Baseline predictors for RUXO d/c: 1)int-2/HR MF; plt <100; tx-dep; unfavorable karyotype
- n=55 (19%)patients died while taking RUXO
- Reasons for RUXO d/c: lack of response (23%); loss of spleen response (12%); ruxo-related AE's (27.5%); progression to BP (23%); unrelated to ruxo AE's (9%) & alloSCT in response (5%)
- Med OS s/p RUXO d/c= 13.2 mo
- The use of investigational agents was associated with improved outcomes vs conventional agents

Defining disease modification in myelofibrosis in the era of targeted therapy

Naveen Pemmaraju, MD ¹; Srdan Verstovsek, MD, PhD¹; Ruben Mesa, MD, FACP ²; Vikas Gupta, MD³; Jacqueline S. Garcia, MD⁴; Joseph M. Scandura, MD ⁵; Stephen T. Oh, MD⁶; Francesco Passamonti, MD⁷; Konstanze Döhner, MD⁸; and Adam J. Mead, MD⁹

Defining disease modification in MF/Pemmaraju et al

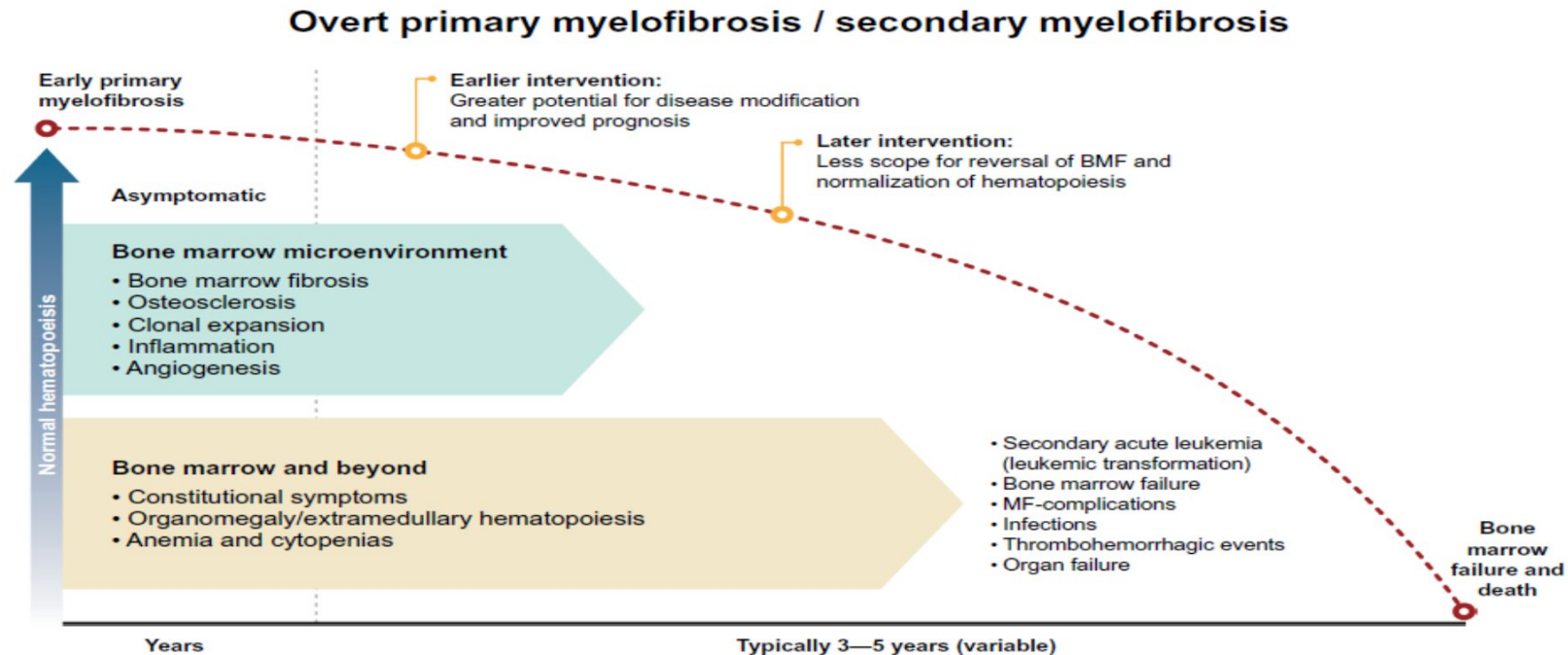
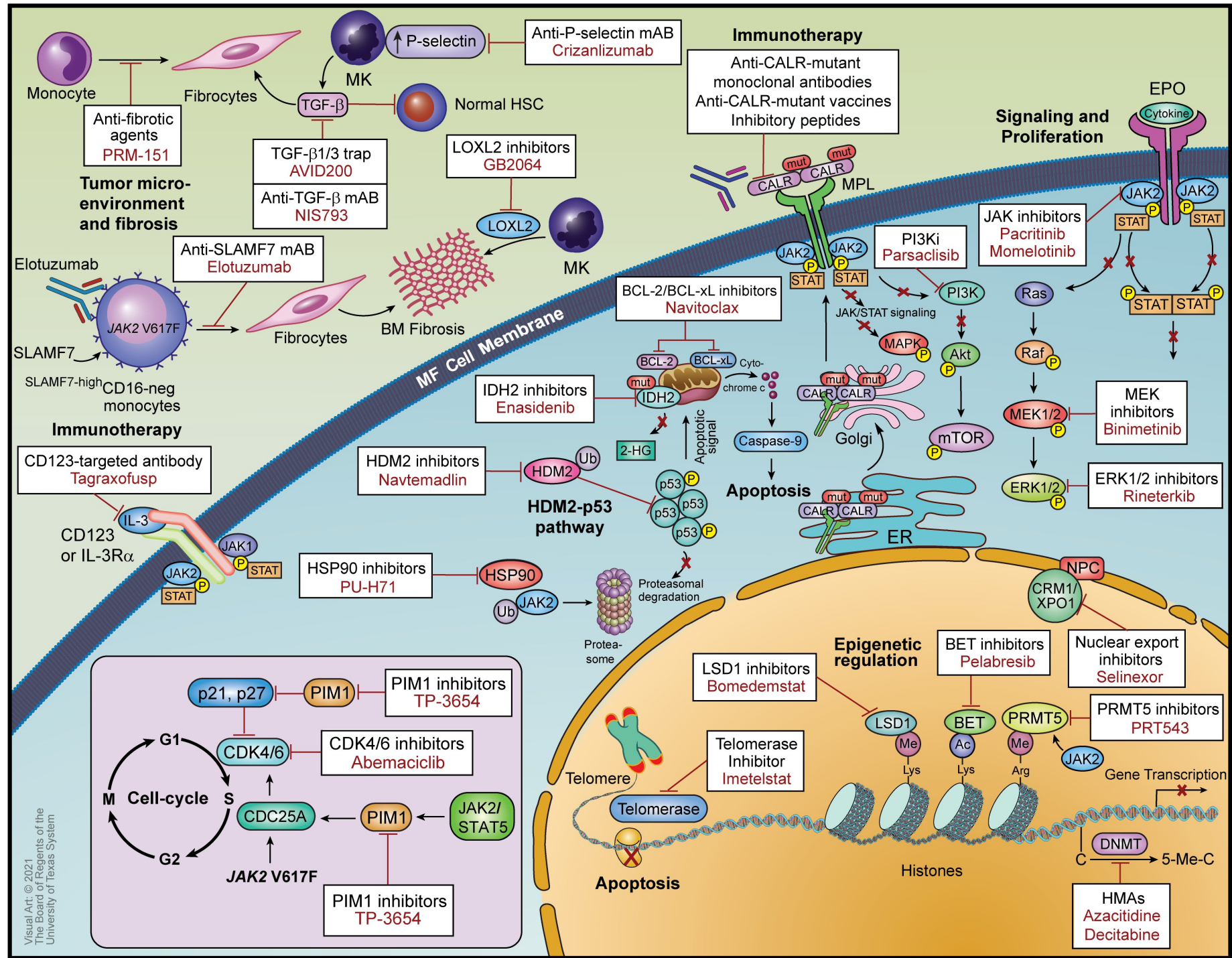


