

Anti-angiogenesis combined with immunotherapeutics

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Disclosure information – Solange Peters

I have received education grants, provided consultation, attended advisory boards and/or provided lectures for the following organizations, from whom I have received honoraria:

- **Consultation / Advisory role:** Abbvie, Amgen, AstraZeneca, Bayer, Biocartis, Bioinvent, Blueprint Medicines, Boehringer-Ingelheim, Bristol-Myers Squibb, Clovis, Daiichi Sankyo, Debiopharm, Eli Lilly, F. Hoffmann-La Roche, Foundation Medicine, Illumina, Janssen, Merck Sharp and Dohme, Merck Serono, Merrimack, Novartis, Pharma Mar, Pfizer, Regeneron, Sanofi, Seattle Genetics and Takeda
- **Talk in a company's organized public event:** AstraZeneca, Boehringer-Ingelheim, Bristol-Myers Squibb, Eli Lilly, F. Hoffmann-La Roche, Illumina, Merck Sharp and Dohme, Novartis, Pfizer, Sanofi, Takeda
- **Receipt of grants/research supports:** (Sub)investigator in trials (institutional financial support for clinical trials) sponsored by Amgen, AstraZeneca, Biodesix, Boehringer-Ingelheim, Bristol-Myers Squibb, Clovis, F. Hoffmann-La Roche, Illumina, Merck Sharp and Dohme, Merck Serono, Novartis, and Pfizer

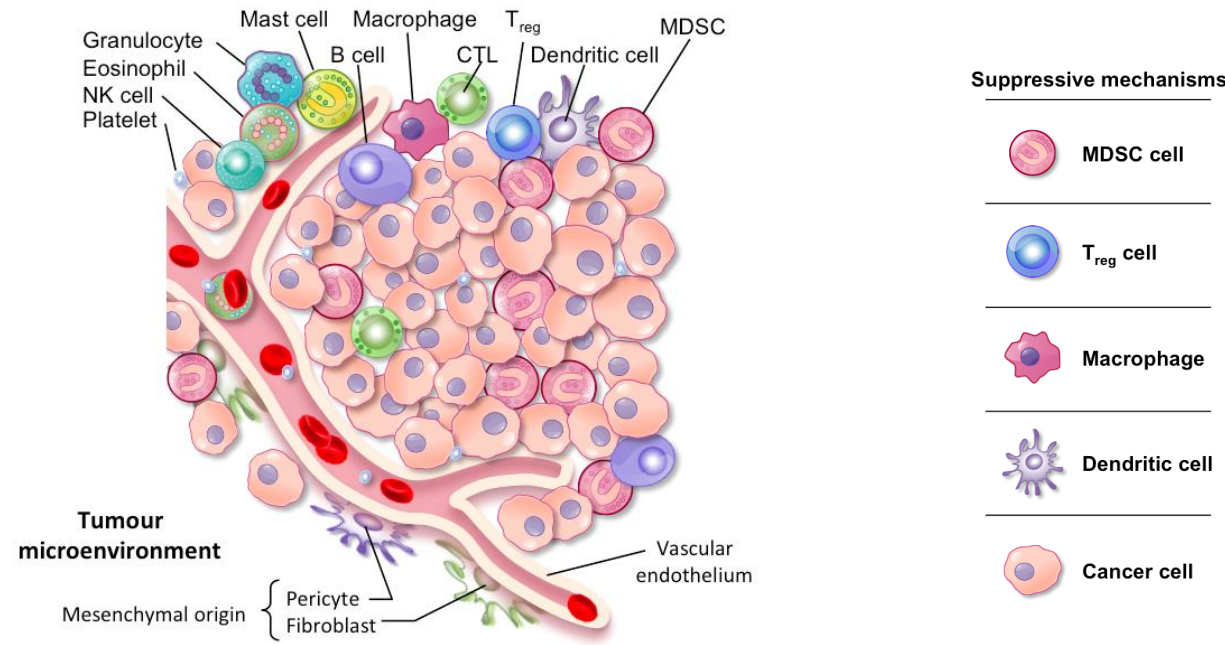
AGENDA

- ◆ Rational for anti-angiogenesis and IO combinations
- ◆ Lung cancer paradigm: from phase 1 to phase 3 trials
- ◆ Combinatorial advances in RCC
- ◆ Ongoing efforts in early clinical trials across diseases

AGENDA

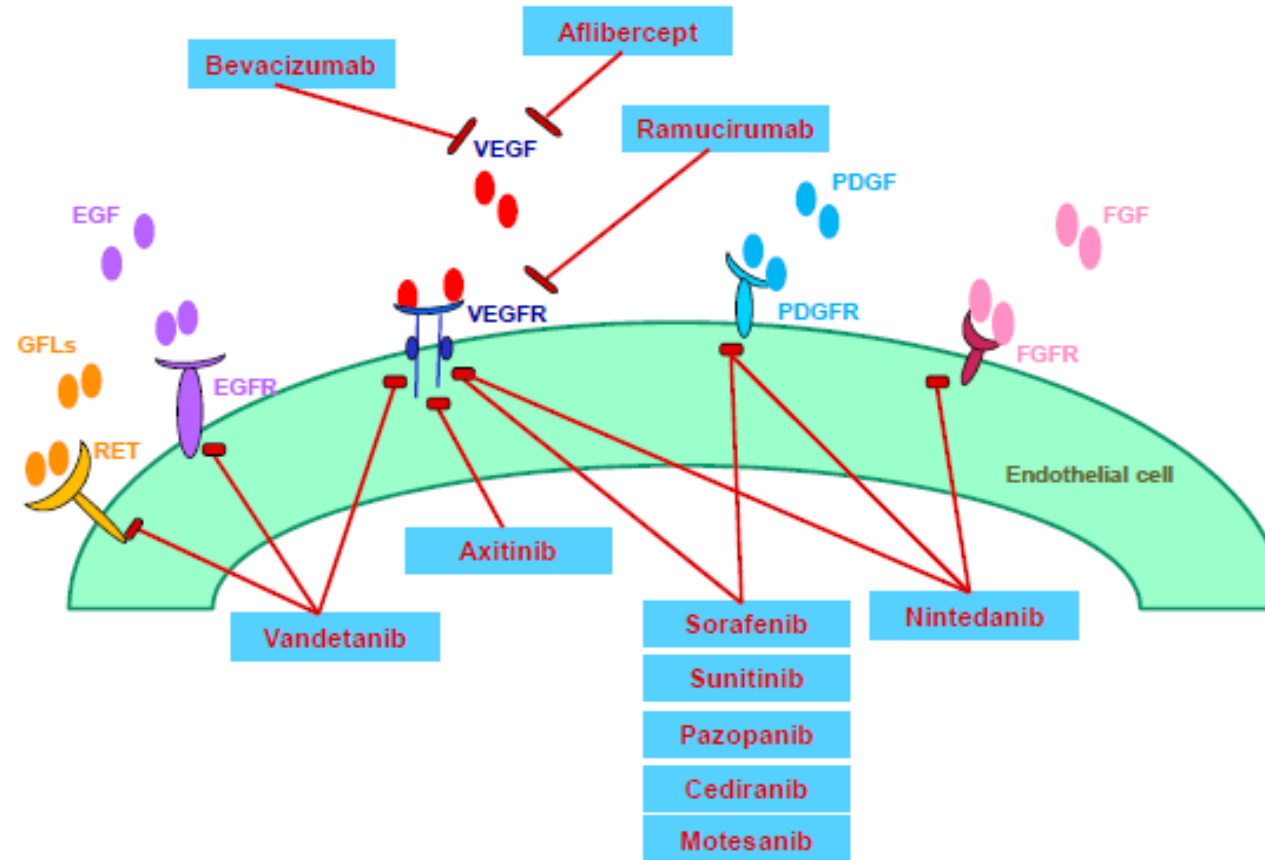
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Cellular constituents of immune escape within the tumour microenvironment



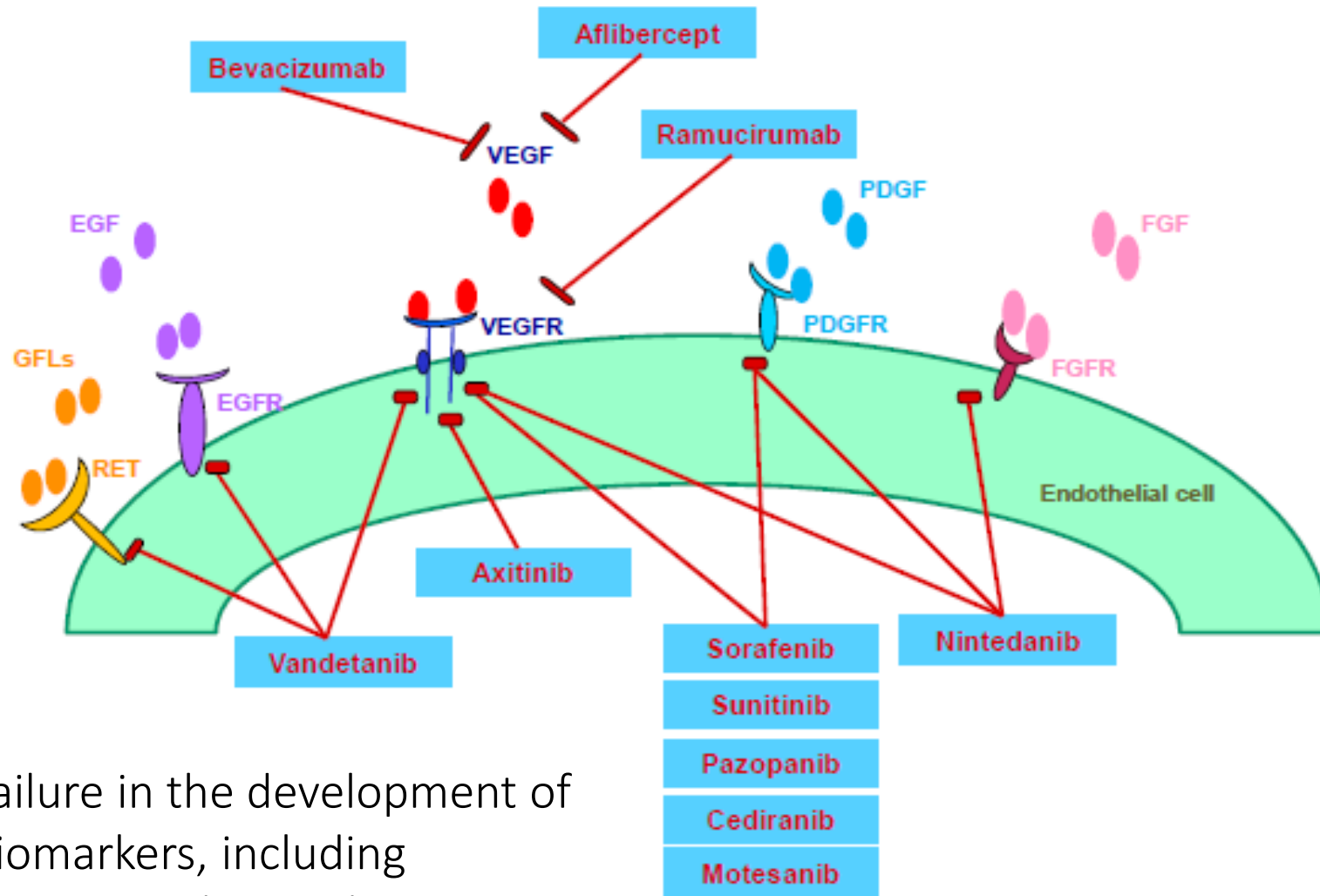
- Tumor masses contain regulatory lymphocytes, myeloid derived suppressor cells, alternatively activated macrophages, and dendritic cells
- Immune cells in tumors are dysregulated and functionally impaired
- Ablation or reprogramming of this aberrant microenvironment might dramatically augment cancer therapies

VEGF targeted therapies



VEGF expression is driven by the tumour and is also an HIF-dependent pro-angiogenic factor, in the context of cancer hypoxic niches

Mechanisms of action of anti-angiogenic therapies



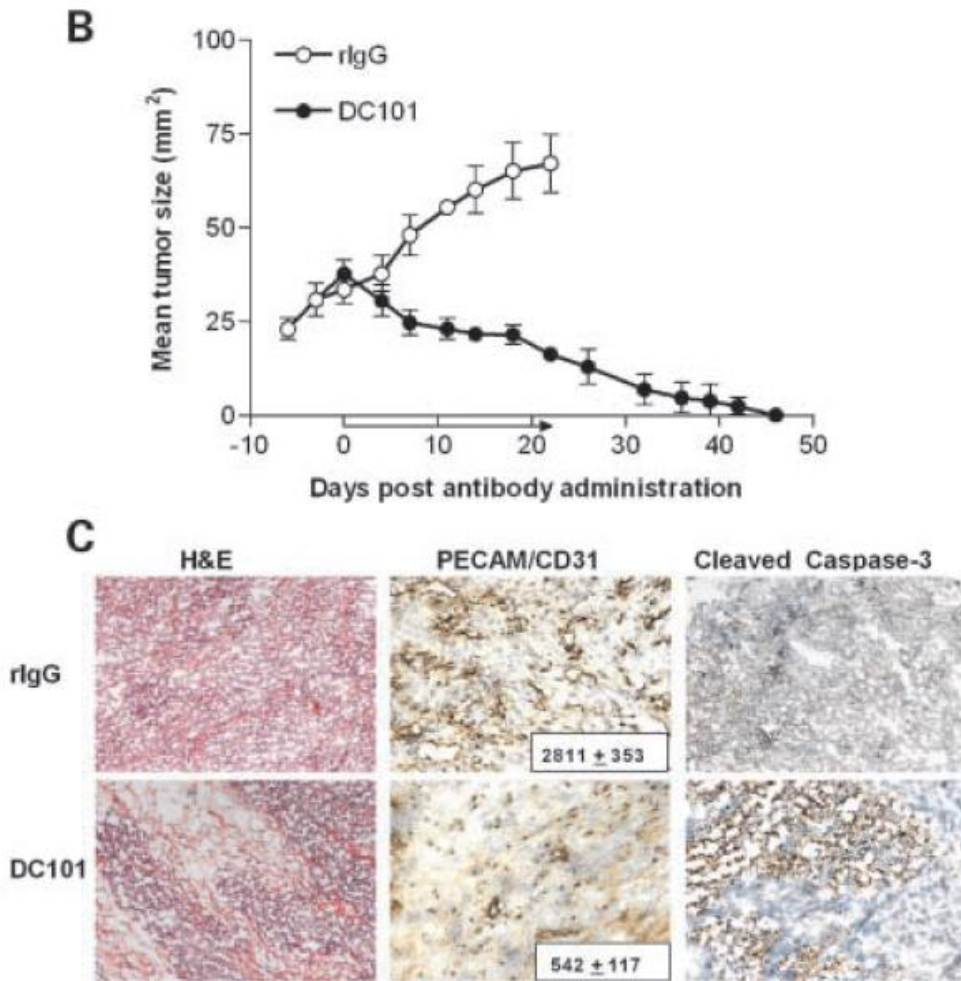
Effects on cancer cell

Hypoxia and effects on vasculature

Effects on the stroma

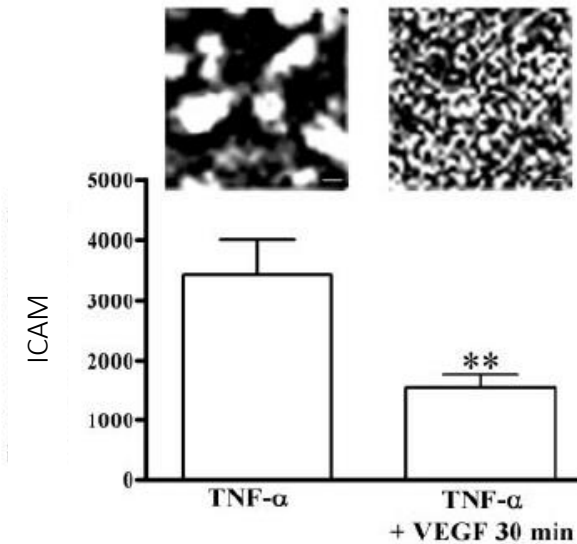
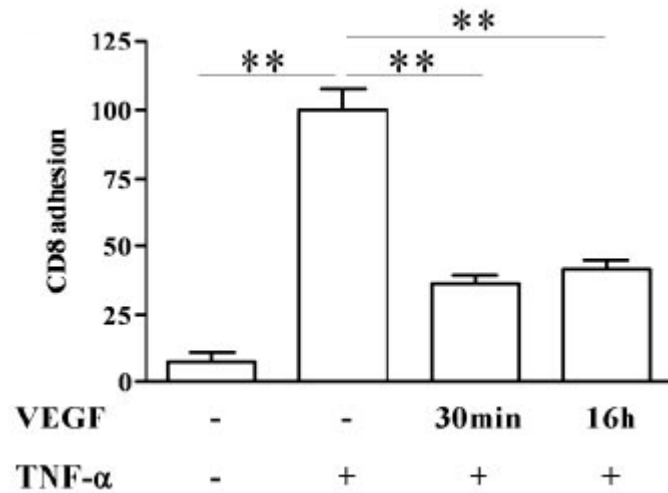
Failure in the development of biomarkers, including angiogenic biomarkers

VEGF blockade induces antitumor immune response, increases T cell homing and improves vaccine therapy



- DC101: monoclonal antibody for VEGFR2
- DC101 inhibits tumor growth, decreases angiogenesis, and increases apoptosis within tumors of mice
- Combining DC101 with neu-specific vaccination accelerated tumor regression

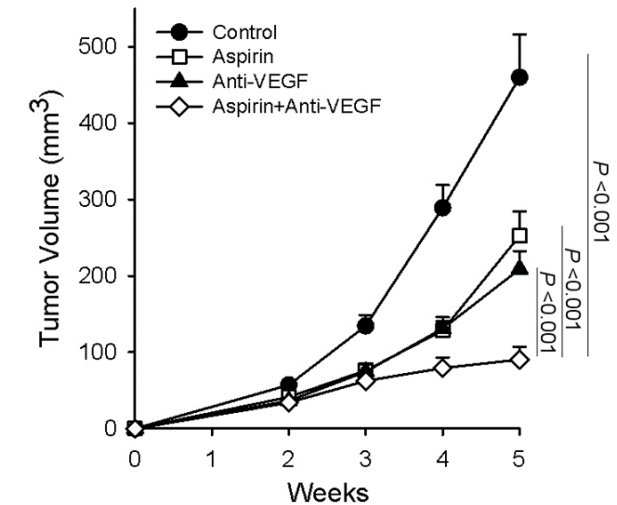
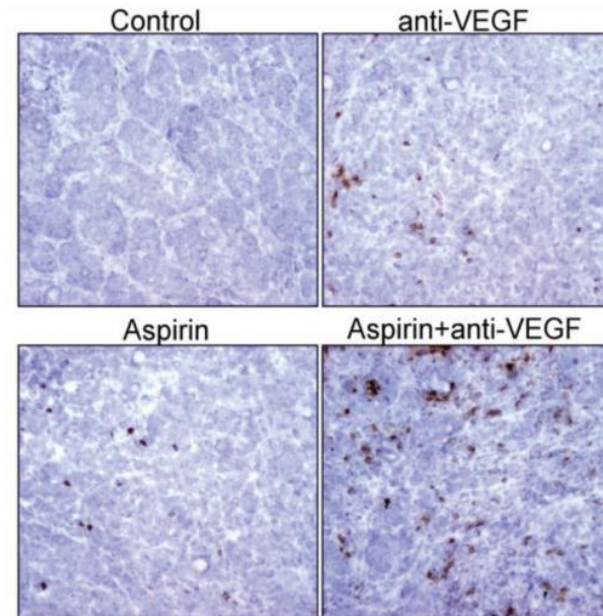
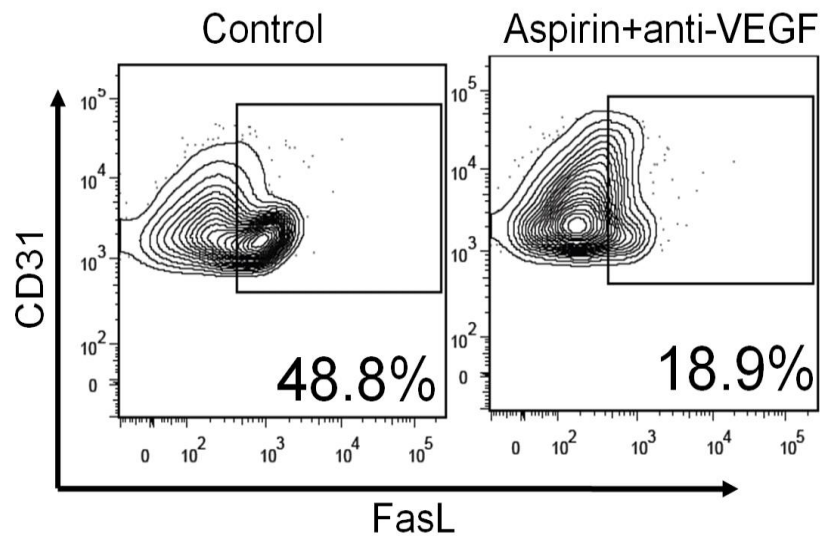
VEGF blocks T cell adhesion on endothelium



Dramatic inhibition of lymphocyte adhesion on activated endothelial cells following either short or long VEGF pretreatments.

