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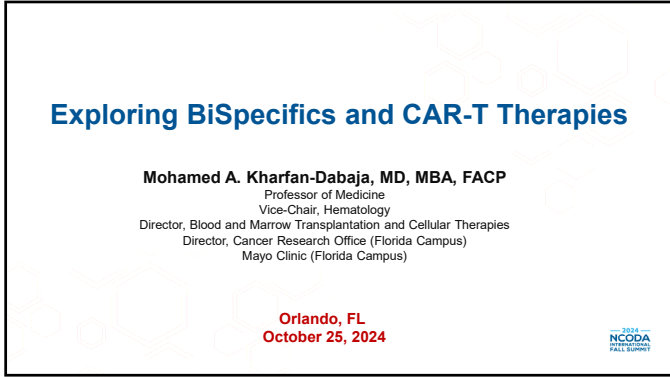
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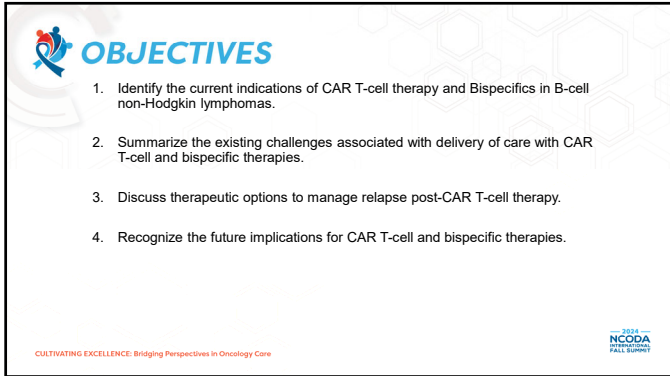
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 **DISCLOSURE**

The following relevant financial relationships from the past 24 months have been identified and disclosed for the following faculty of this CE activity:

- **Mohamed A. Kharfan-Dabaja, MD, MBA, FACP**
  - Research/Grant:
    - Mayo Clinic Florida site PI for clinical trial
      - Novartis
      - Bristol Myers Squibb
      - Pharmacyclics
  - Lecture/Honoraria:
    - Kite Pharma

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 **DISCLOSURE**

The following relevant financial relationships within the past 24 months have been identified and disclosed for the reviewers of this CE presentation:

- **Chris Eider, PharmD, BCOP**
  - Advisory board member for which honorarium was received for the following:
    - Boehringer Ingelheim
    - Eliasi
    - Janssen
    - Mirati
    - Novartis
    - Pfizer
    - Pharmacosmos
    - Sanofi

No relevant financial relationships from the past 24 months have been identified and disclosed for other planners of this CE activity:

- **Daisy Doan, PharmD**

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**Definition of abbreviations**

- BCMA: B-cell maturation antigen
- CAR T-cell: Chimeric antigen receptor T-cell
- CLL: Chronic lymphocytic leukemia
- DLBCL: Diffuse large B-cell lymphoma
- FL: Follicular lymphoma
- MCL: Mantle cell lymphoma
- MZL: Marginal Zone lymphoma
- NRM: Non-relapse mortality
- PFS: Progression-free survival
- OS: Overall survival

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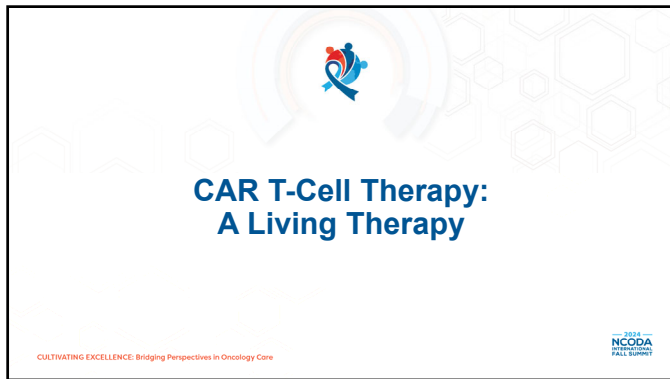
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**CAR T-Cell Therapy:  
A Living Therapy**

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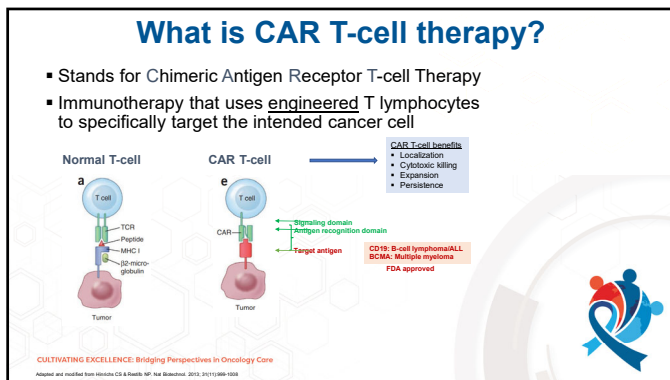
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**What is CAR T-cell therapy?**

- Stands for Chimeric Antigen Receptor T-cell Therapy
- Immunotherapy that uses engineered T lymphocytes to specifically target the intended cancer cell