FIGURE 2. Natural history of myelofibrosis and potential time points for intervention. The red dotted line represents the decline in normal hematopoiesis along the natural course of disease.^{1,2,23,79} BMF indicates bone marrow fibrosis; MF, myelofibrosis.

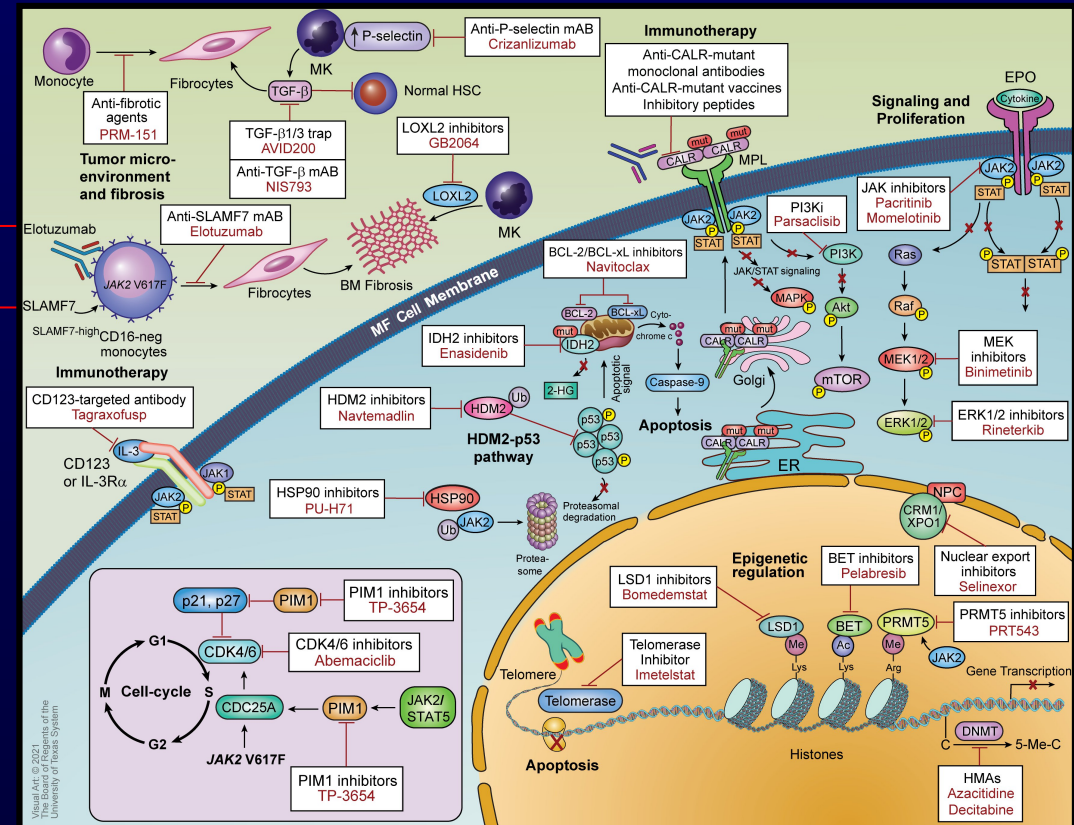
Targets of Novel Therapeutic Agents in Development for Myelofibrosis



Chifotides HT, Bose P, Masarova L, Pemmaraju N, Verstovsek S. *Clin.Lymph. Myeloma Leuk.* 2022; 22(4):210-223.

Ph I/II Combinations: JAKi + another agent/ “add-back or add-on” for MF

- **RUXO + AZA** – frontline (MF) and MDS/MPN-U
– MDACC : MF (Masarova et al BLOOD 2018)
- **RUXO + HSP90i (MF)**
– ClinicalTrials.gov Identifier: NCT03373877
- **RUXO + BCL-xLi (MF) (Navitoclax)**
– ClinicalTrials.gov Identifier: NCT03222609
- **RUXO + PI3Ki (MF) (Parsaclisib)**
– ClinicalTrials.gov Identifier: NCT01730248
- **RUXO + THAL (MF) - frontline & R/R**
– ClinicalTrials.gov Identifier: NCT03069326
- **RUXO + HDACi (Pracinostat) (MF)** – frontline
- **RUXO + IFN (2 ongoing clinical trials – Europe)**
- **RUXO + BETi (MF) (Pelabresib)**
- **RUXO + Sotatercept /Luspatercept**
- **RUXO + MDM2i (Navtemadlin)**
- **RUXO + XPO1i (Selinexor)**



Allo SCT in MF=only curative approach in MF

- **Leukemia, 2015: Consensus working group:**
 - Int-2 or high risk MF & age <70 should be considered
 - Int-1 and age <65 should be considered if either refractory, tx-dep anemia or a % of blasts in periph blood >2%, or unfav cytogen
- **Popat et al : ASCO 2015:**
 - Final prospective ph 2 results: flu/bu conditioning pts with MF
 - n=46; 50% male, med age 58 [27-74 y]
 - Int risk (28) or high risk (18)
 - All pts engrafted; median time 13 days (neutrophil)
 - Med f/u of 5.1 years (1-8.3 y); 3 yOS: 69%; 3yEFS: 48%; CI relapse: 39%
- **Questions remaining: JAKi pre/post; splenectomy pre-/post, timing of SCT, pt populations**

MPN Clinical Pearls for : MF

- **Include thinking about MPNs /MF in workup of patient with unknown hepatosplenomegaly, including in the young patient**
- **Pay attention to CBC and especially diff: look for circulating blasts, immature granulocytes, metamyelocytes, “tear drop” cells**
- **Remember: MF can transform to AML, early death rates; allo-SCT is potentially curative for intermediate/higher risk; remember referral for clinical trials including frontline**

Thank you: To our Rapidly Growing MPN Community

- Please email me npemmaraju@mdanderson.org or call me 713-792-4956 if you have any questions
- **#MPNSM:** Twitter @doctorpemm



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