Tumor endothelium FasL establishes a selective immune barrier promoting tolerance in tumors nature medicine

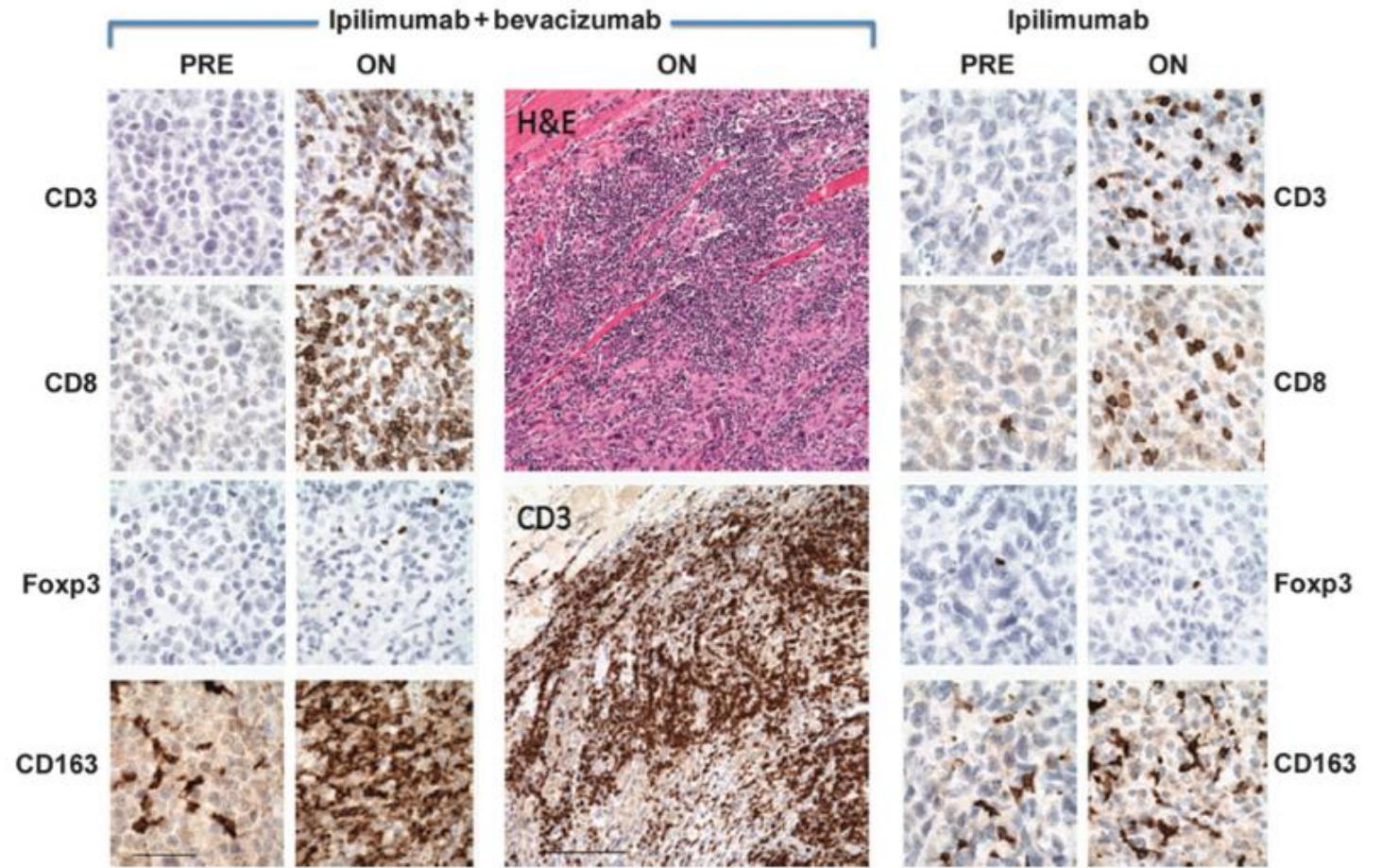
Gregory T Motz¹, Stephen P Santoro¹, Li-Ping Wang², Tom Garrabrant¹, Ricardo R Lastra², Ian S Hagemann², Priti Lal², Michael D Feldman², Fabian Benencia¹ & George Coukos^{1,3}



- VEGF-A induced FasL expression on endothelial cells, which acquired the ability to kill CD8⁺ T cells, but not Tregs
-> VEGF and PGE2 blockade reduce endothelial FasL and increase in the influx of tumor-rejecting CD8⁺ over FoxP3⁺ T cells.

Bevacizumab plus Ipilimumab in Patients with Metastatic Melanoma

F. Stephen Hodi¹, Donald Lawrence⁴, Cecilia Lezcano¹⁰, Xinqi Wu¹, Jun Zhou¹, Tetsuro Sasada¹, Wanyong Zeng¹, Anita Giobbie-Hurder², Michael B. Atkins¹¹, Nageatte Ibrahim¹, Philip Friedlander¹², Keith T. Flaherty⁴, George F. Murphy⁵, Scott Rodig⁵, Elsa F. Velazquez^{7,9}, Martin C. Mihm Jr⁵, Sara Russell⁶, Pamela J. DiPiro³, Jeffrey T. Yap³, Nikhil Ramaiya³, Annick D. Van den Abbeele³, Maria Gargano¹, and David McDermott⁸



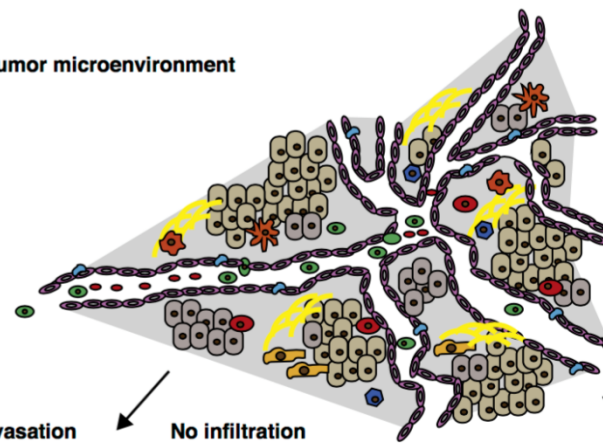
- Endothelial activation with increased lymphocyte and myeloid/monocyte cell trafficking into tumor deposits
- Peripheral blood circulating memory T cells count was increased resulting from the addition of bevacizumab

In Summary

Angiogenic factors and immune response

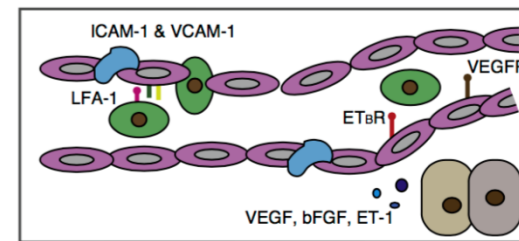
- Angiogenic factors impair lymphocyte trafficking across endothelia
- VEGF has profound effects on cancer immunity
 - By inhibiting dendritic cell maturation and antigen presentation
 - By inhibiting T-cell responses (upregulation PD-L1, PD-L2, IDO-1, IL-6, IL-10...)
 - By inducing proliferation of regulatory T cells
 - By favoring accumulation of myeloid-derived suppressor cells

(a) Solid tumor microenvironment

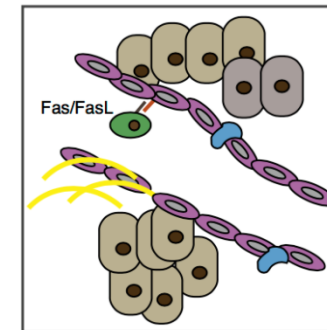


(b) T cell extravasation

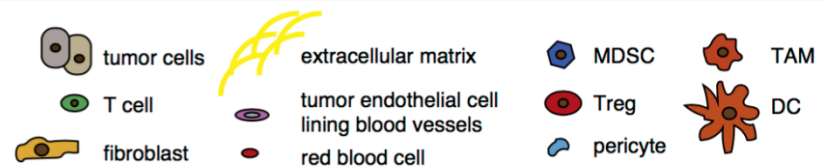
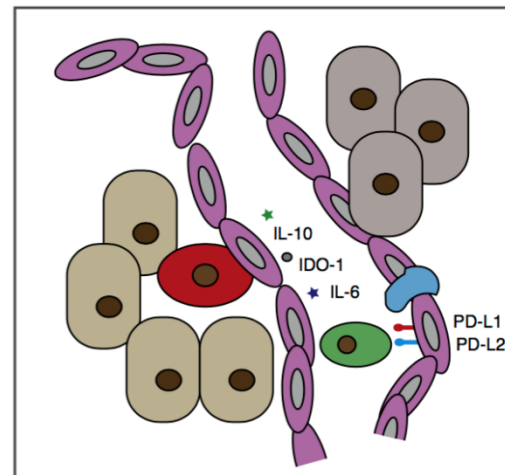
No infiltration



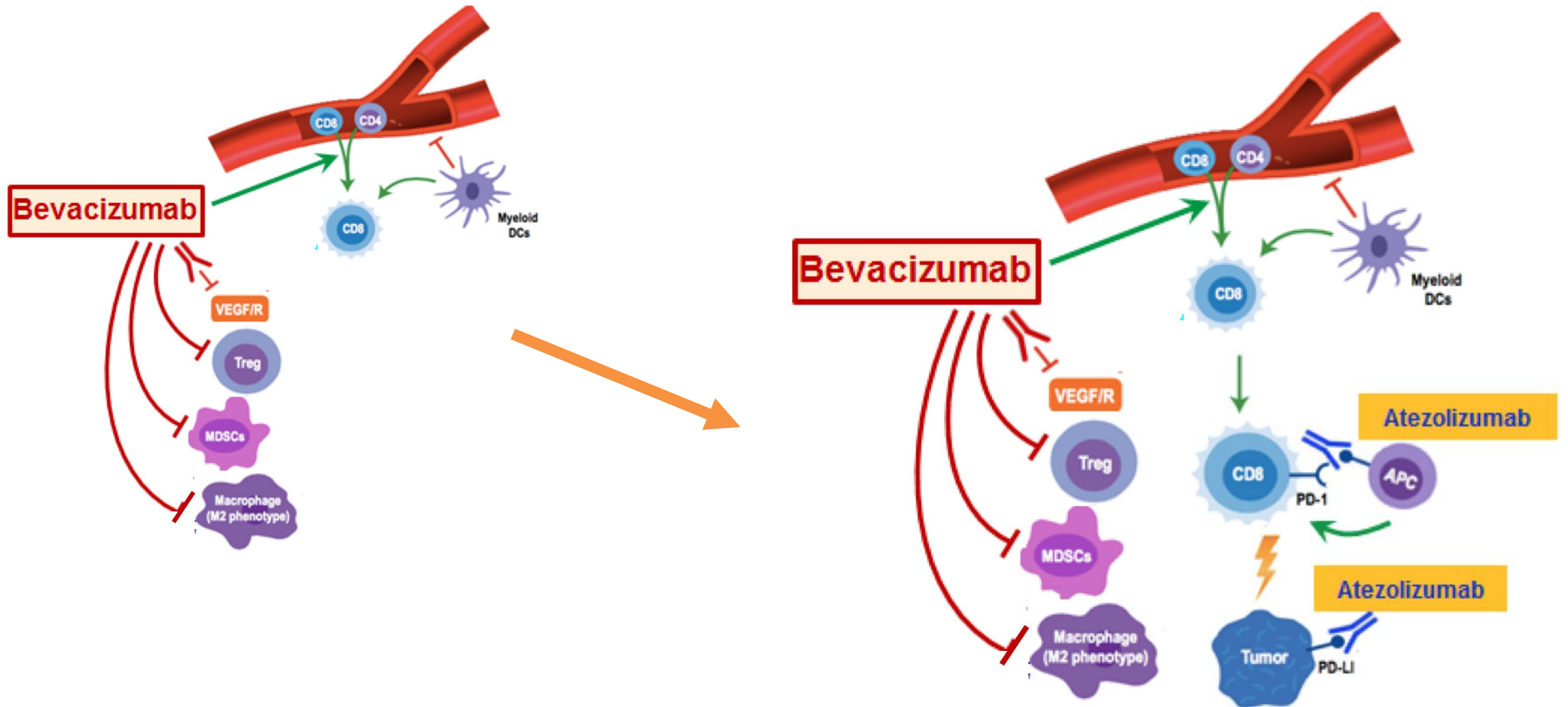
(c) FasL induced T cell apoptosis



(d) T cell suppression



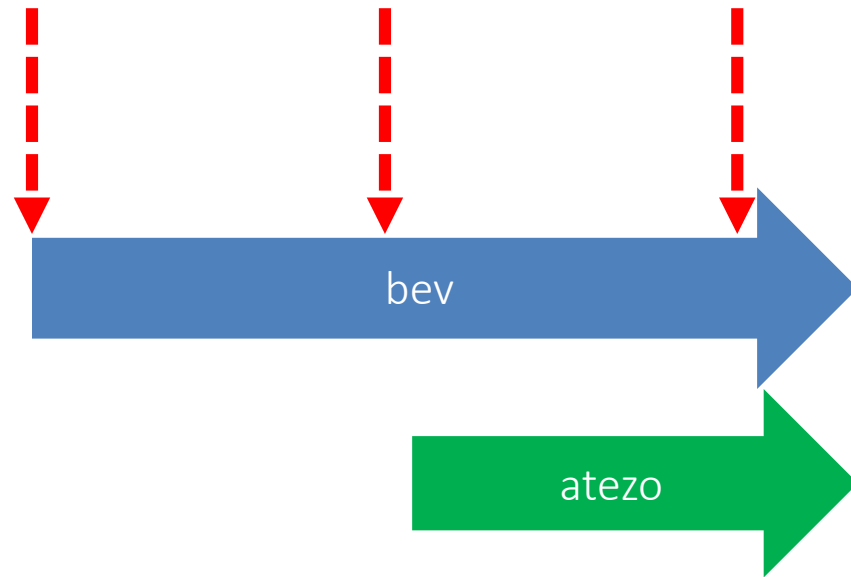
Pharmas' schemes



Effects of bevacizumab and atezolizumab on key VEGF and immune parameters

10 patients with metastatic RCC

Biopsy at 3 time points

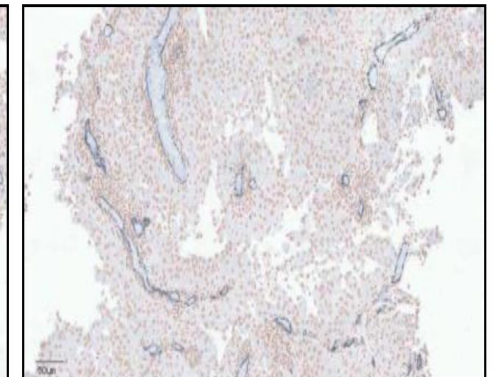
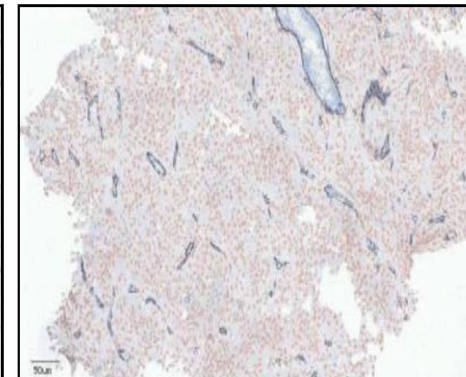
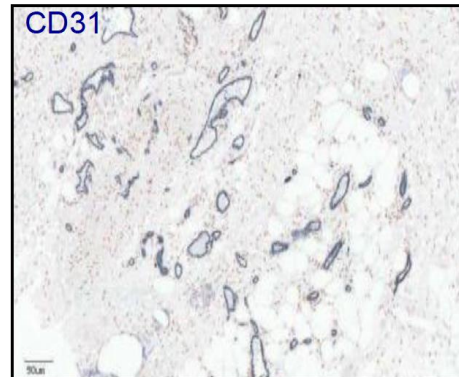


Patient 3, Female, 62 years old

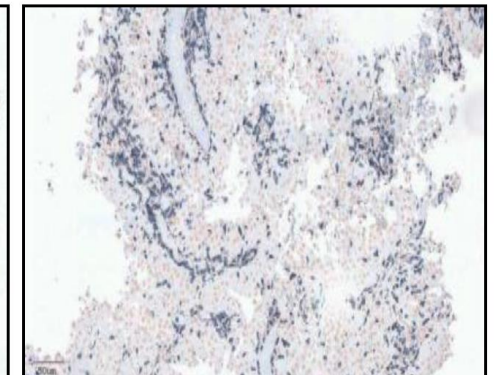
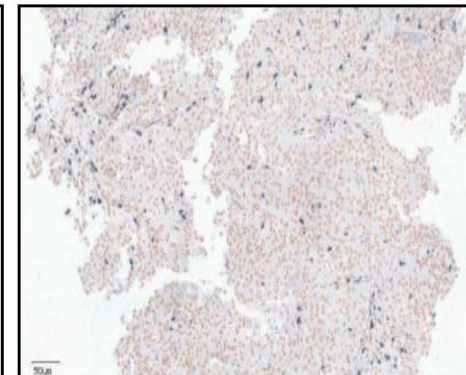
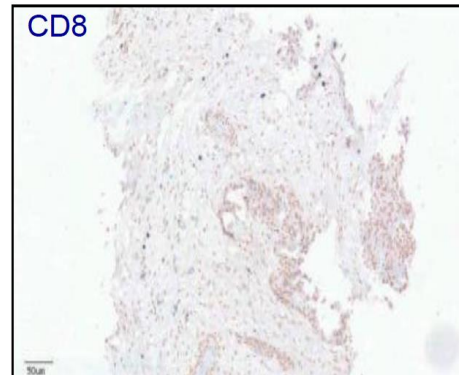
Pre-treatment

Post Bev

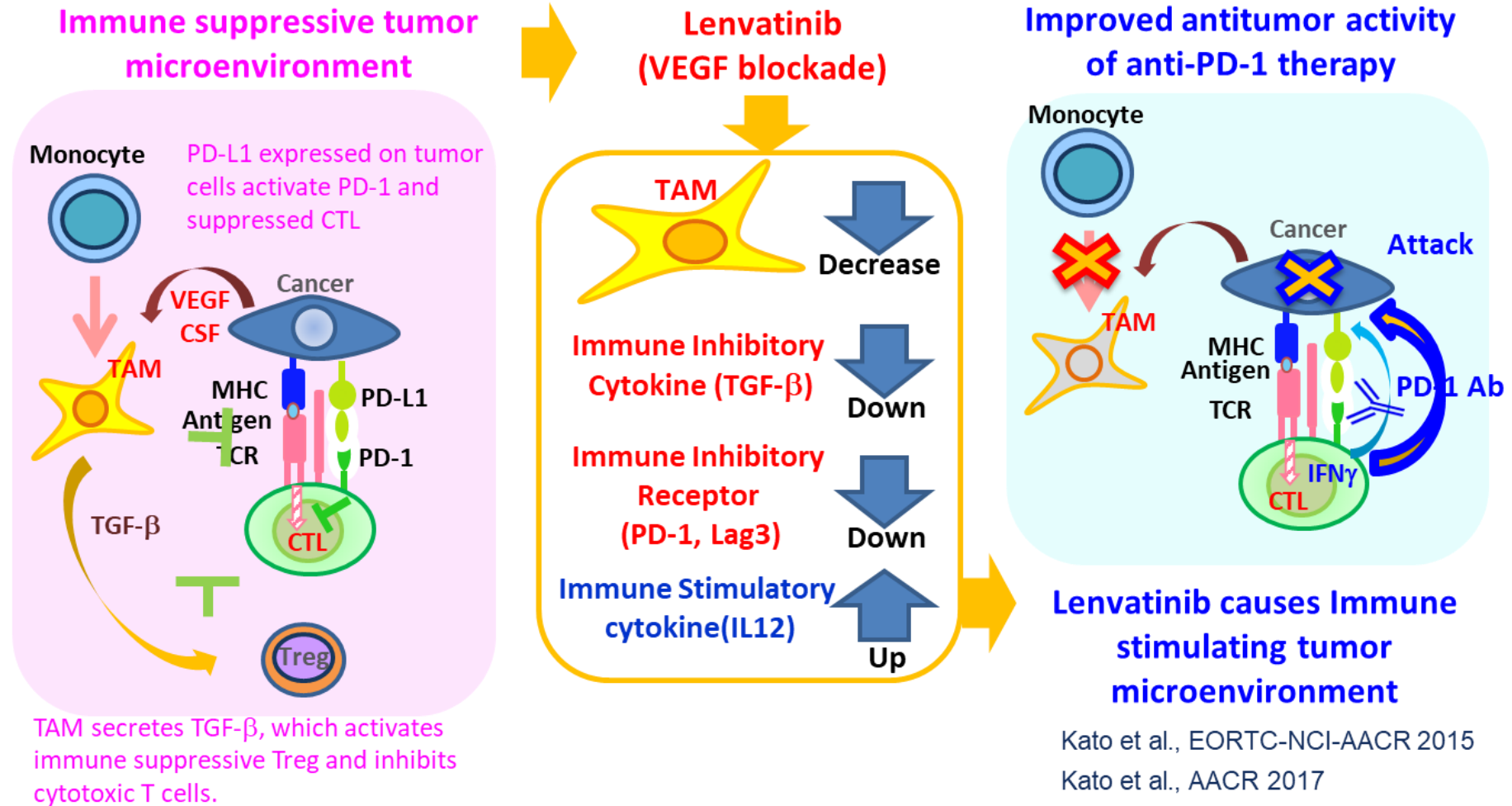
Post Bev+Atezo



Bendell, SCRI



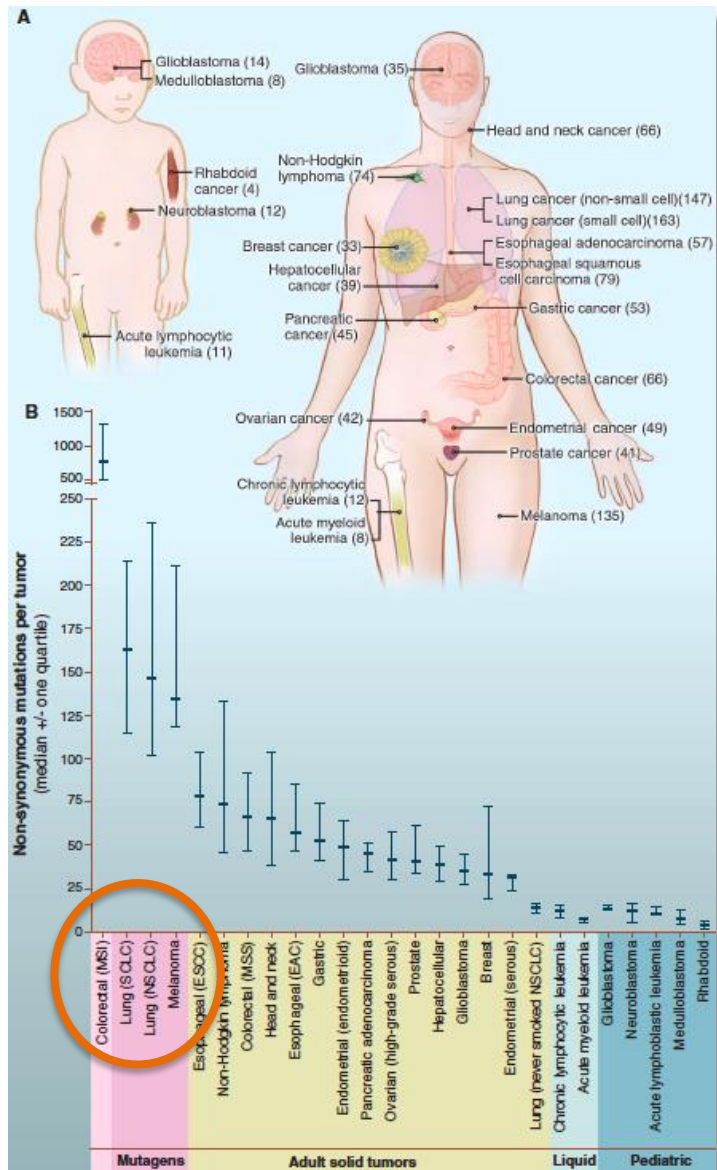
Pharmas' schemes (2)



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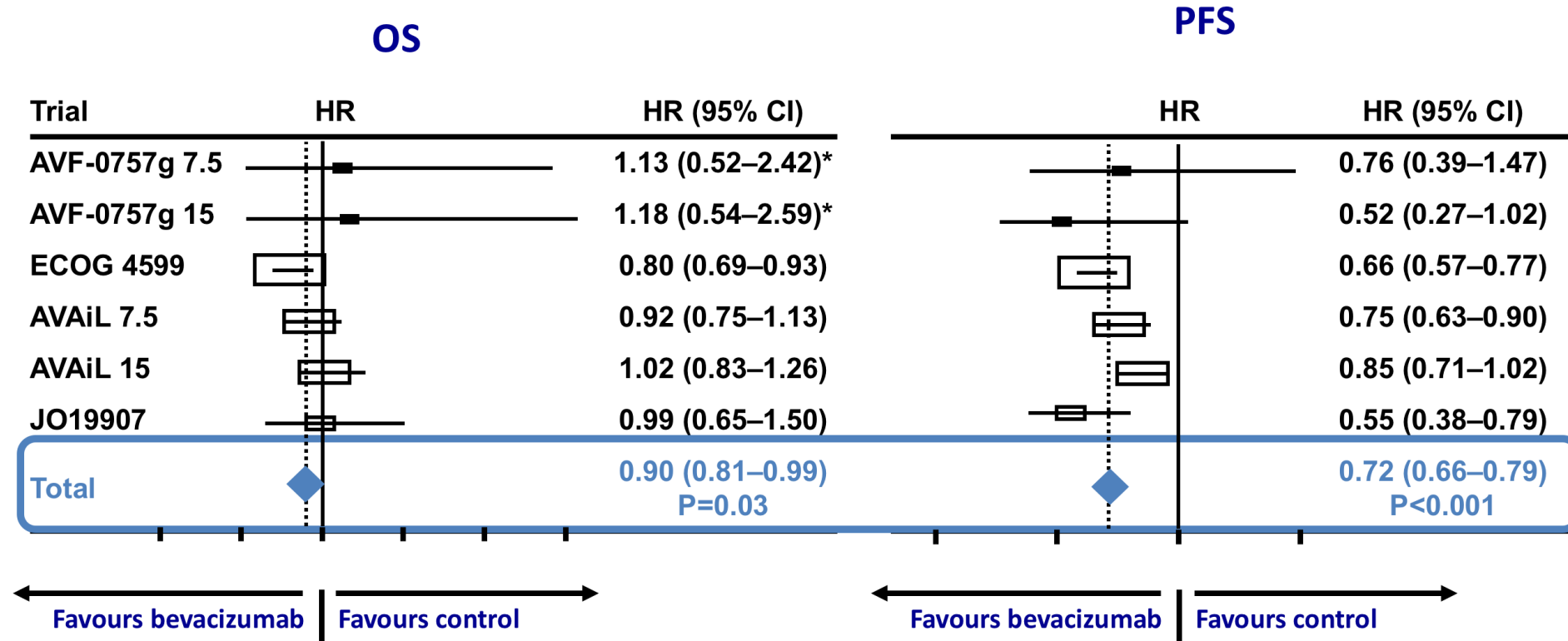
Lung cancer facts



- Lung cancer is characterized by a strongly immunosuppressive environment
- We have been enrolling thousands of patients in strictly negative vaccine trials
- Lung tumors display ~200 nonsynonymous mutations per tumor. Lung cancers from smokers have 10 times more mutations
- Checkpoint blockade is active in selected NSCLC patients only – and resistance is our ceiling

Bevacizumab with platinum-based chemotherapy

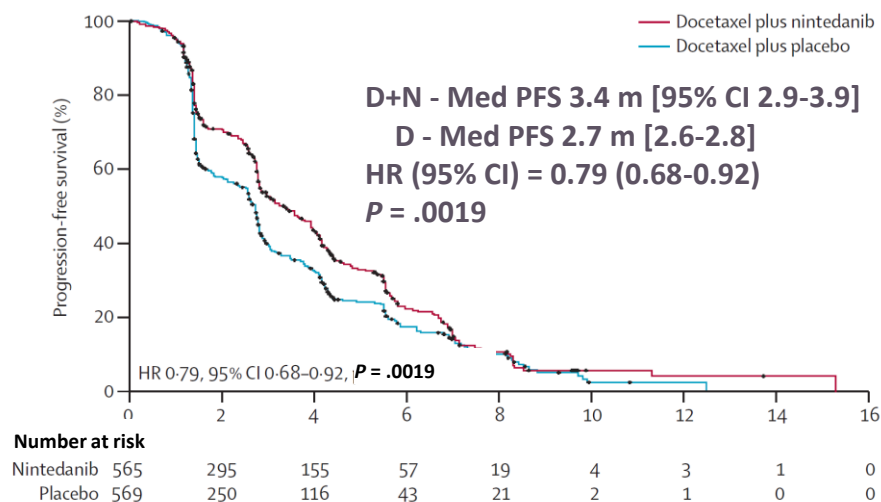
Pooled Analysis in NSCLC



Antiangiogenic Agents in 2nd Line?

LUME-LUNG 1 Trial¹: Docetaxel +/- nintedanib (VEGFR TKI)

- PFS (primary endpoint)

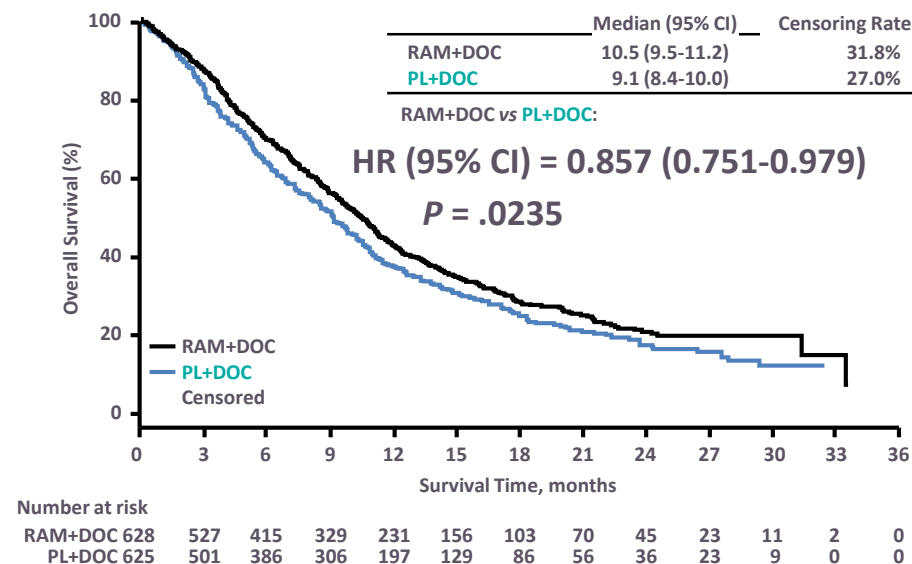


OS benefit in adenocarcinoma

PFS benefit in first-line refractory patients
(HR= 0.67 [0.43-1.04], P = .0725)

REVEL Trial²: Docetaxel +/- ramucirumab (VEGFR2 Ab)

- OS (primary endpoint)

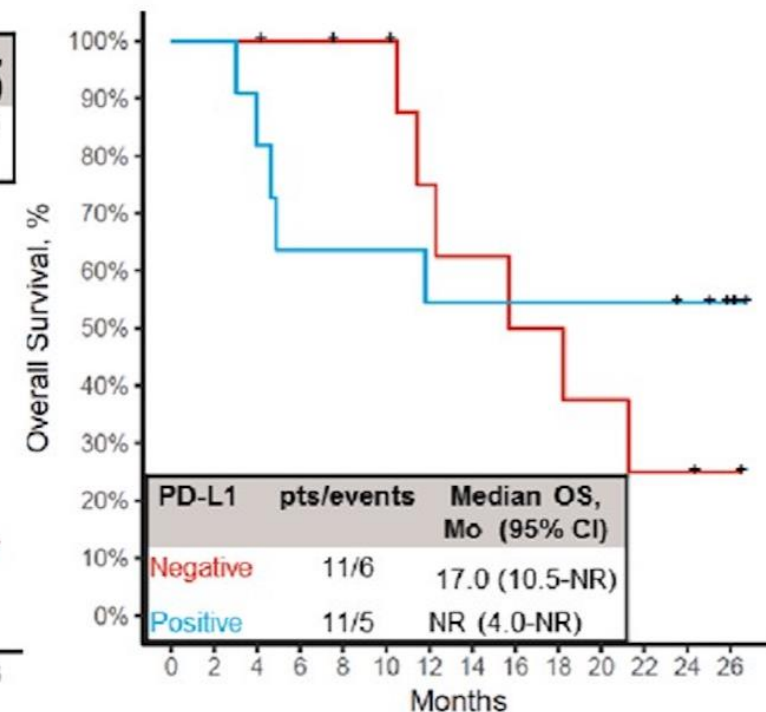
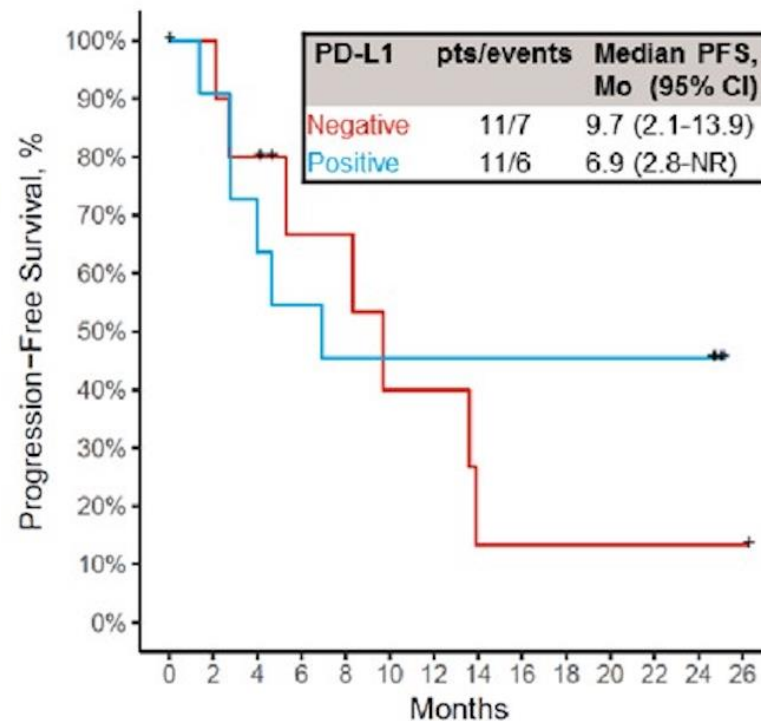
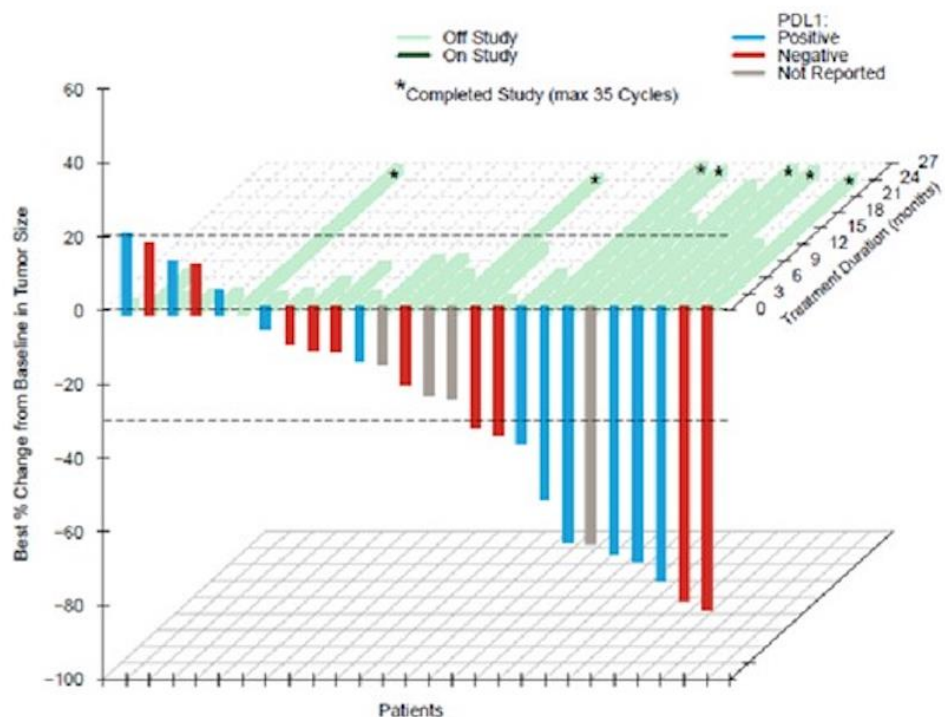


OS benefit in SCC and non SCC

VEGFR, vascular endothelial growth factor receptors

Reck M, et al. *Lancet Oncol.* 2014;15(2):143-155. Perol M, et al. *J Clin Oncol.* 2014;32(5S): Abstract LBA8006.

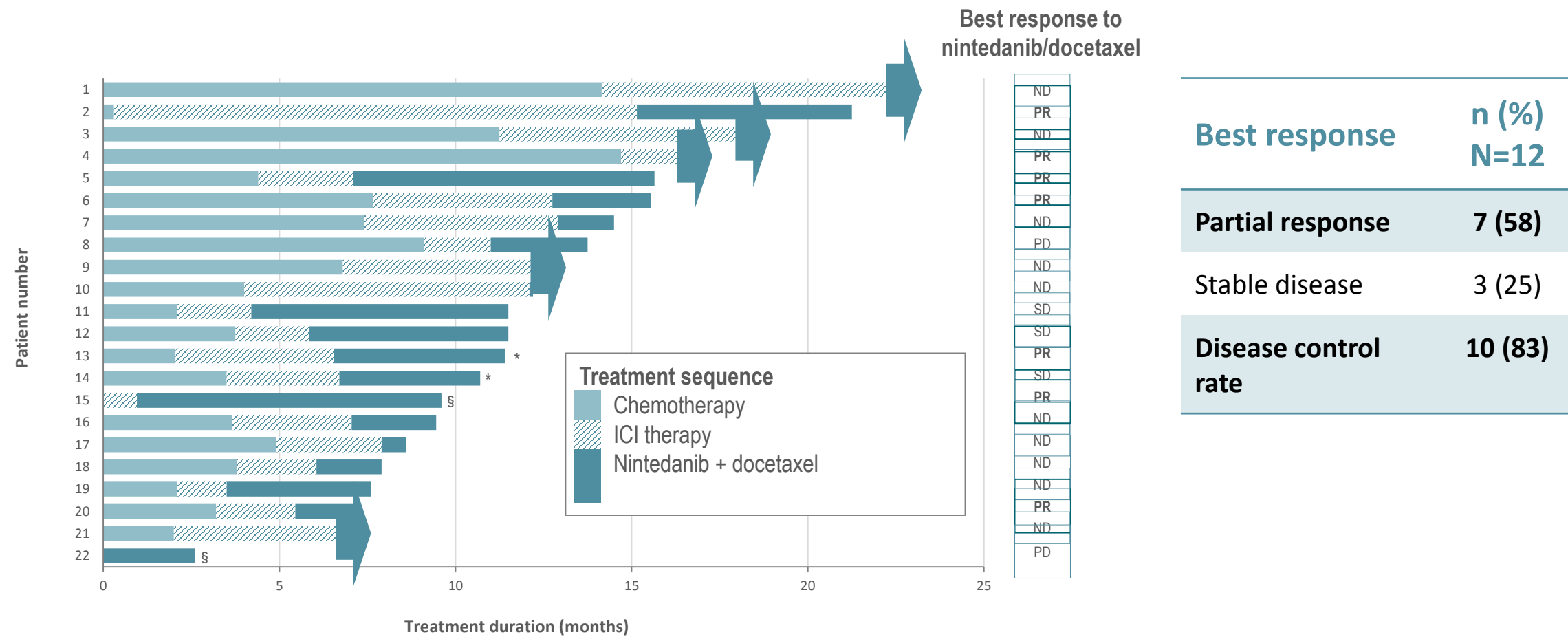
Pembrolizumab + ramucirumab in NSCLC



Lung-MAP ongoing phase 2 trial
in IO-resistance

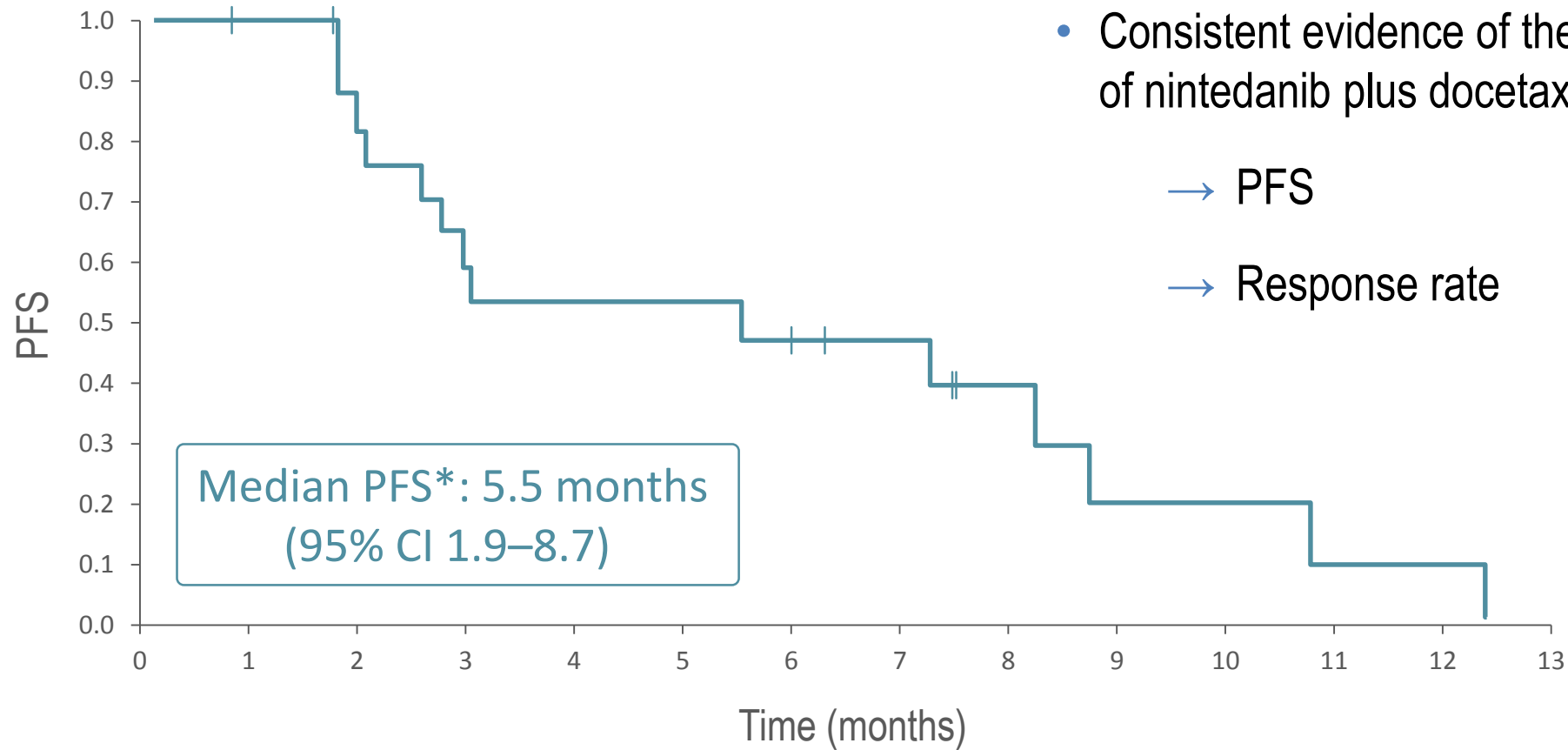
NSCLC (2 nd -4 th line)		
PD-L1 Status	TPS <1% n=11	TPS ≥1% n=11
ORR, % (95% CI)	18 (2.3-51.8)	45 (16.7-76.6)
Time to response	2.8 (2.8-2.8)	1.4 (1.3-5.3)
Duration of response	NR (11.1-NR)	NR (NR-NR)
Disease control, % (95% CI)	82 (48.2-97.7)	91 (58.7-99.8)
Duration of stable disease	8.3 (2.7-13.6)	4.0 (2.8-6.9)

Nintedanib + docetaxel after anti PD(L)-1 in NSCLC



ICI, immune checkpoint inhibitor; ND, not documented; PD, progressive disease; PR, partial response; SD, stable disease.
*Single-agent nintedanib treatment ongoing; § Previous therapies not documented.

Nintedanib + docetaxel after anti PD(L)-1 in NSCLC



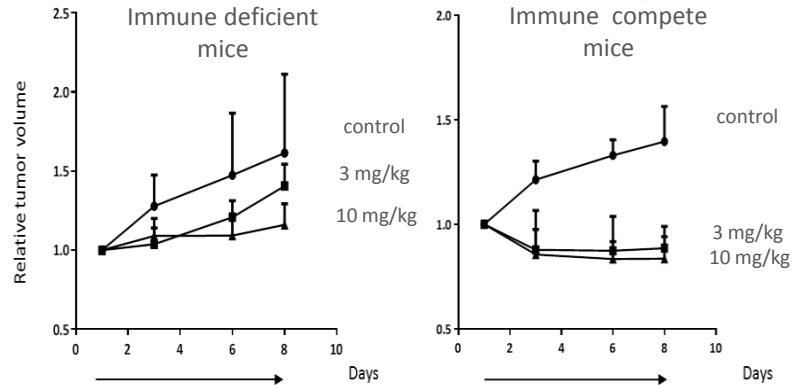
CI, confidence interval; PFS, progression-free survival.

*n=21: 10 patients had disease progression, four patients had died, and seven patients had been censored.

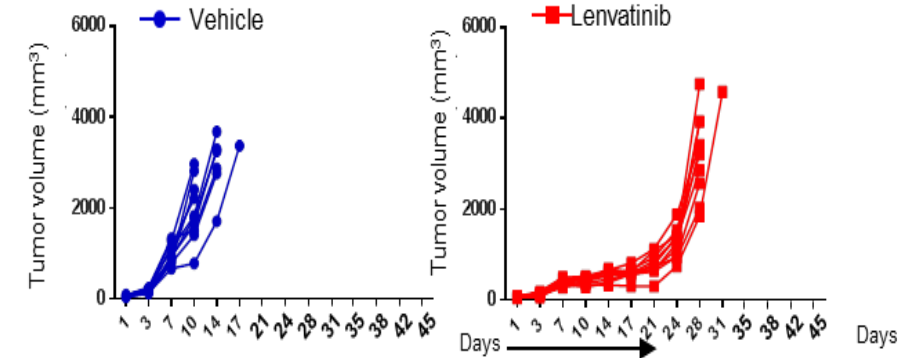
Data not yet available for one patient.

Lenvatinib and pembrolizumab in IO naive (KEYNOTE-146)

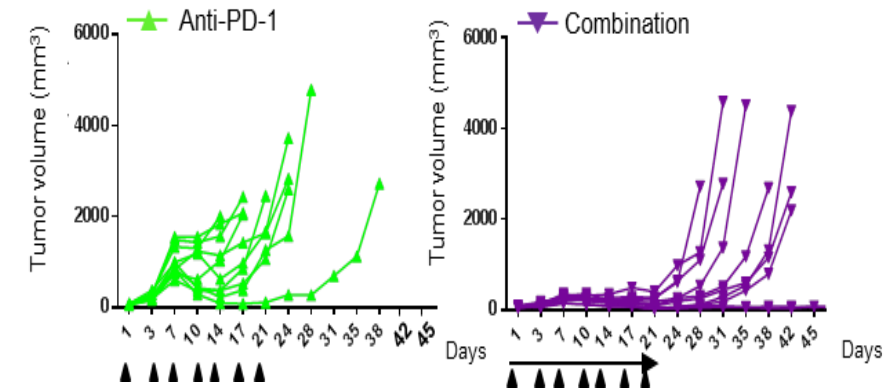
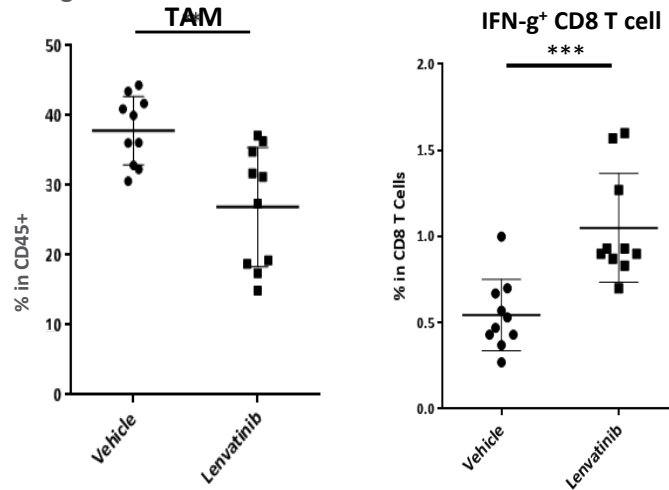
Lenvatinib is more effective in immune competent mice in HCC model



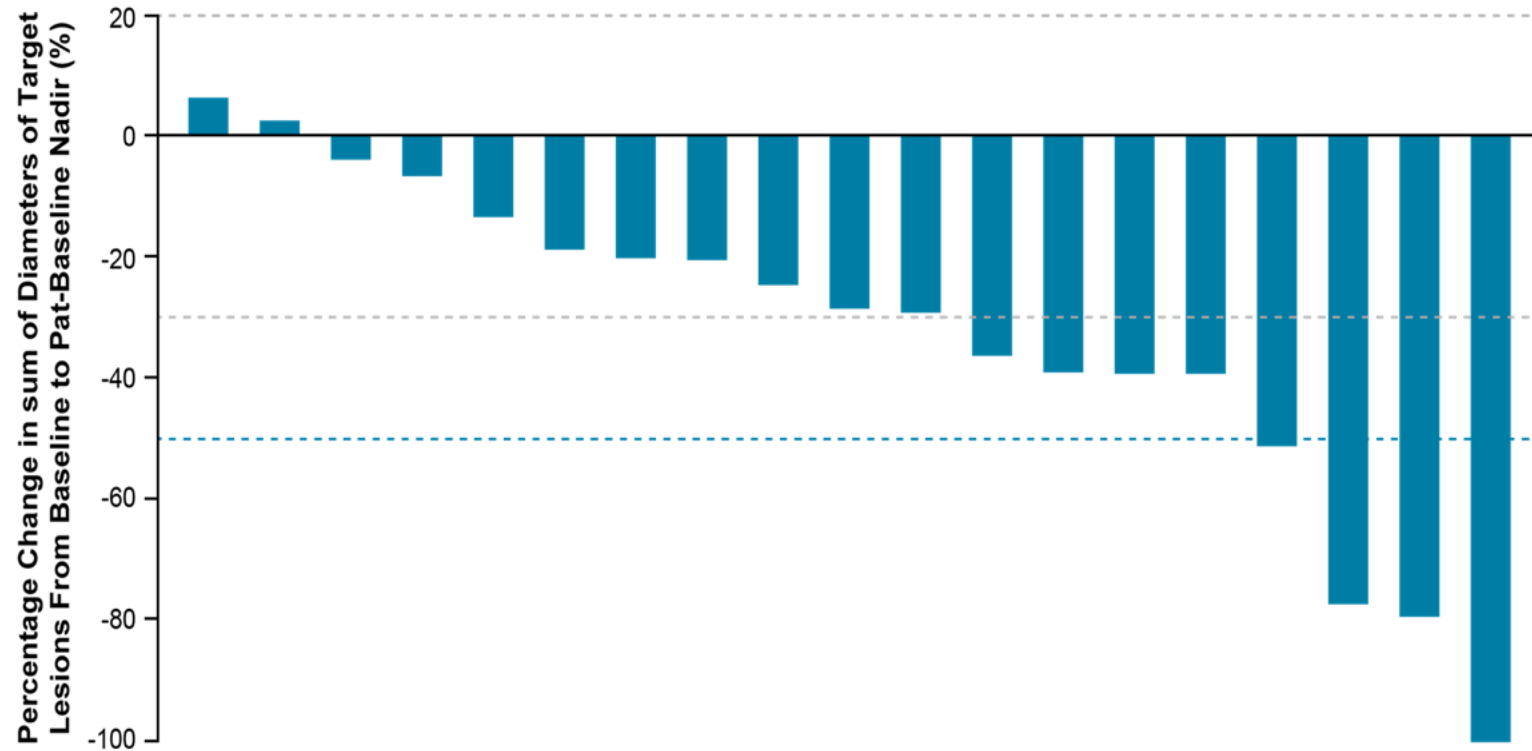
Combination antitumor activity in combination with lenvatinib and mice anti-PD-1 Ab in CT26 mice model



Immune cell profiling



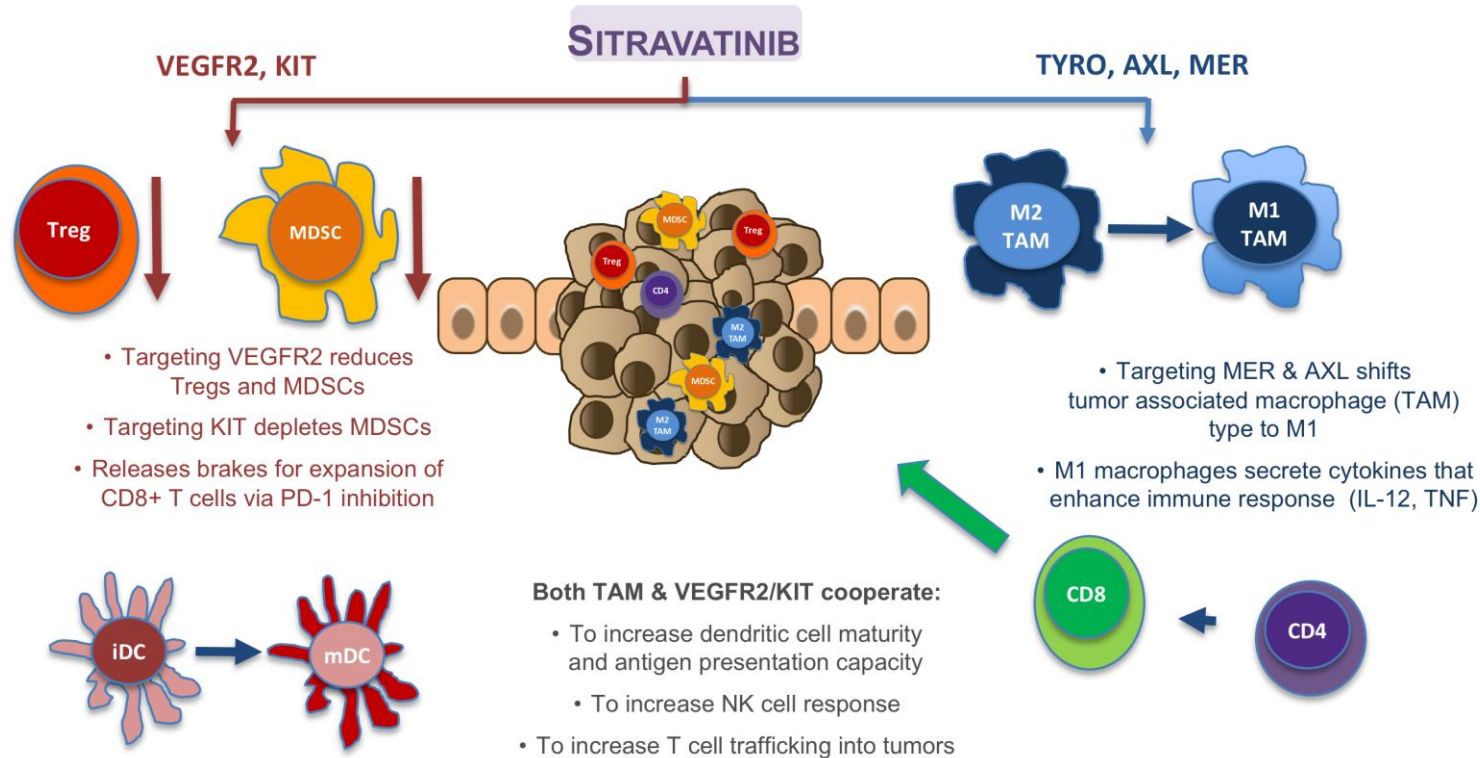
Lenvatinib and pembrolizumab in IO naive (KEYNOTE-146)



Primary end point: ORR_{Week24}: 33% (95% CI: 14.6–57.0)

Multi-steps immune simulation

Sitravatinib/nivolumab in IO resistant NSCLC

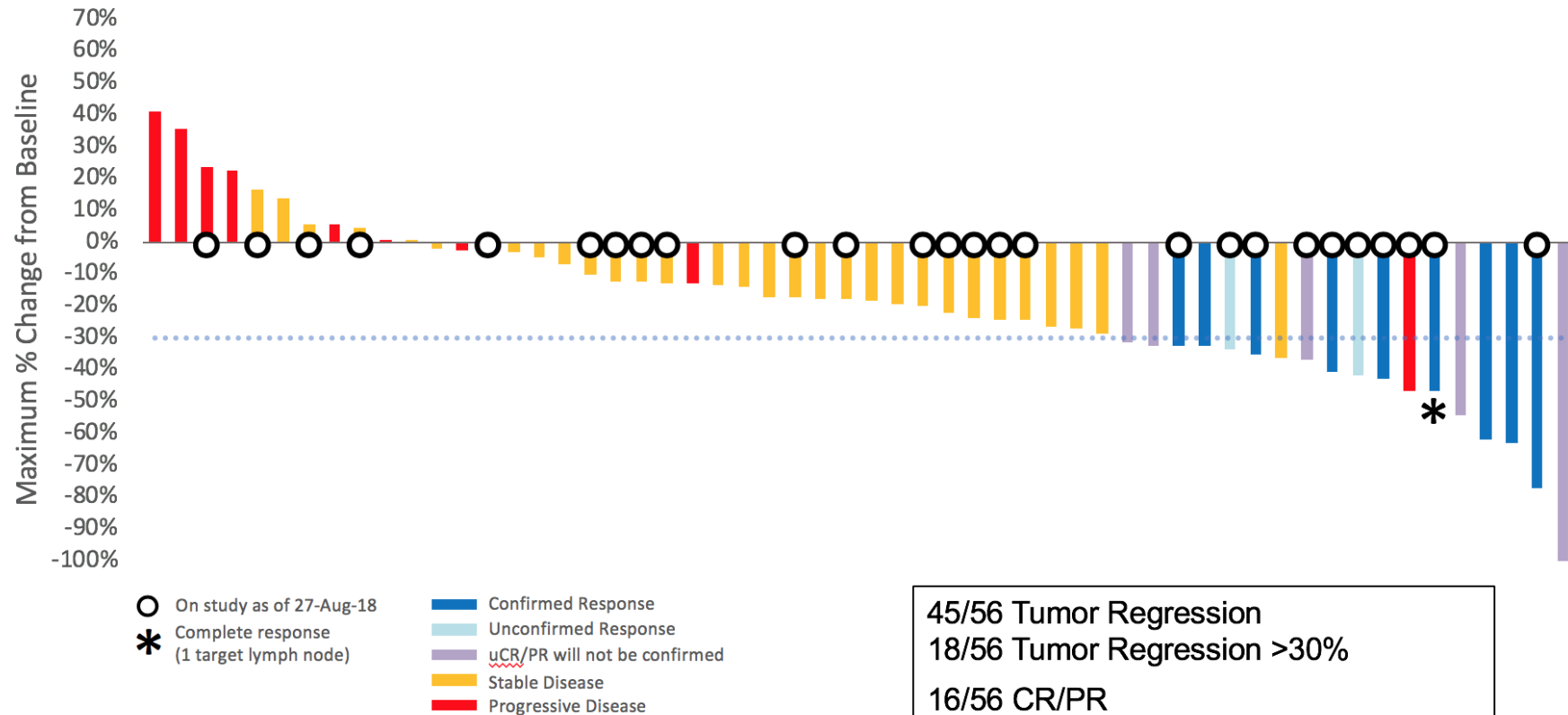


Sitravatinib (MGCD516) TKI

- TAM family (AXL and MER)
 - Target cellular IC₅₀: 1nM.
- Split family RTKs (**VEGFR₂**, PDGFR α and KIT)
 - Target cellular IC₅₀: 5-10 nM.
- RET, MET, DDR₂, TrkA
 - Target cellular IC₅₀: 10-25 nM.

MRTX-500 Clinical Activity

Preliminary Maximum Response in NSCLC Patients Who Failed Prior Checkpoint Therapy by Best Response
(CIT-Experienced Cohorts – Clinical Activity Evaluable Patients, N=56)

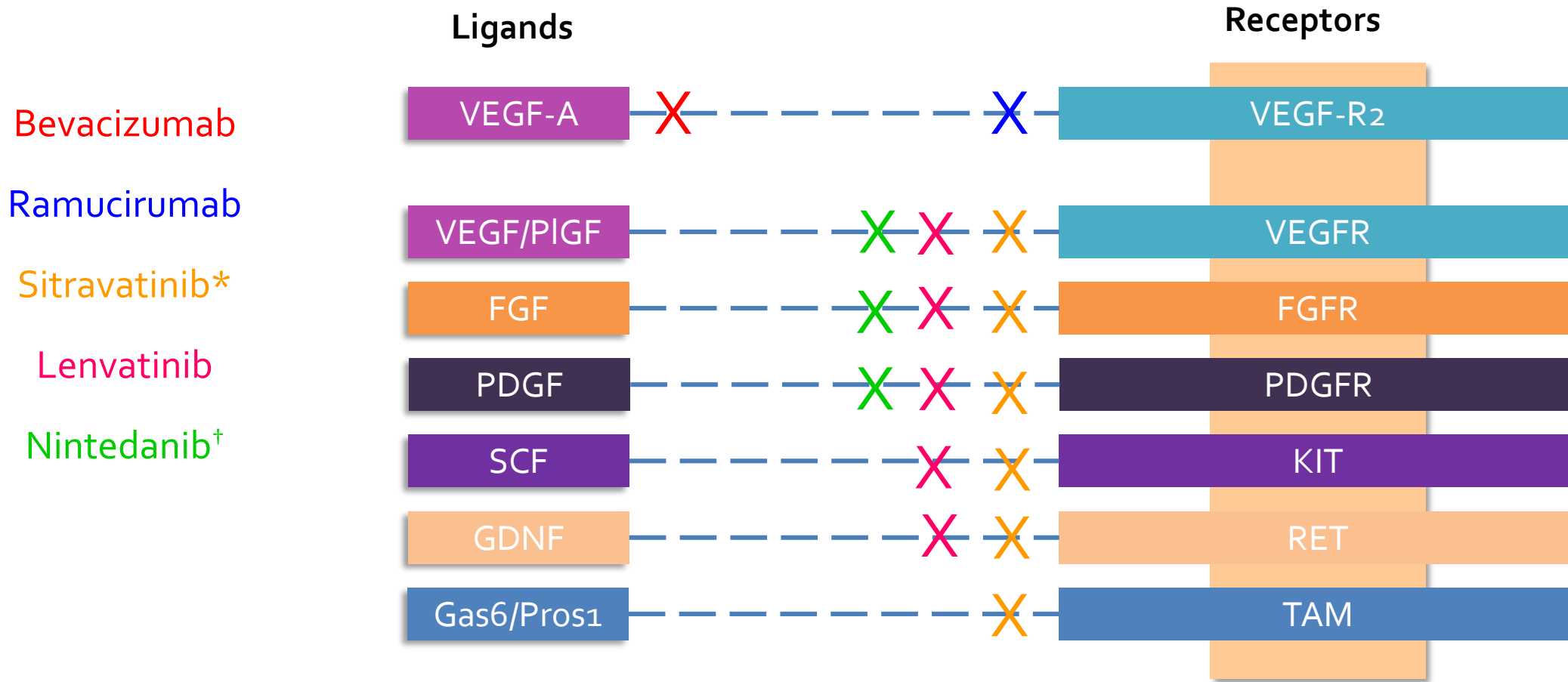


Study cycles of 28 days, with disease assessment scans every 2 cycles
Data as of 27-Aug-2018

45/56 Tumor Regression
18/56 Tumor Regression >30%

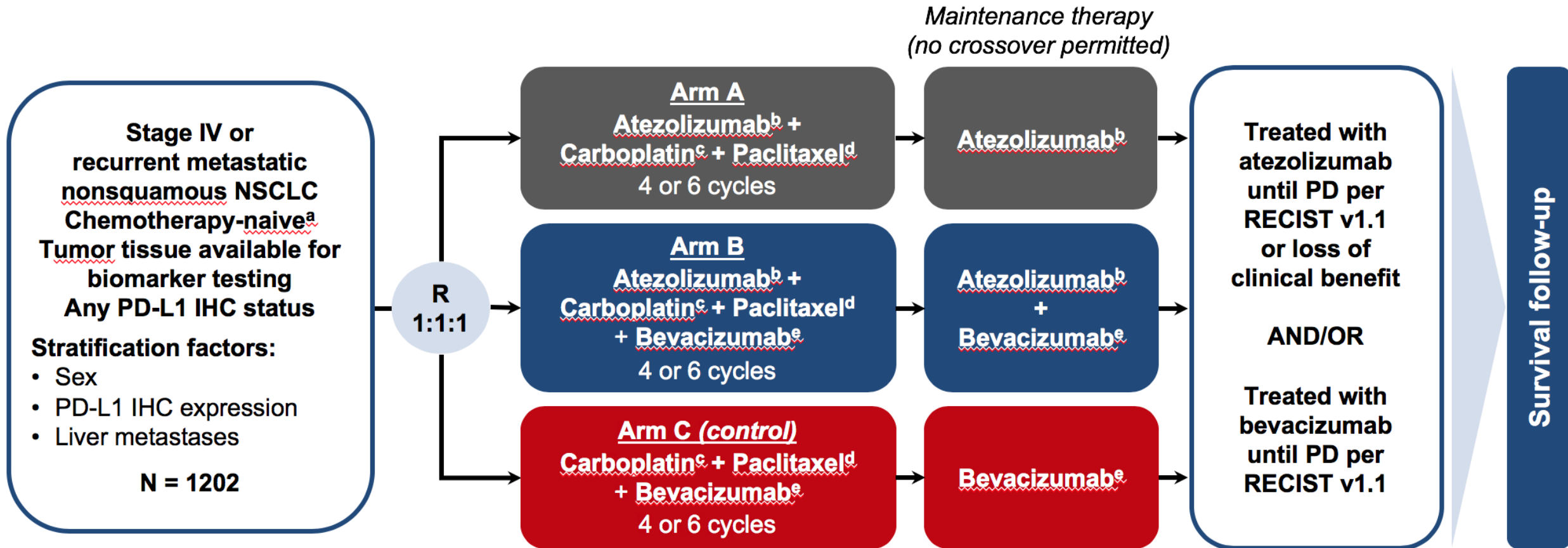
16/56 CR/PR
9 confirmed
2 yet to be confirmed and on study
5 will not be confirmed

Diversity of inhibitors in multiple tyrosine kinase pathways researched in I-O-experienced NSCLC



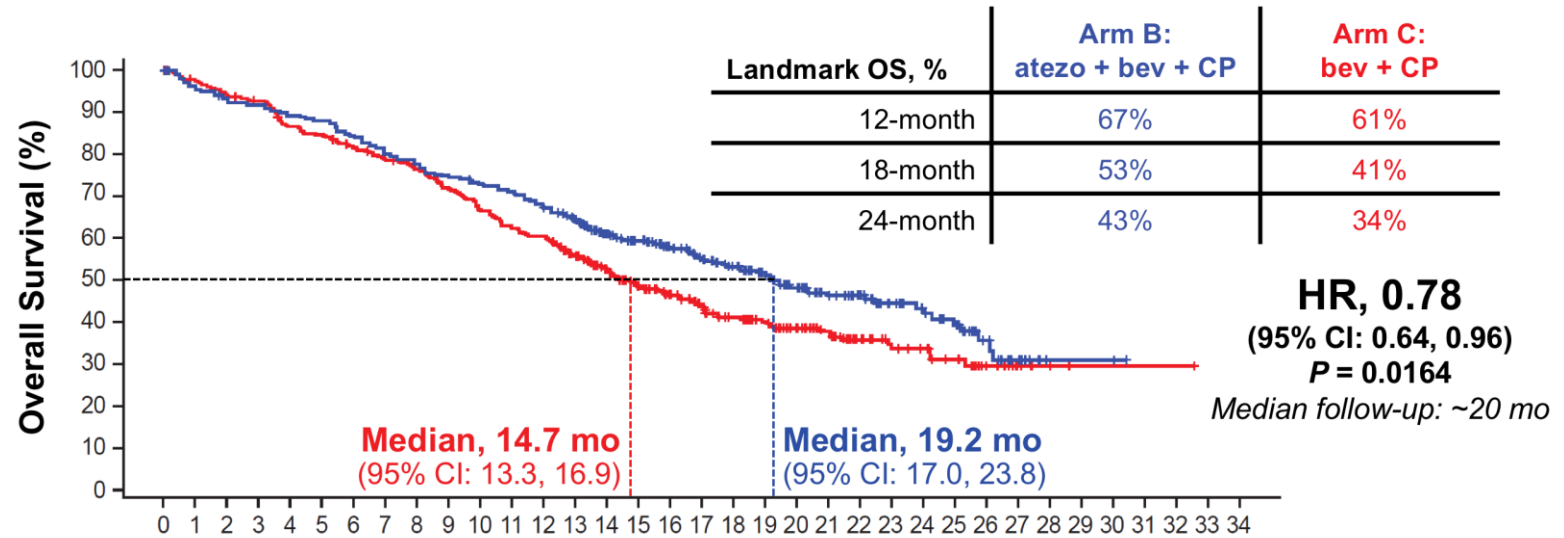
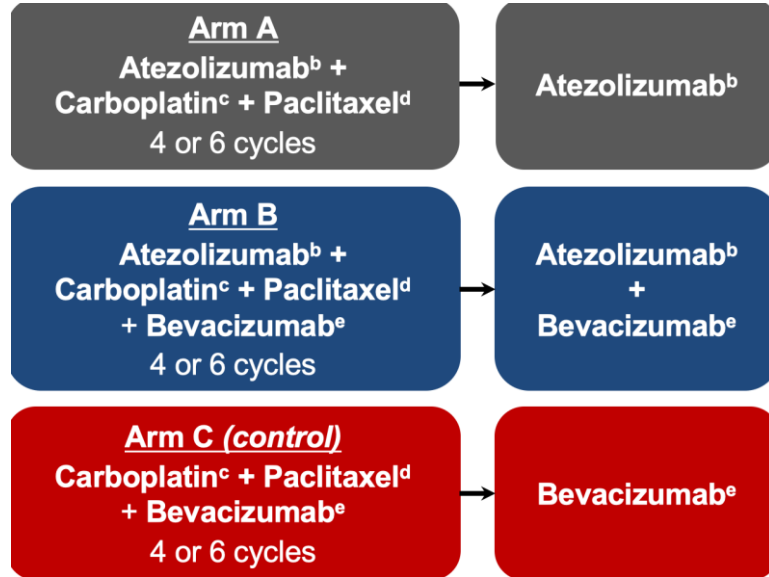
* Additional targets of sitravatinib include DDR₂, Ephs, MET, and TRK; † Additional targets of nintedanib include Src, Lck, Lyn, and FLT-3

Impower 150 trial design

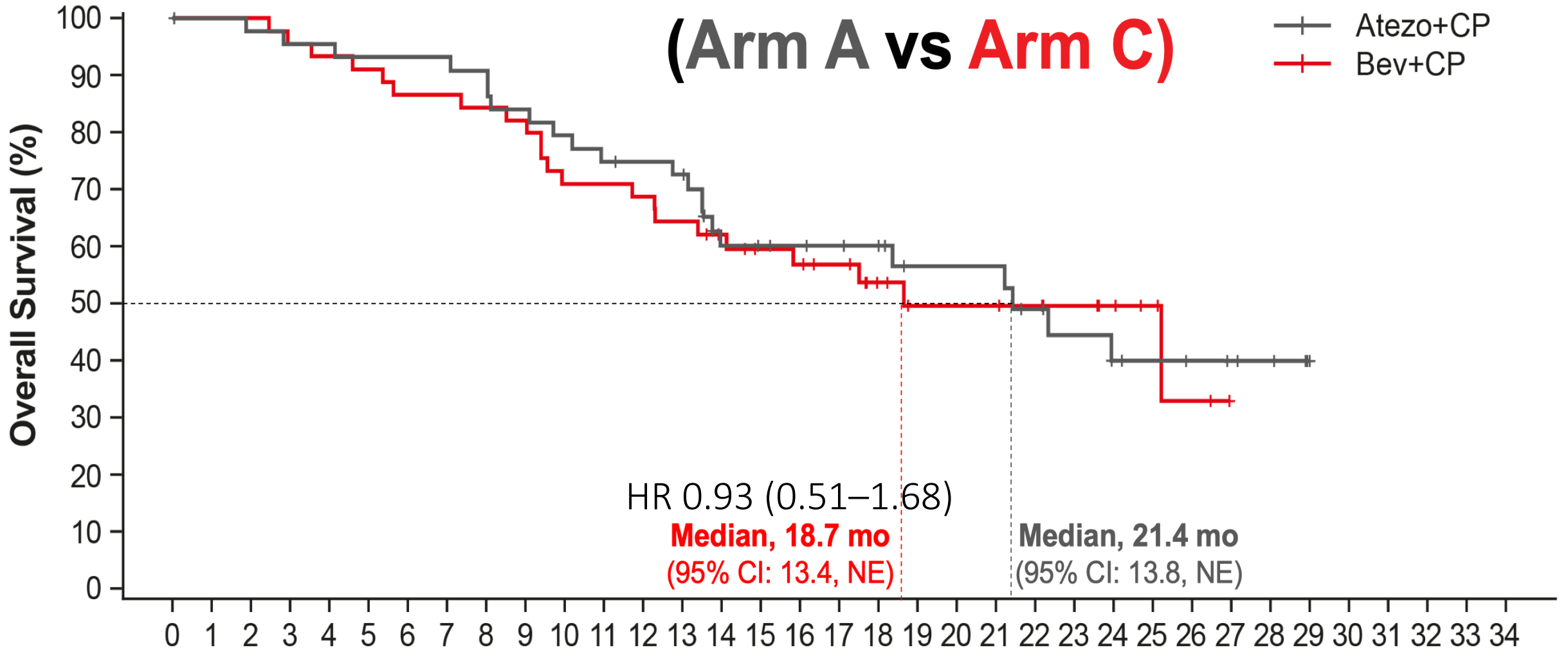


Carboplatin/paclitaxel/atezolizumab/bevacizumab is superior to carbo/pac/li/bev irrespective of PD-L1

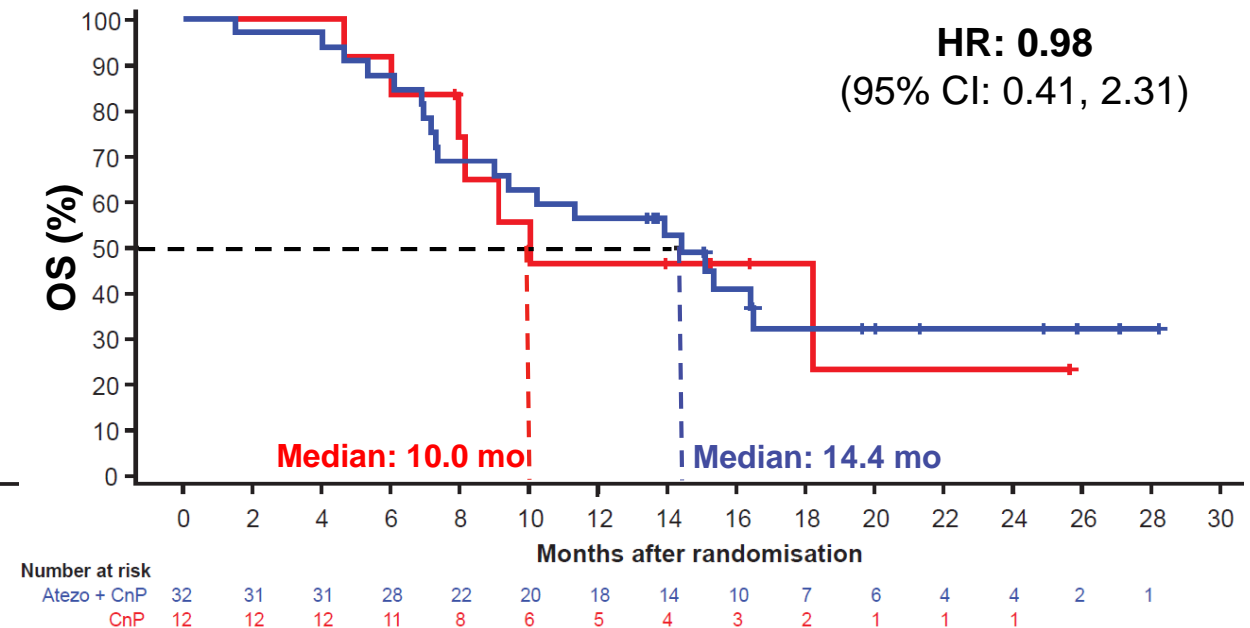
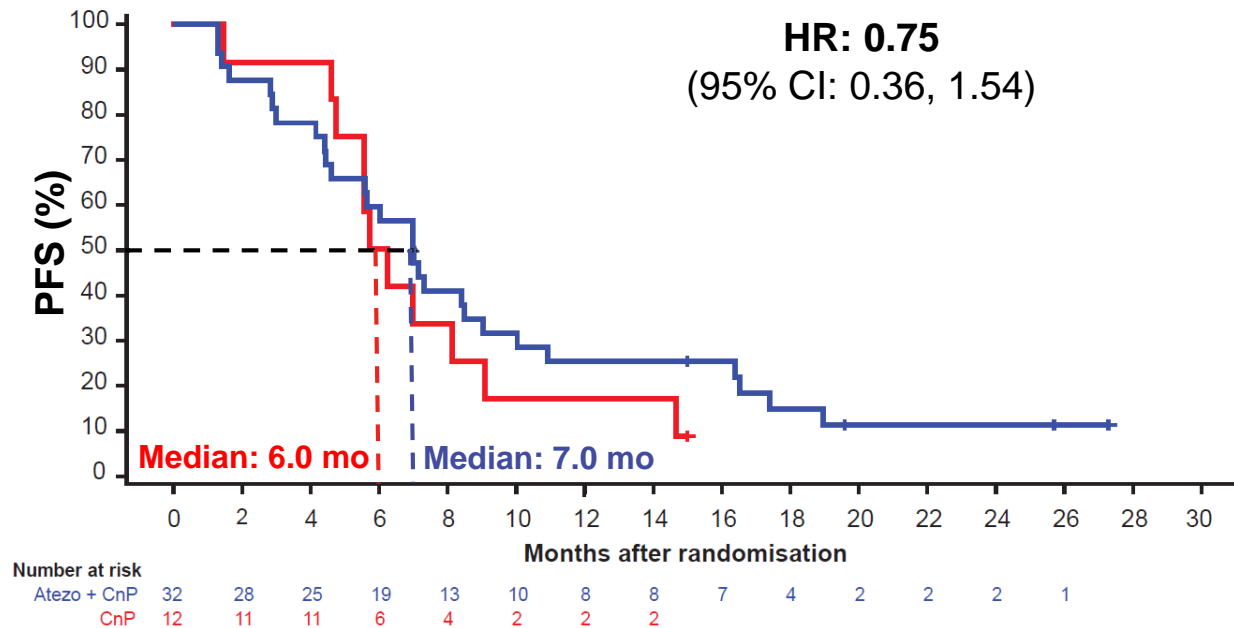
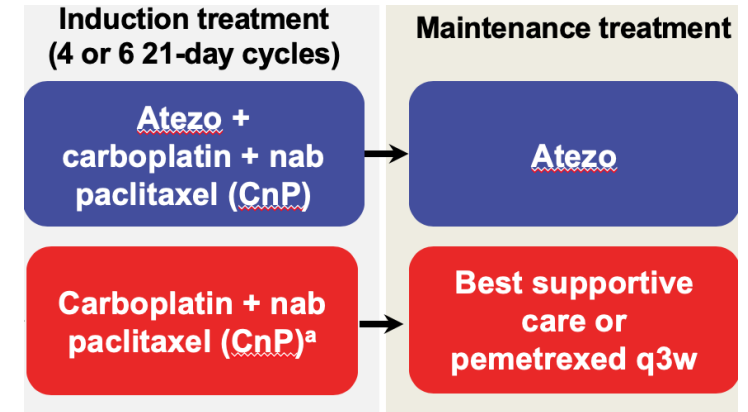
IMpower150



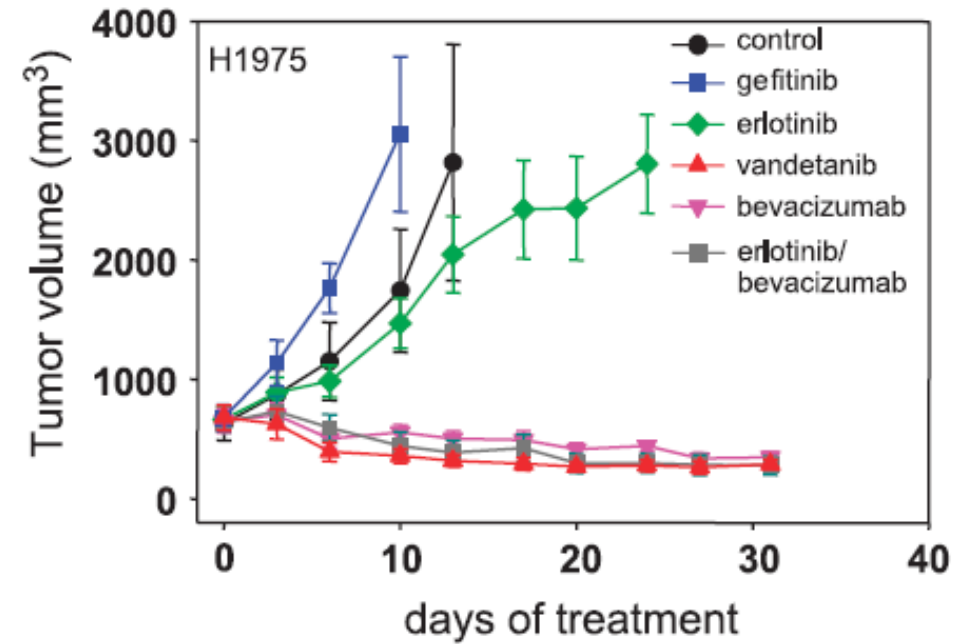
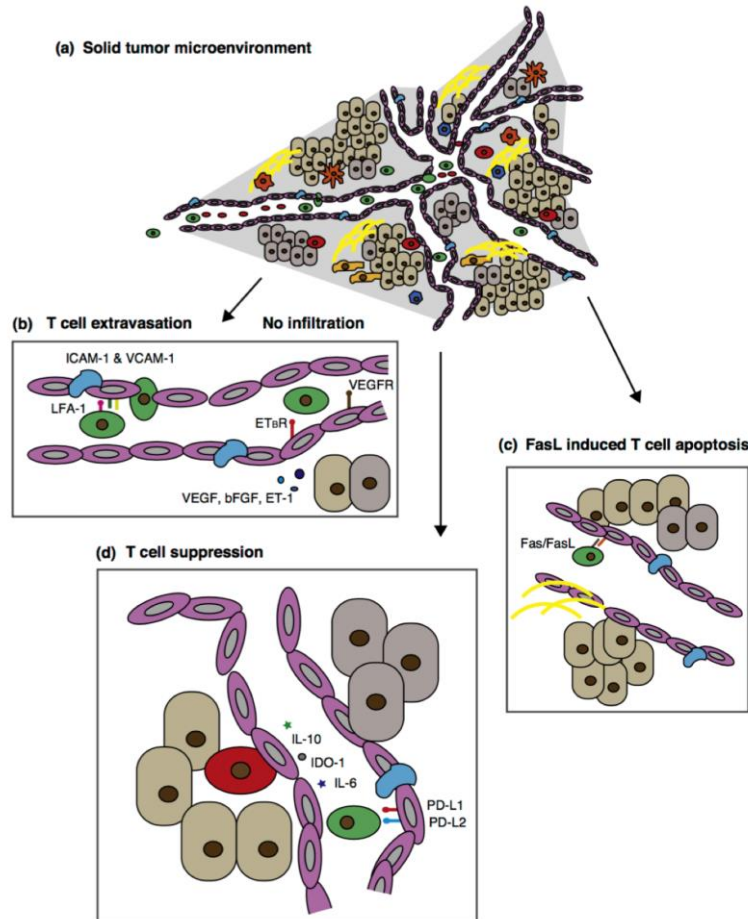
OS in EGFR-mt patients (Arm B vs Arm C)



IMPower 130: Investigator-assessed PFS and OS in EGFR/ALK+

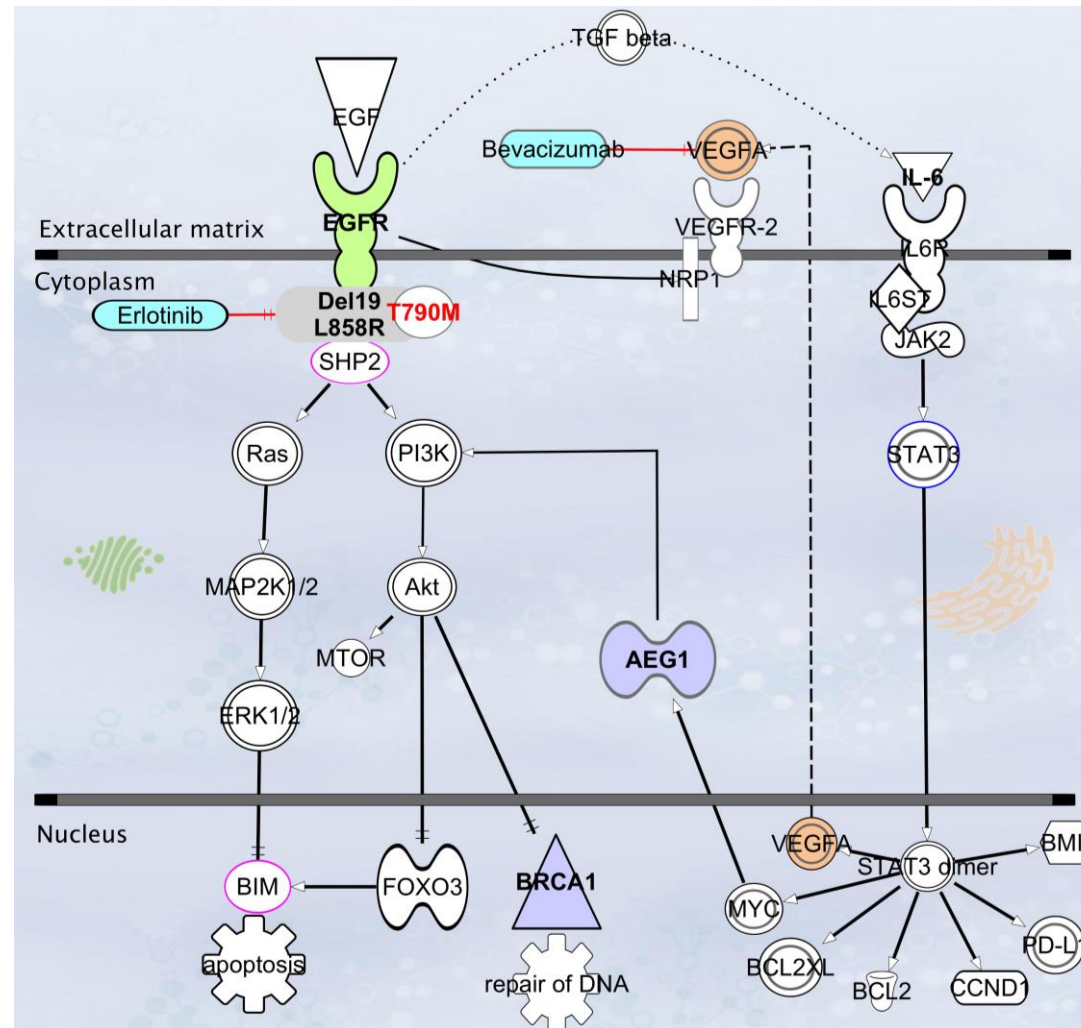


Is bevacizumab the game changer?



Combined VEGFR/EGFR pathway blockade may be beneficial in the presence EGFR mutation

Immune modulation in poorly immunogenic tumour?



Anti-VEGF antibody inhibits IL-6/IL-6R regulation of VEGF.

Neither inhibition of PI3K or MAPK inhibits IL-6 mediated transcriptional up-regulation of VEGF.

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Anti-angiogenesis and IO in RCC : early trials

Combination	Line of therapy	# patients	ORR (% CR/% PR)	DCR (CR/PR/SD)	mPFS
Axitinib Avelumab	1 st line	55	58% (6/52)	78%	N/A
Axitinib Pembrolizumab	1 st line	52	67% (4/63)	88%	N/A
Pazopanib Pembrolizumab	1 st line	10	60% (20/40)	100%	N/A
Lenvatinib Pembrolizumab	Post-VEGF	30	63% (0/63)	96%	N/A
Lenvatinib Pembrolizumab	1 st line	12	83% (0/83)	100%	N/A
Bevacizumab Atezolizumab	1 st line	101	32% (7/25)	N/A	11.7 mo
Cabozantinib Ipilimumab Nivolumab	Post-SOC	42 (GU: UC, RCC, others)	33% (8/25)	83%	5.8 mo

N/A: Not available
SOC: Standard of Care

Atkins M et al, ESMO 2016
McDermott D et al, GU ASCO 2017
Choueiri TK et al, ASCO 2017
Chowdhury S et al, ASCO 2017
Lee C et al, ESMO 2017
Nadal R et al, ESMO 2017

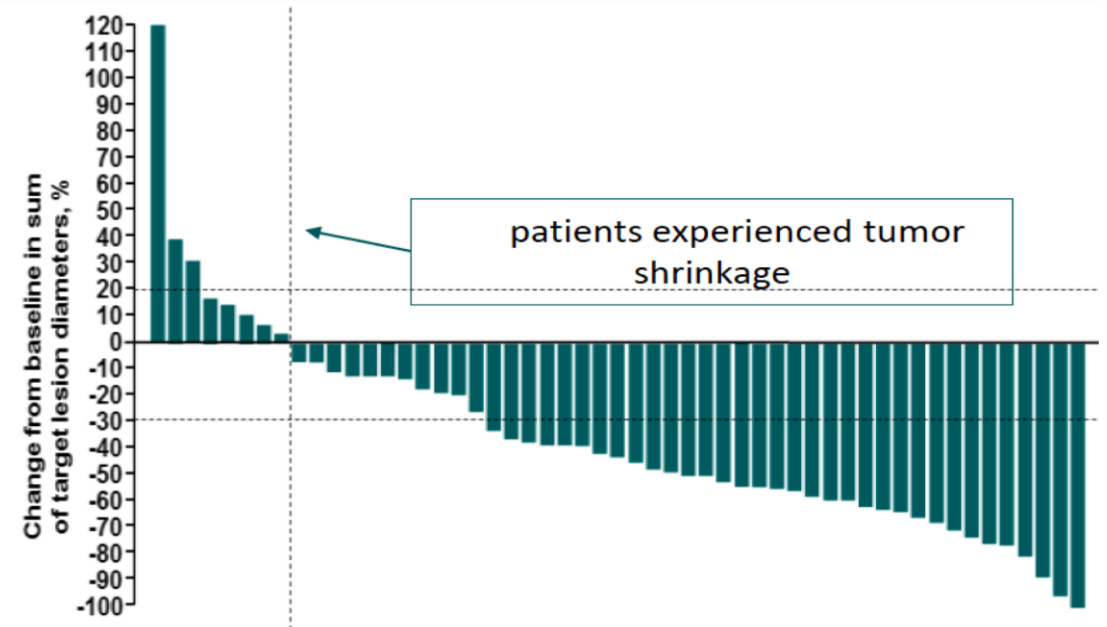
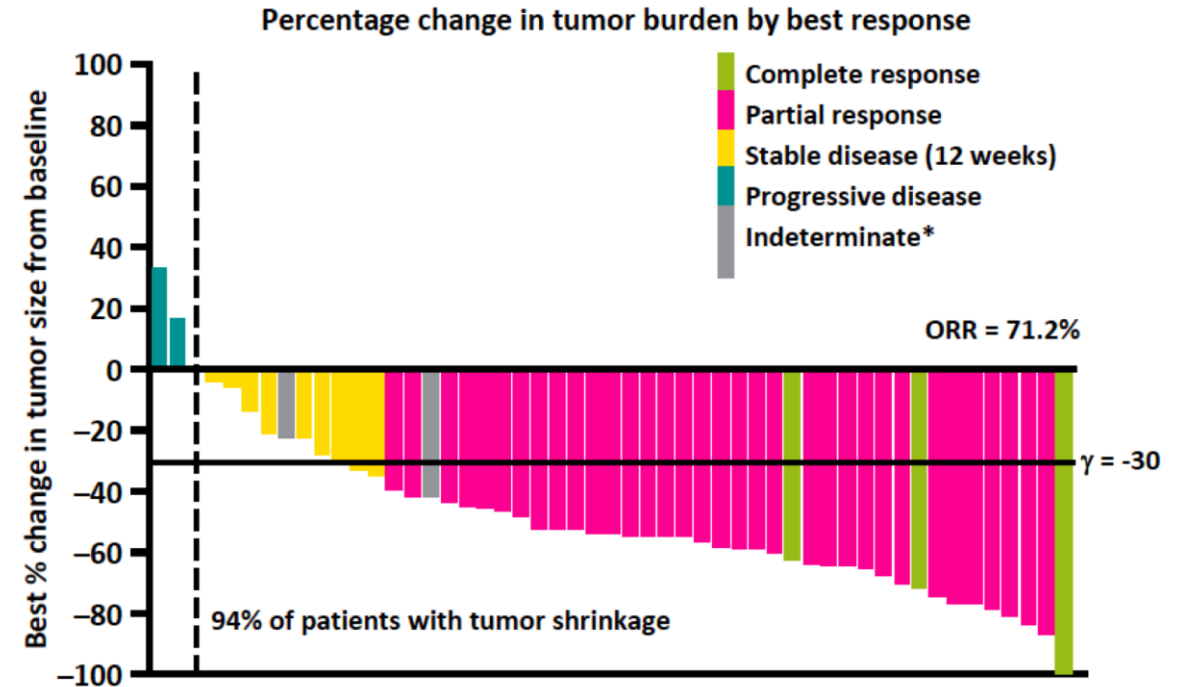
Axitinib in combination with pembrolizumab in patients with advanced renal cell cancer: a non-randomised, open-label, dose-finding, and dose-expansion phase 1b trial

Michael B Atkins, Elizabeth R Plimack, Igor Puzanov, Mayer N Fishman, David F McDermott, Daniel C Cho, Ulka Vaishampayan, Saby George, Thomas E Olencki, Jamal C Tarazi, Brad Rosbrook, Kathrine C Fernandez, Mariajose Lechuga, Toni K Choueiri



Preliminary results for avelumab plus axitinib as first-line therapy in patients with advanced clear-cell renal-cell carcinoma (JAVELIN Renal 100): an open-label, dose-finding and dose-expansion, phase 1b trial

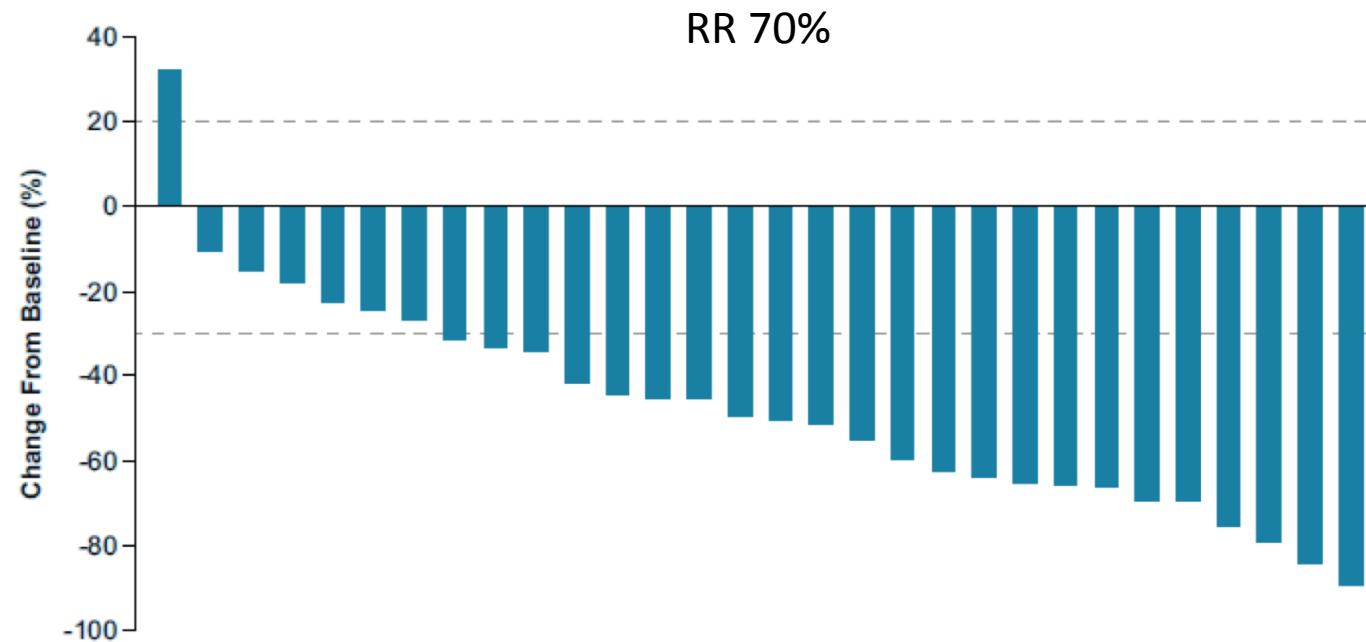
Toni K Choueiri, James Larkin, Mototsugu Oya, Fiona Thistlethwaite, Marcella Martignoni, Paul Nathan, Thomas Powles, David McDermott, Paul B Robbins, David D Chism, Daniel Cho, Michael B Atkins, Michael S Gordon, Sumati Gupta, Hirotsugu Uemura, Yoshihiko Tomita, Anna Compagnoni, Camilla Fowst, Alessandra di Pietro, Brian I Rini



Lenvatinib and pembrolizumab in RCC

KEYNOTE-146

LENVIMA + KEYTRUDA FOR TREATMENT OF PATIENTS WITH aRCC



ALMOST ALL PATIENTS (N=29) EXPERIENCED TUMOR REDUCTION FROM BASELINE

JAVELIN RENAL 101: STUDY DESIGN

Key eligibility criteria:

- Treatment-naïve aRCC with a clear cell component
- ≥ 1 measurable lesion as defined by RECIST v1.1
- Tumor tissue available for PD-L1 staining
- ECOG PS 0 or 1

Stratification:

- ECOG PS (0 vs 1)
- Geographic region (USA vs Canada/Western Europe vs ROW)

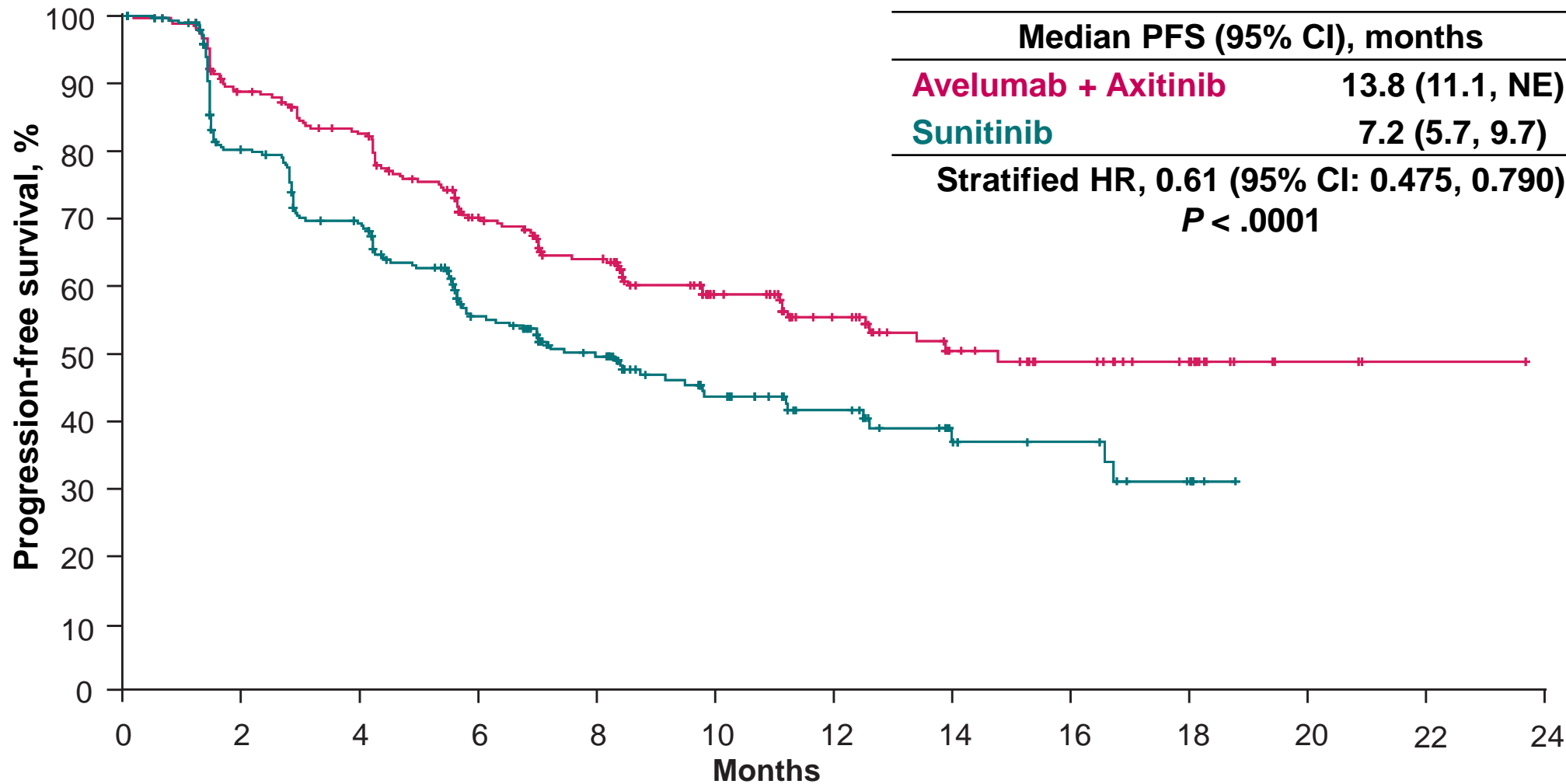
N = 886

**R
1:1**

**Avelumab 10 mg/kg IV Q2W
+
Axitinib 5 mg PO BID
(6-week cycle)**

**Sunitinib 50 mg PO QD
(4 weeks on, 2 weeks off)**

PFS PER IRC IN THE PD-L1+ GROUP



Number at risk

Avel + Axit:	270	227	205	154	120	76	53	32	23	13	3	1	0
Sunitinib:	290	210	174	119	85	49	35	16	13	5	0		

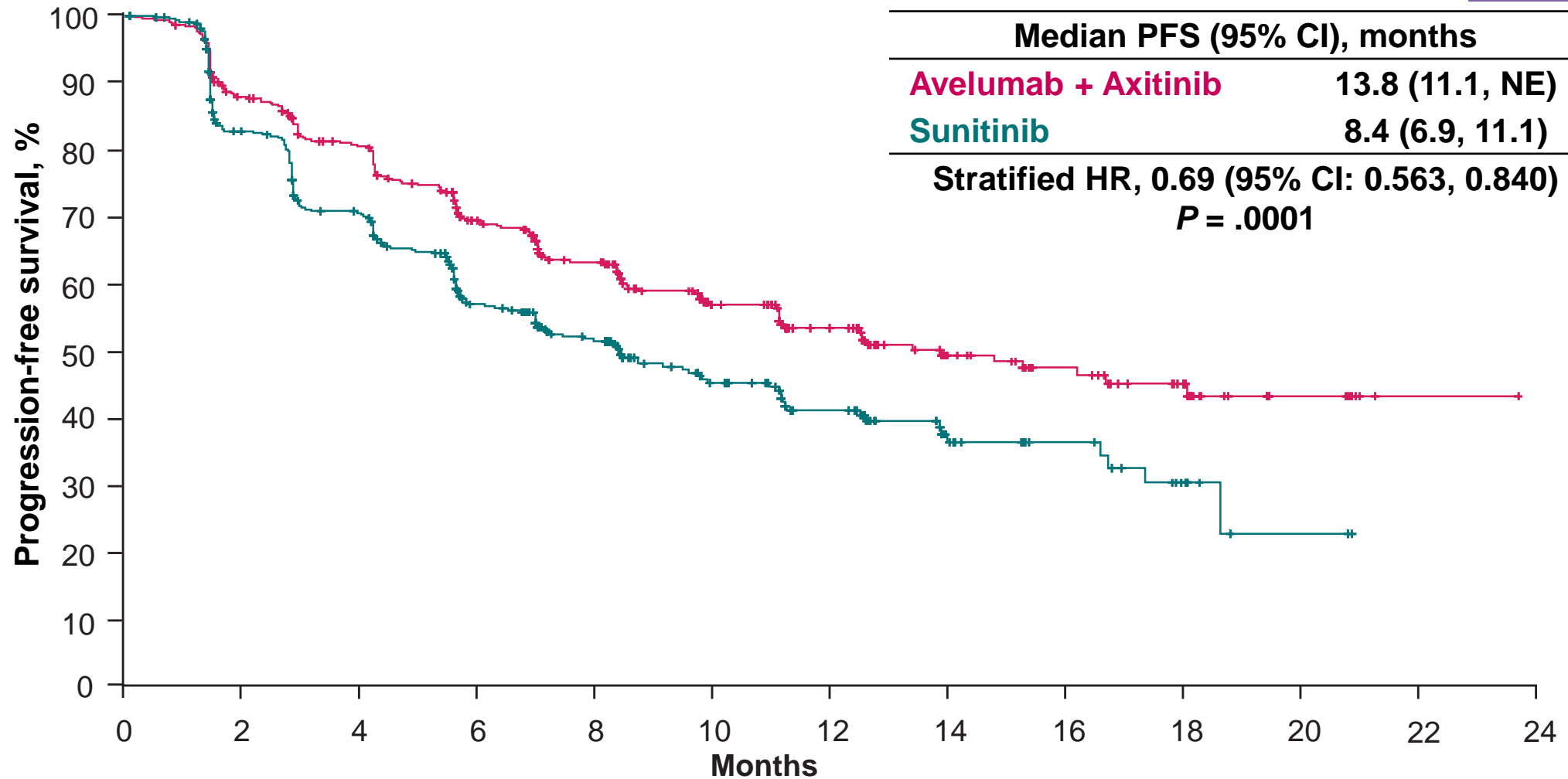
Minimum follow-up, 6 months. Median follow-up, 9.9 months (avelumab + axitinib) and 8.4 months (sunitinib).

The PFS analysis crossed the prespecified efficacy boundary based on the alpha-spending function ($P = .001$).

NE, not estimable.

PFS PER IRC IN THE OVERALL POPULATION

Key
secondary
endpoint



Number at risk

Avel + Axit:	442	364	321	250	193	127	94	57	42	24	8	1	0
Sunitinib:	444	329	271	192	144	90	64	29	20	8	2	0	

Minimum follow-up, 6 months. Median follow-up, 10.8 months (avelumab + axitinib) and 8.6 months (sunitinib).

The PFS analysis crossed the prespecified efficacy boundary based on the alpha-spending function ($P = .001$).

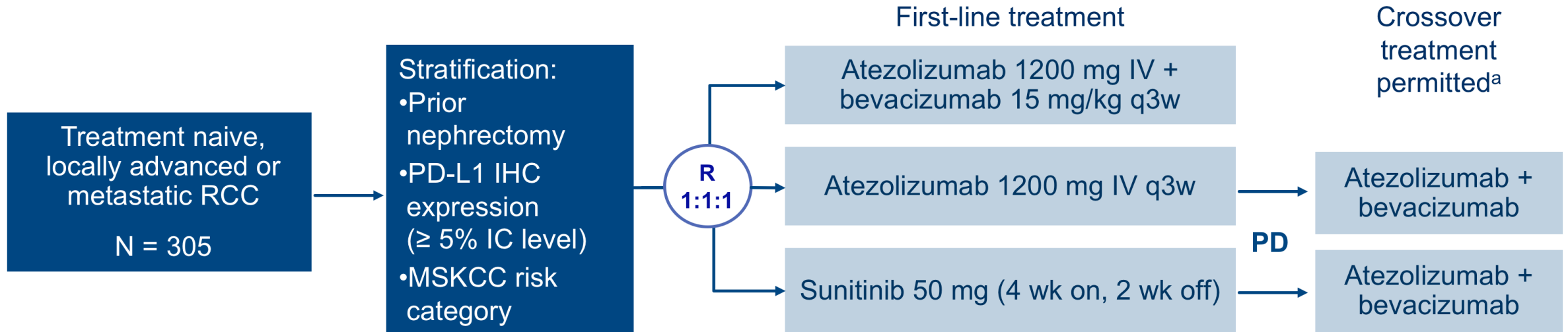
IMmotion150 (Phase II) Trial Design

nature
medicine

ARTICLES

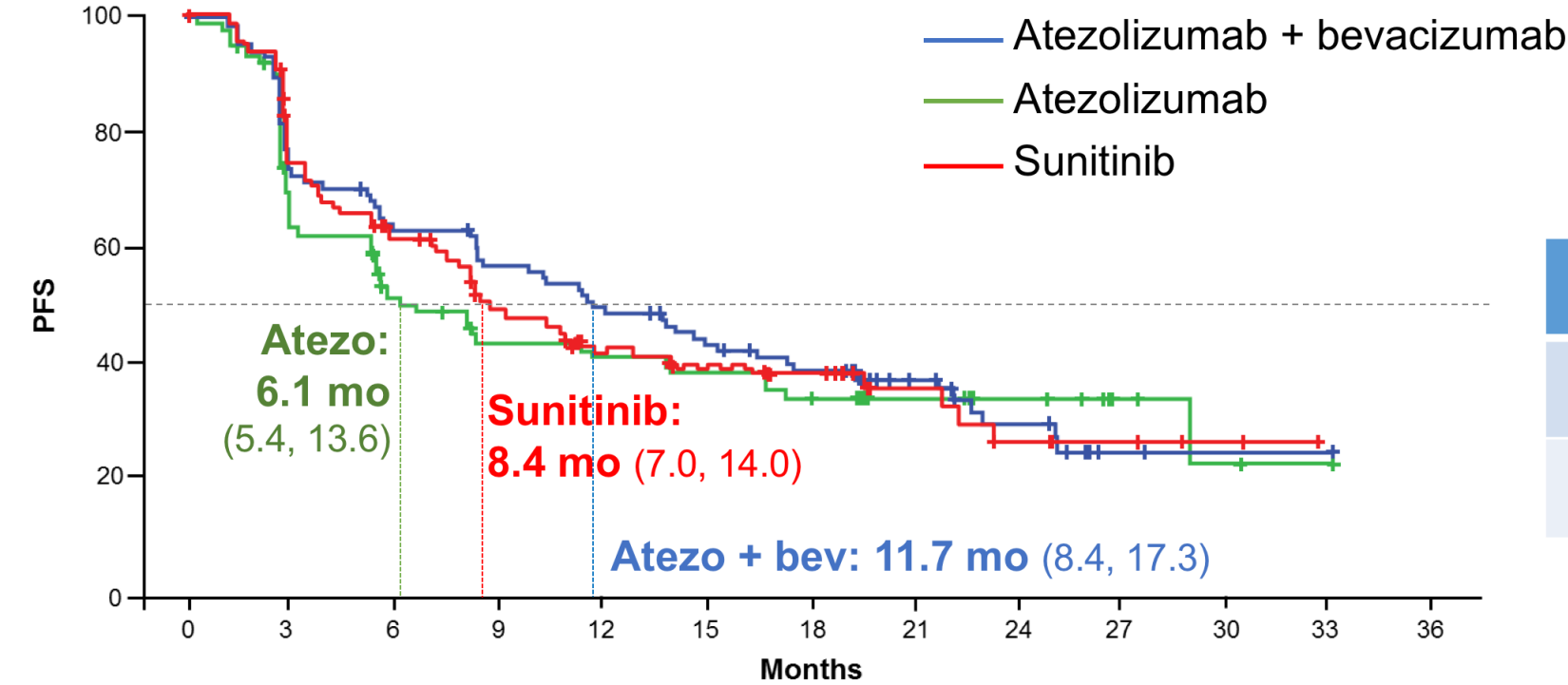
<https://doi.org/10.1038/s41591-018-0053-3>

Clinical activity and molecular correlates of response to atezolizumab alone or in combination with bevacizumab versus sunitinib in renal cell carcinoma



- The coprimary endpoints are PFS (RECIST v1.1 by IRF) in ITT and PD-L1+ patients

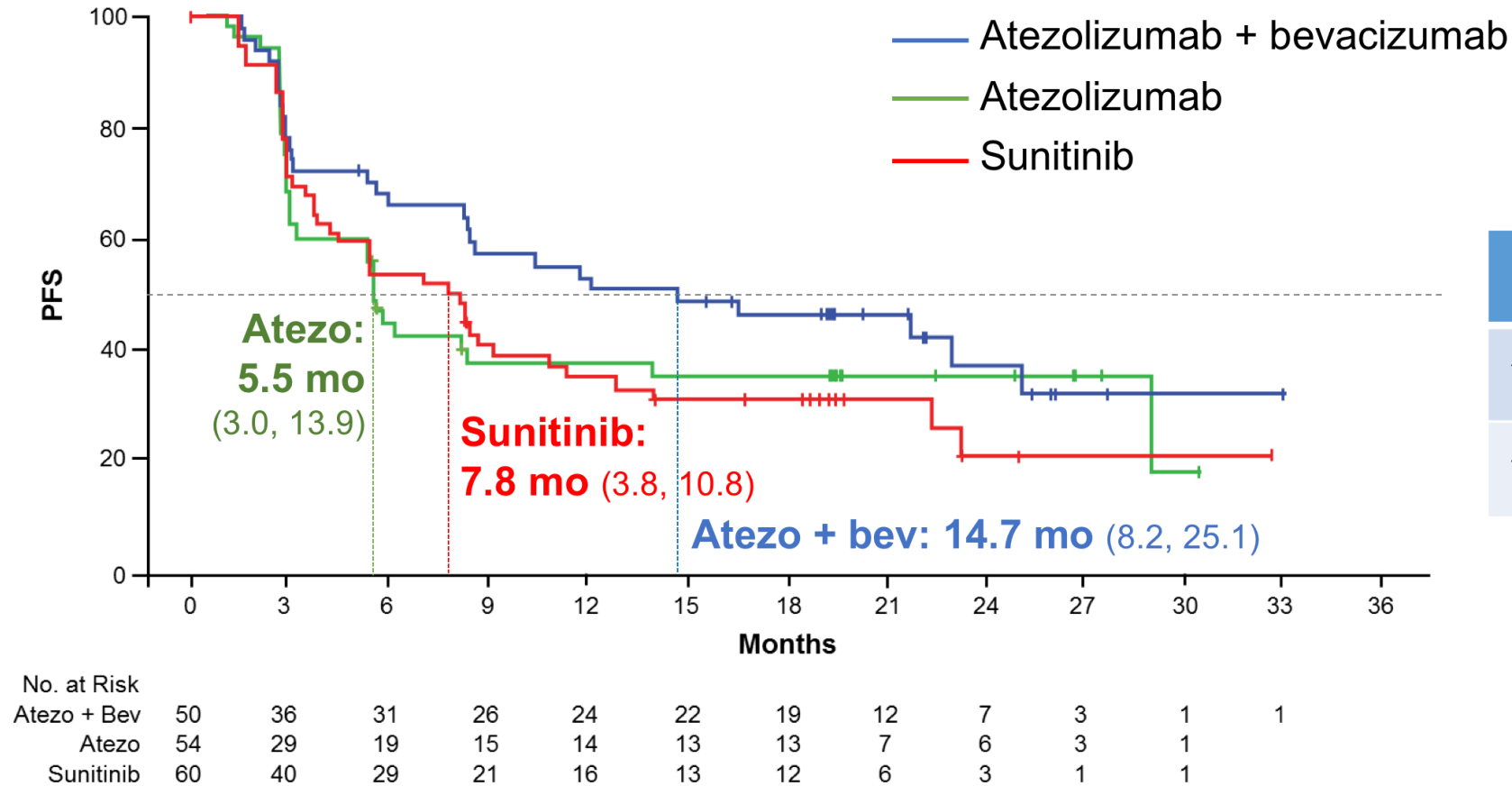
IMmotion150: IRF-Assessed PFS



No. at Risk												
Atezo + Bev	101	73	62	55	48	40	34	21	13	5	1	1
Atezo	103	59	43	35	31	29	24	14	10	4	2	1
Sunitinib	101	69	53	37	30	26	22	11	7	4	2	

	Stratified HR (95% CI)	P Value ^a
Atezo + bev vs sunitinib	1.00 (0.69, 1.45)	0.982
Atezo vs sunitinib	1.19 (0.82, 1.71)	0.358

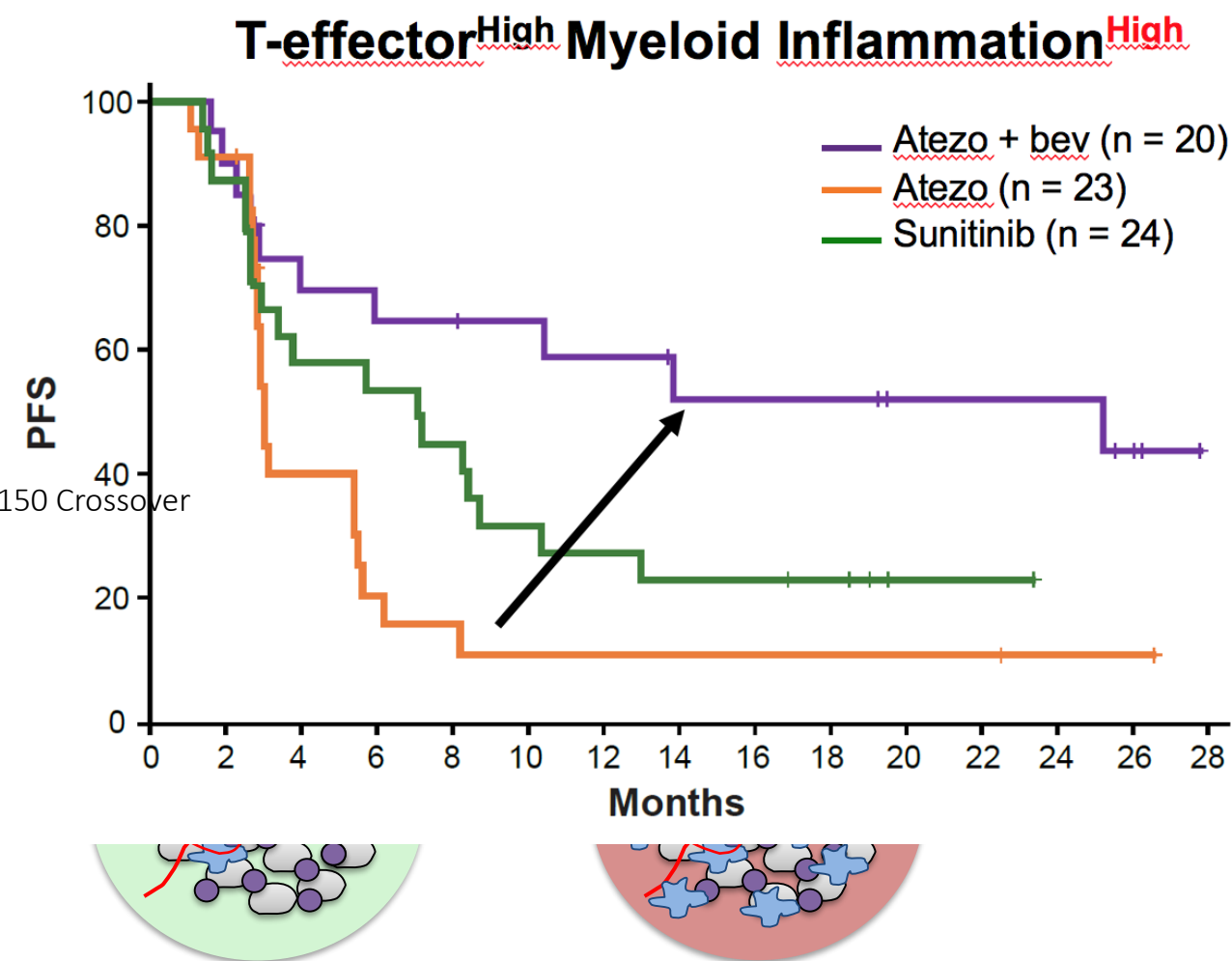
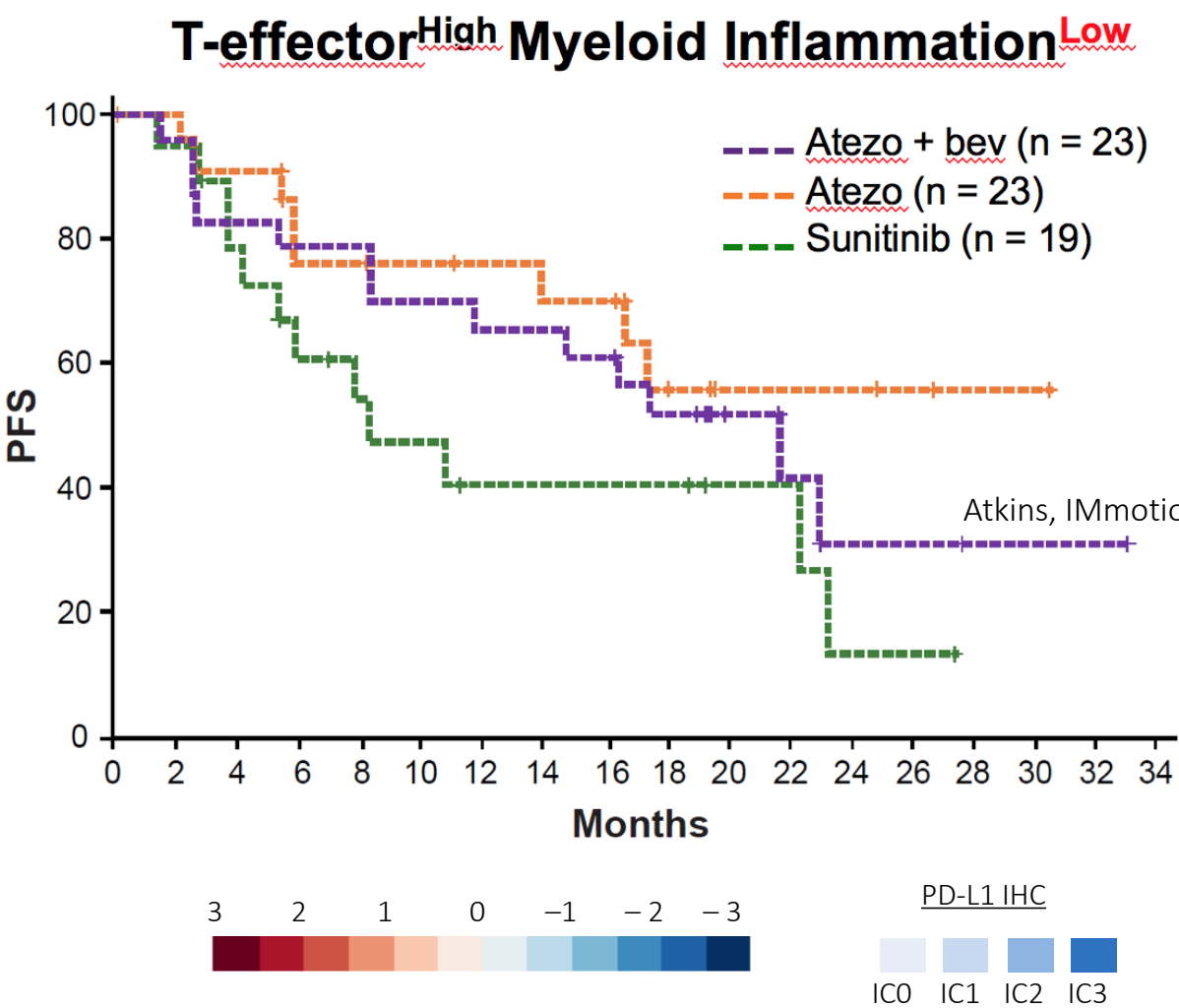
IMmotion150: IRF-Assessed PFS: PD-L1 positive (IC)



	Stratified HR (95% CI)	P Value ^a
Atezo + bev vs sunitinib	0.64 (0.38, 1.08)	0.095
Atezo vs sunitinib	1.03 (0.63, 1.67)	0.917

Transcriptome Map of Angiogenesis and Immune-Associated Genes

Renal Cell Carcinoma



1. Brauer, Clin Cancer Res. 2012; 2. Herbst, Nature 2014; 3. Powles, SITC 2015; 4. Fehrenbacher, Lancet 2016. McDermott, AACR 2017.

IMmotion151: Trial design

Key eligibility

- Treatment-naïve advanced or metastatic RCC
- Clear cell and/or sarcomatoid histology
- KPS ≥ 70
- Tumor tissue available for PD-L1 staining

Stratification

- MSKCC risk score
- Liver metastases
- PD-L1 IC IHC status ($< 1\%$ vs $\geq 1\%$)^a

N = 915

R
1:1

Atezolizumab 1200 mg IV q3w
+
Bevacizumab 15 mg/kg IV q3w

Sunitinib 50 mg PO QD
(4 weeks on, 2 weeks off)

Co-primary endpoints

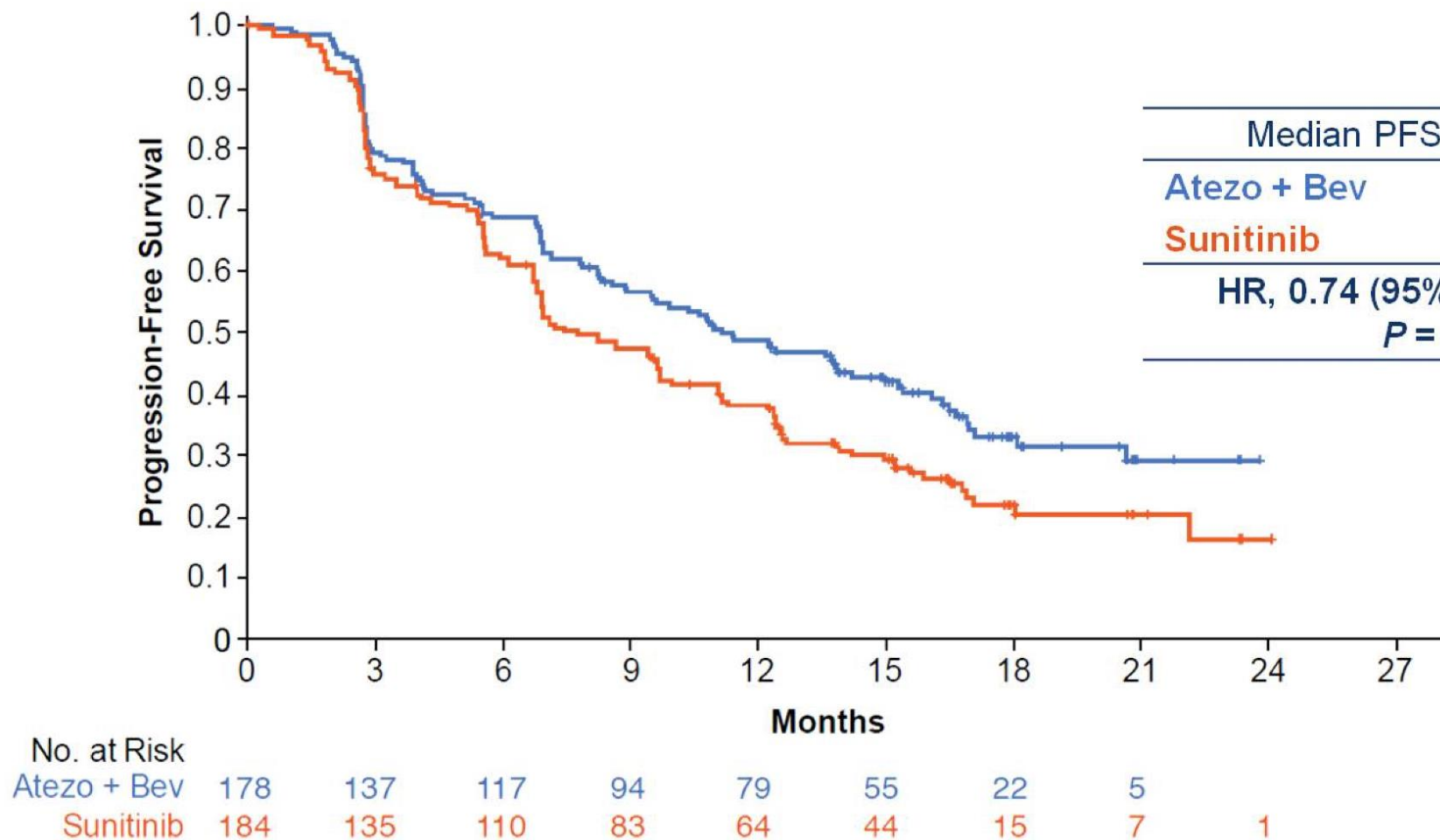
- PFS by INV assessment in PD-L1+
- OS in ITT

Other key endpoints

- PFS in ITT
- OS in PD-L1+
- ORR

- Patient-reported outcomes
- Safety

IMmotion151: PFS in PD-L1 positive



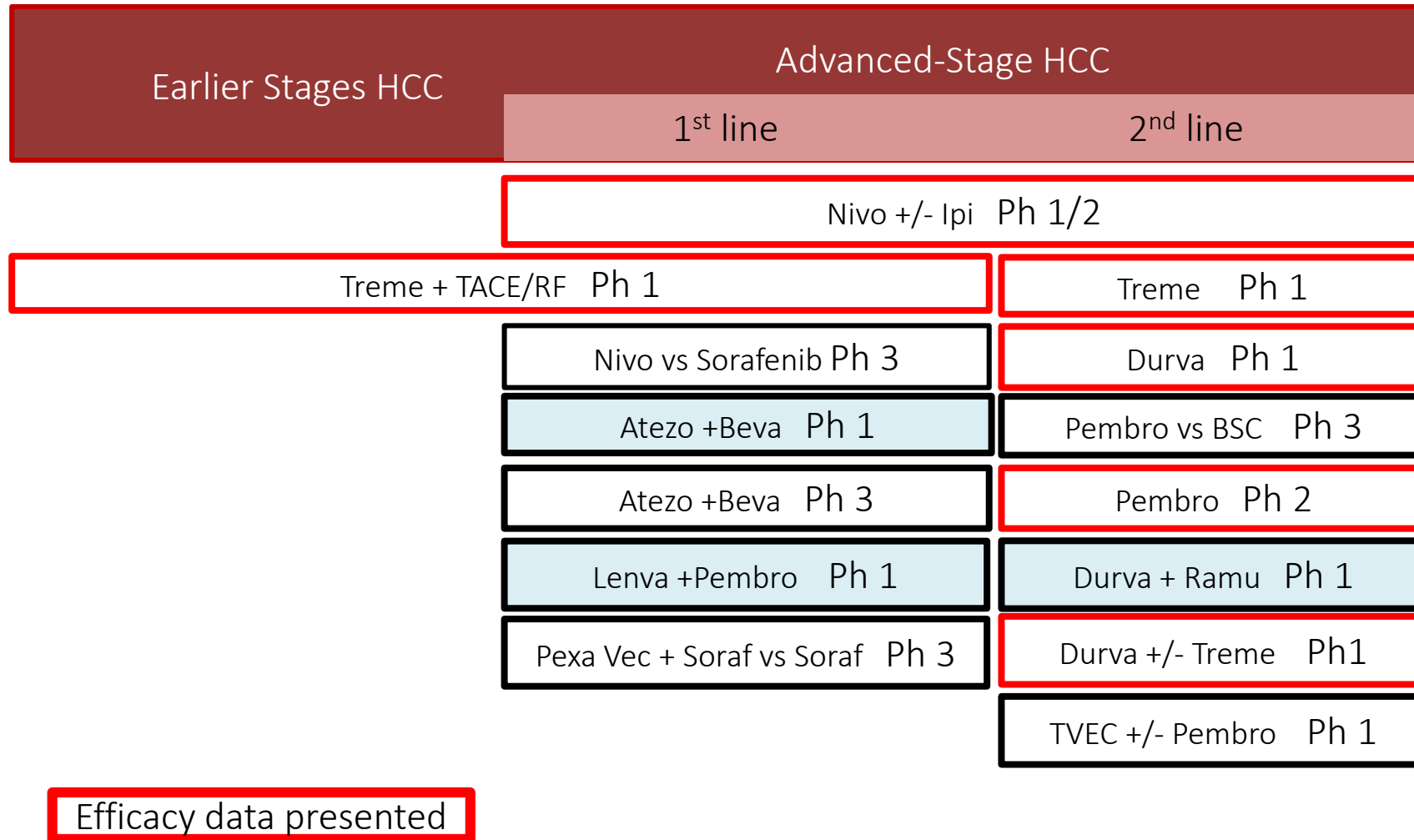
Median PFS, mo (95% CI)	
Atezo + Bev	11.2 (8.9, 15.0)
Sunitinib	7.7 (6.8, 9.7)
HR, 0.74 (95% CI: 0.57, 0.96)	
$P = 0.02^a$	

PD-L1 ^a	
Atezo + Bev n = 276	Sunitinib n = 277 ^b
11.0 (8.3, 13.3)	8.4 (7.4, 10.1)
0.84 (0.67, 1.04)	

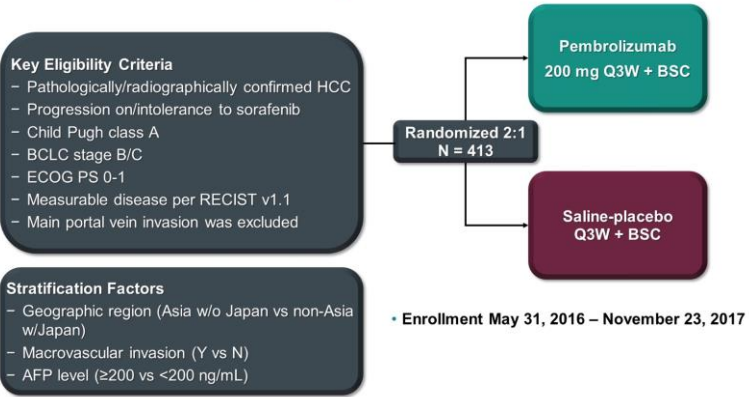
AGENDA

- ◆ Rational for anti-angiogenesis and IO combinations
- ◆ Lung cancer paradigm: from phase 1 to phase 3 trials
- ◆ Combinatorial advances in RCC
- ◆ **Ongoing efforts in early clinical trials across diseases**

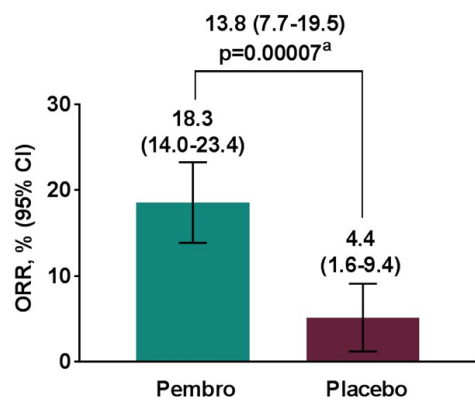
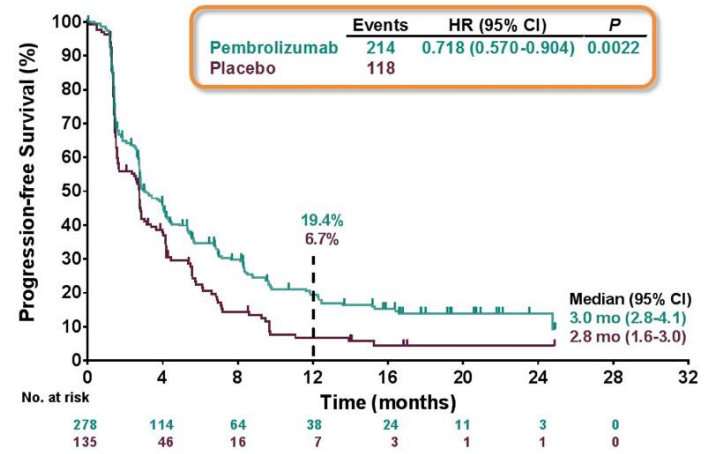
Anti-angiogenesis and IO trials for advanced HCC



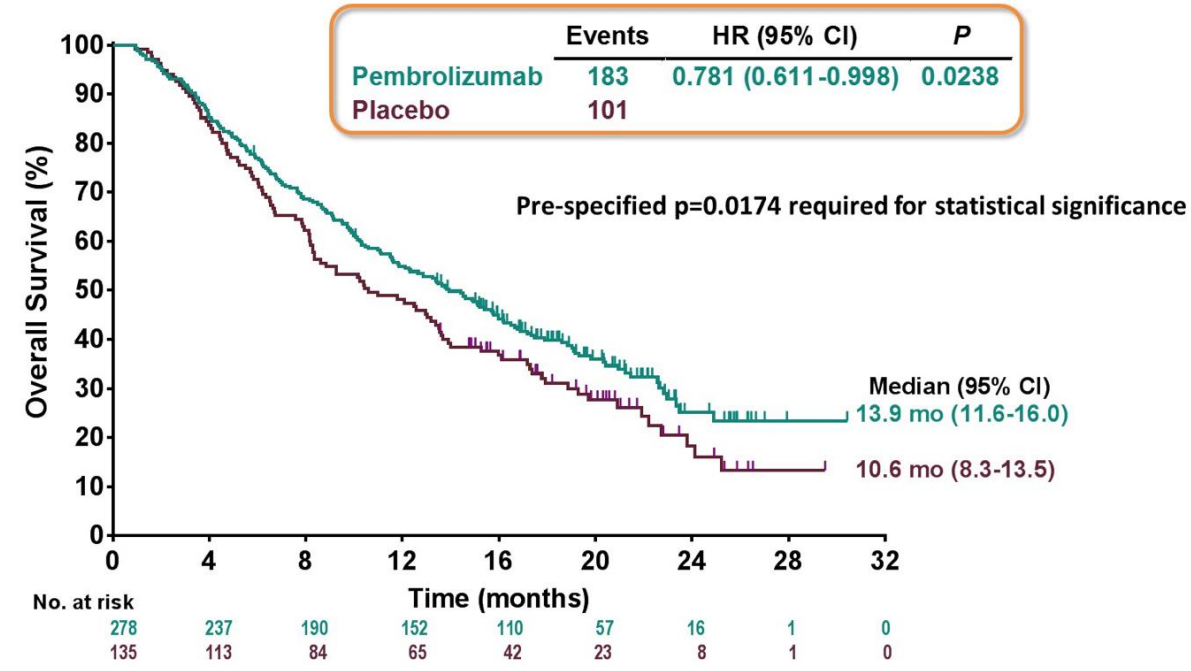
Reminder KEYNOTE-240



Final Analysis



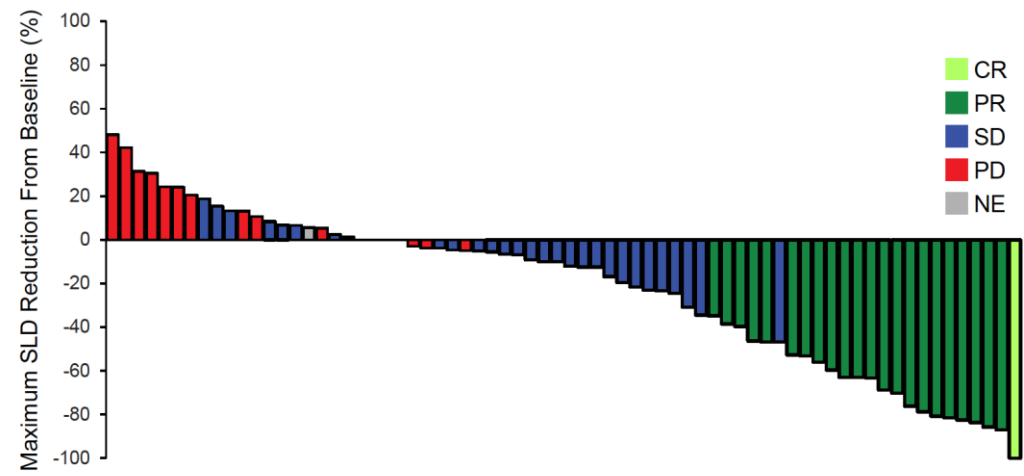
Overall Survival



PFS and OS: Not statistically significant

Expanding the atezolizumab-bevacizumab opportunity

HCC cohort



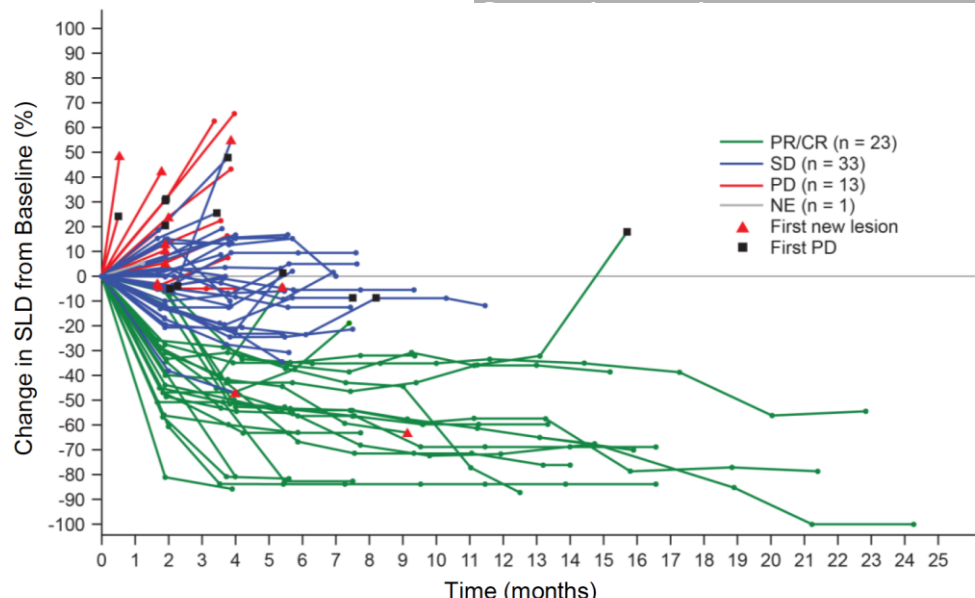
n = 73	
Median PFS (range), mo	14.9 (0.5 to 23.9+)
PFS events, n (%)	29 (40)
6-month PFS, %	65
Median follow-up, mo	7.2

Gastric cancer
Pancreatic cancer
olizumab)
essed OF

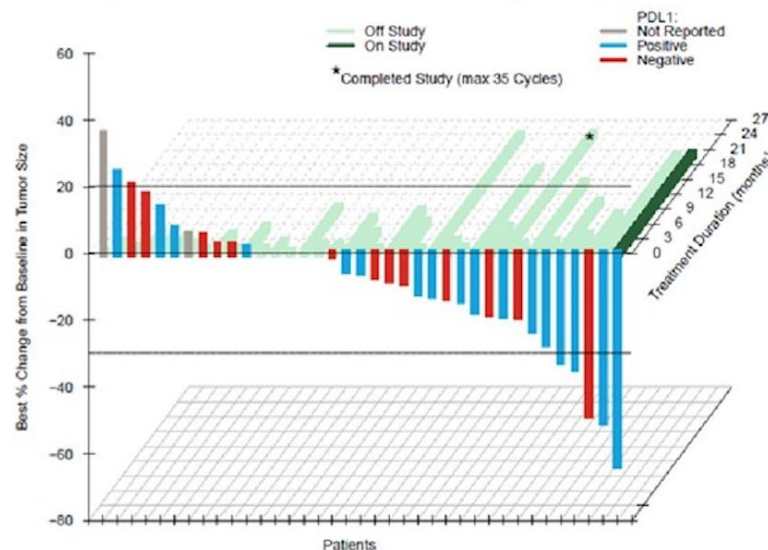
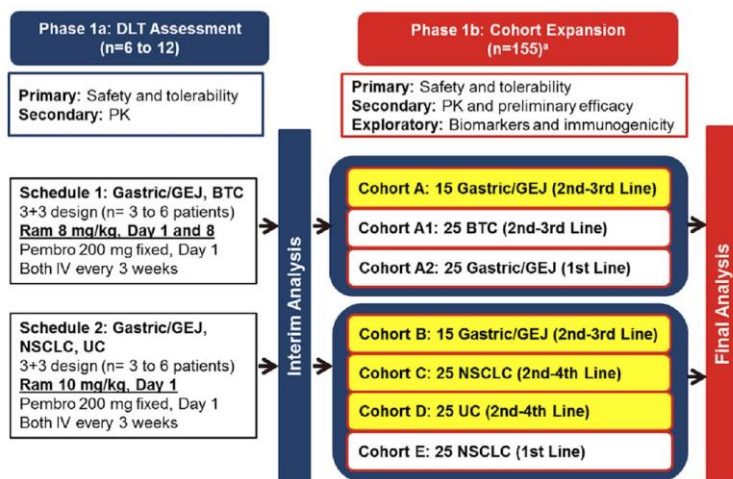
ORR	
Overall, n (%) ^a	23/73 (32)
CR	1/73 (1)
PR	22/73 (30)
SD	33/73 (45)
PD	13/73 (18)
By region, n/n (%) ^b	
Asia excluding Japan	12/41 (29)
Japan/USA	10/31 (32)
By aetiology, n/n (%)	
HBV	11/36 (31)
HCV	10/23 (43)
Non-viral	2/14 (14)
By baseline AFP, n/n (%) ^c	
< 400 ng/mL	12/41 (29)
≥ 400 ng/mL	11/27 (41)
By EHS/MVI, n/n (%) ^d	
EHS and/or MVI	18/64 (28)
MVI negative	13/32 (41)
EHS negative	9/22 (41)
Neither EHS nor MVI	5/8 (63)

anti-PD-1 or anti-PD-L1
therapeutic antibodies

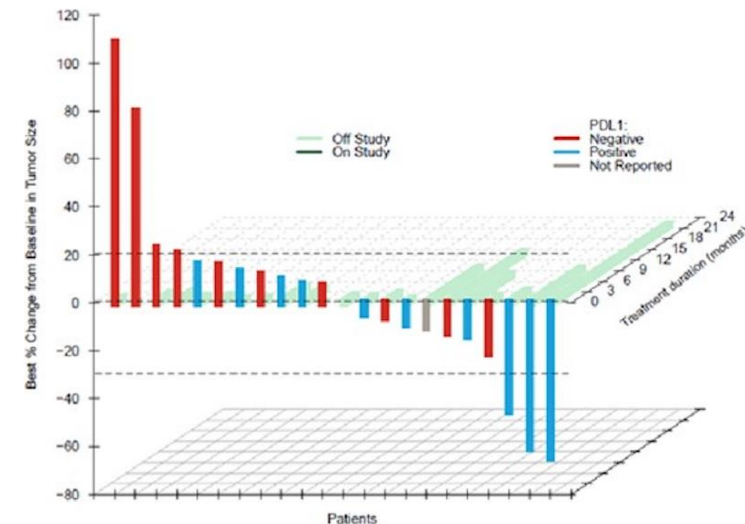
Primary endpoints



Basket with pembrolizumab-ramucirumab



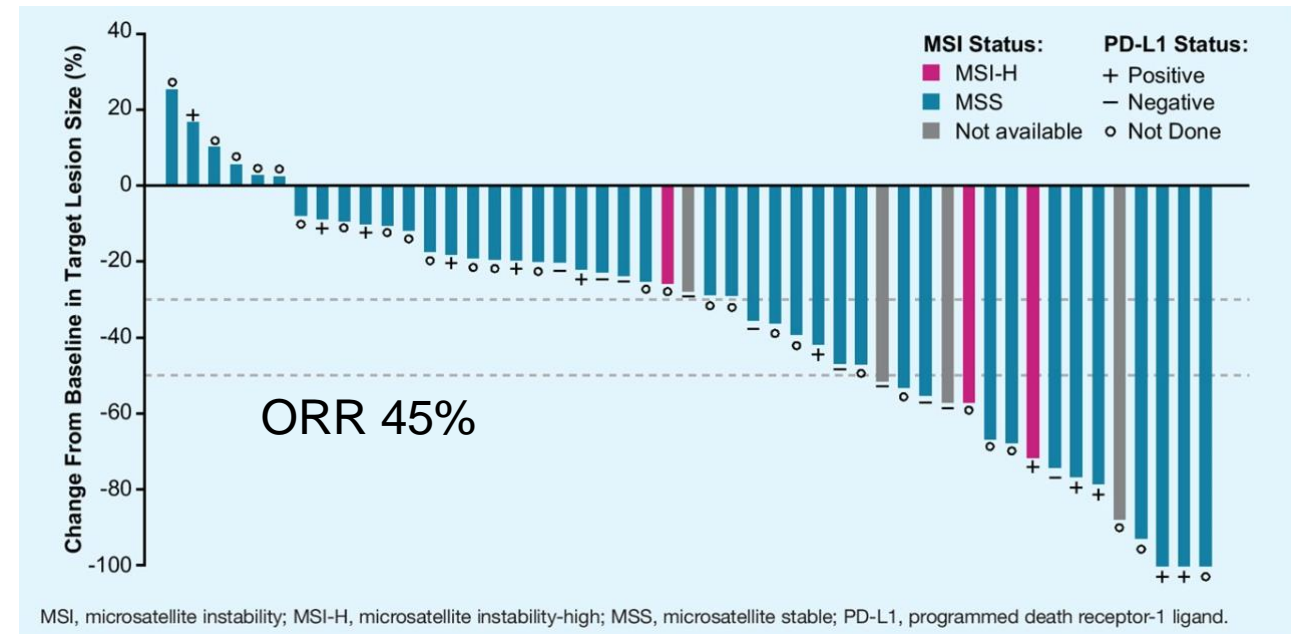
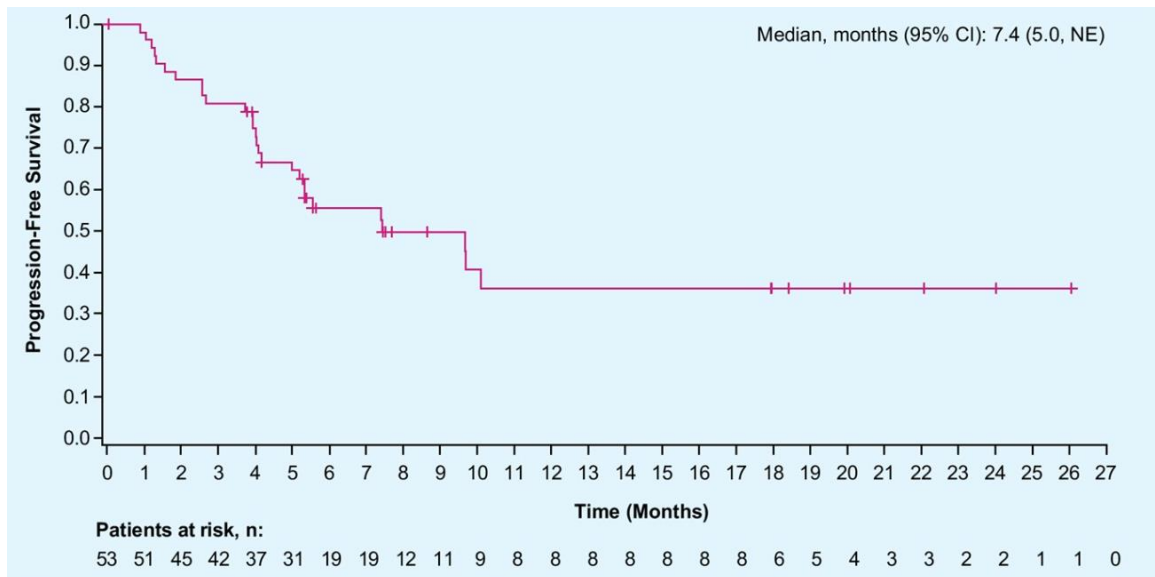
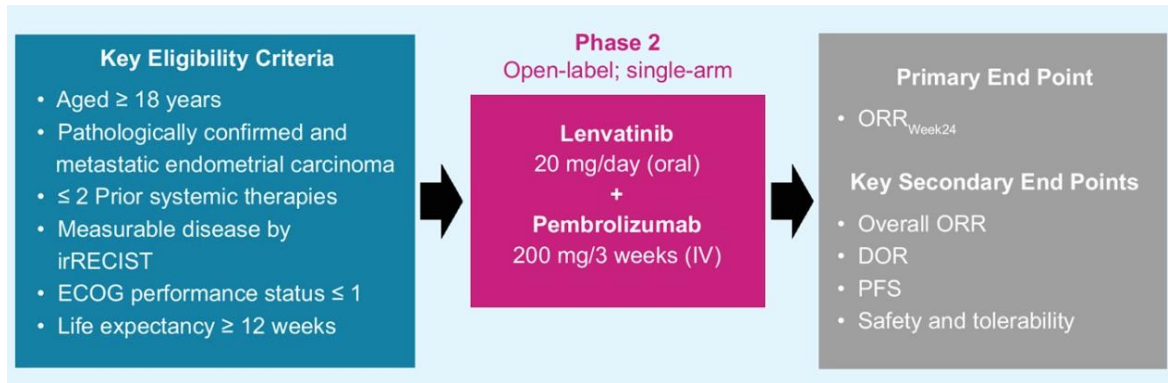
GEJ



UC

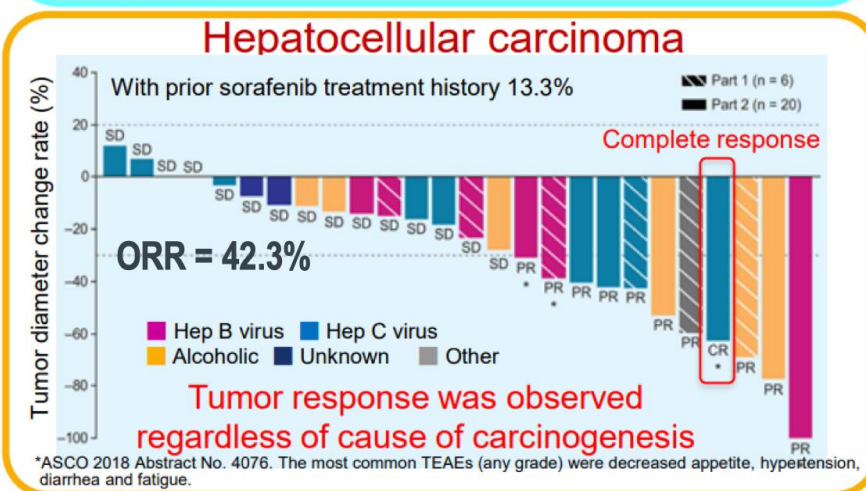
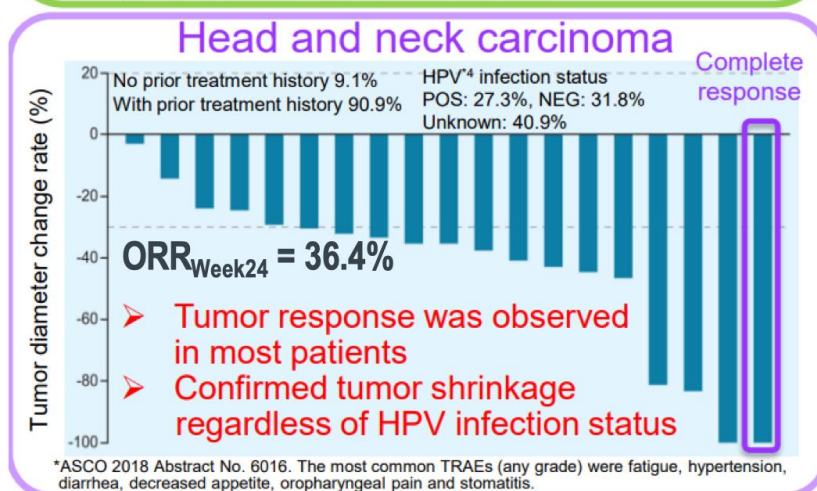
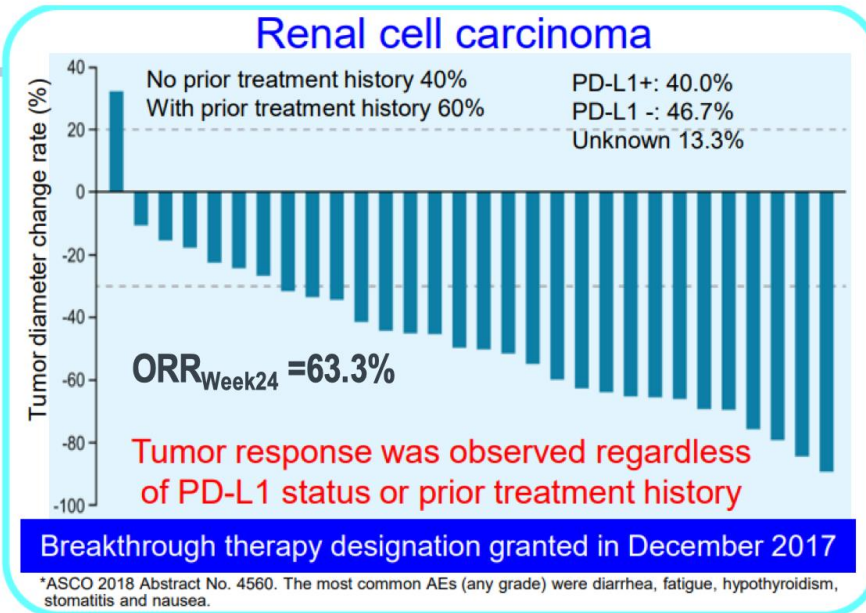
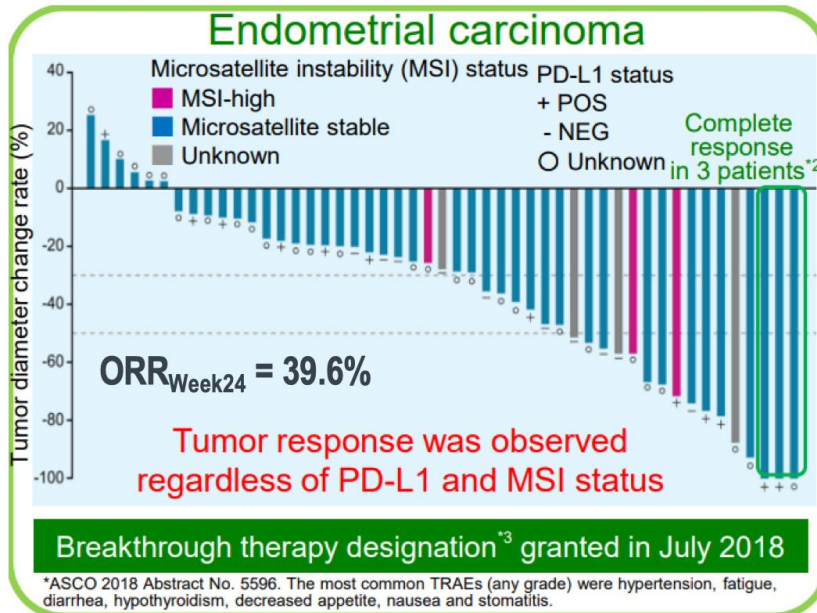
	G/GEJ (2 nd -3 rd line)		NSCLC (2 nd -4 th line)		UC (2 nd -4 th line)	
PD-L1 Status	CPS <1% n=17	CPS ≥1% n=22	TPS <1% n=11	TPS ≥1% n=11	CPS <1% n=11	CPS ≥1% n=12
ORR, % (95% CI)	6 (0.1-28.7)	9 (1.1-29.2)	18 (2.3-51.8)	45 (16.7-76.6)	0	25 (5.5-57.2)

Lenvatinib and pembrolizumab in endometrial cancer



- FDA breakthrough designation August 2018
- Ongoing cohorts across diseases (3 randomized phase 2 trials in lung)

Lenvatinib and pembrolizumab across malignancies



Conclusions


Immunologic Research 2001;23–2/3:263–272

VEGF as a Mediator of Tumor-Associated Immunodeficiency

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David P. Carbone

Department of Medicine and
Vanderbilt-Ingram Cancer Center
Vanderbilt University Medical
Center, Nashville, TN

- Rational for anti-angiogenic combination with immunotherapy is very solid and known since 20 years
- This strategy is extensively being explored in RCC, NSCLC, endometrial cancer and HCC, where it will define new standards of care
- Both anti-angiogenic TKIs and anti-VEGF therapies transversally demonstrate interesting signals of activity
- Integration of PD1, PD-L1 and possibly CTLA-4 inhibition have all shown some synergistic activity with anti-angiogenic drugs

A scenic landscape featuring terraced vineyards on a steep hillside, a winding road, a small village, and a large lake in the background under a clear sky.

Thank you for your attention