**Normal T-cell** (a) vs **CAR T-cell** (e)

**CAR T-cell benefits:**

- Localization
- Cytotoxic killing
- Expansion
- Persistence

CD19: B-cell lymphoma/ALL, MCL, Multiple myeloma, FDA approved

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Reprinted and modified from Heston CD & Beatty, NP, Nat Biotechnol. 2012; 30(11):1086-1093

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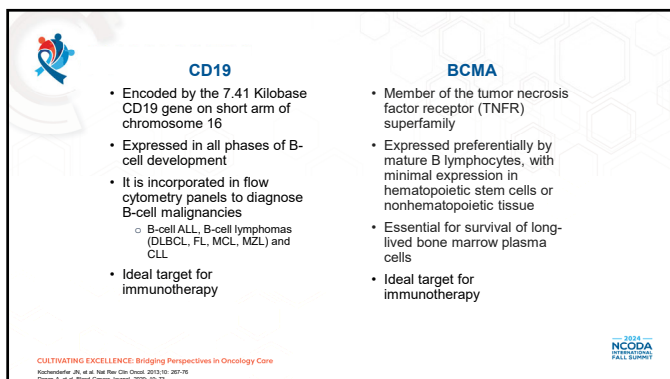
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**CD19**

- Encoded by the 7.41 Kilobase CD19 gene on short arm of chromosome 16
- Expressed in all phases of B-cell development
- It is incorporated in flow cytometry panels to diagnose B-cell malignancies
  - B-cell ALL, B-cell lymphomas (DLBCL, FL, MCL, MZL) and CLL
- Ideal target for immunotherapy

**BCMA**

- Member of the tumor necrosis factor receptor (TNFR) superfamily
- Expressed preferentially by mature B lymphocytes, with minimal expression in hematopoietic stem cells or nonhematopoietic tissue
- Essential for survival of long-lived bone marrow plasma cells
- Ideal target for immunotherapy

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Kucharske-Lorant, JM, et al. Nat Rev Clin Oncol. 2015;11(10):587-79

Cheng, A, et al. Blood Cancer Journal. 2020; 10: 72

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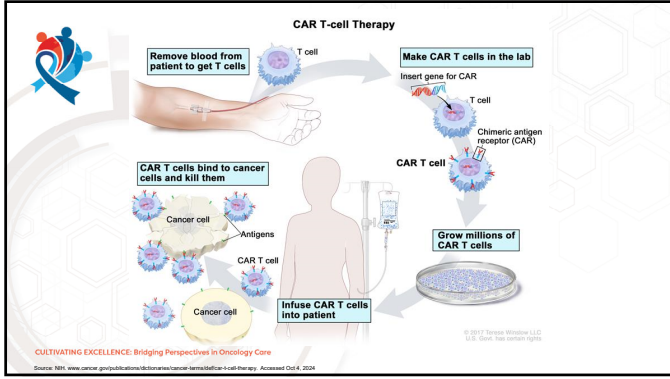
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### B-cell lymphoid malignancies: indications by commercially available products 2024 (adults)

	Brexucabtagene autoleucel	Axicabtagene ciloleucel	Tisagenlecleucel	Lisocabtagene maraleucel
3 <sup>rd</sup> line DLBCL	No	Yes	Yes	Yes
Transformed FL	No	Yes	Yes	Yes
PMBCL	No	Yes	No	Yes
2 <sup>nd</sup> line DLBCL	No	Yes	No	Yes
R/R MCL	Yes	No	No	Yes
R/R FL (non-transformed)	No	Yes	Yes	Yes
R/R CLL	No	No	No	Yes
R/R B-cell ALL	Yes	No	Yes	No

Nadelgo, SS, et al. N Engl J Med. 2017; 377:2331-44. Schuster, et al. N Engl J Med. 2019; 380:45-56.  
Aghajani, JI, et al. Lancet Oncol. 2020; 21:158-65. Locke, FT, et al. N Engl J Med. 2019; 381:859-66.  
Ghaly, M, et al. N Engl J Med. 2022;387(7):624-630. Kamada, M, et al. Lancet. 2022; 399:2259-2268.  
Wang, H, et al. NCI Thesaurus. 2020; C127133.  
Wang, H, et al. J Clin Oncol. 2022; 40:1146-57.  
Jacobson, C, et al. Lancet Oncol. 2022; 23:94-103. Fowler, NR, et al. Nature Med. 2022; 28:325-32.  
Mackinnon, S, et al. N Engl J Med. 2017; 376:2471-83.  
Siddiq, T, et al. Lancet. 2022; 400(10421):641-656.

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**Diffuse Large B-cell Lymphoma**

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### Before availability of CAR-T

Outcomes of R/R DLBCL after failing 2 prior Rx were **dismal**

	MDACC (n = 165)	IABC (n = 82)	LY-12 (ECOG) (n = 219)	CORAL (LYSARC) (n = 176)	Pooler* (N = 636)
Patients evaluated for response, n†	165	82	156	176	633
Response rate, % (95% CI)	30	36	28	23	26 (21-31)
CR rate	13	18	25	16	7 (5-15)
PR rate	17	18	3	7	18 (13-23)
Response rate by refractory category, % (95% CI)					
Primary refractory					
RR	—	25	27	10	20 (11-34)
CR rate	—	10	1	2	3 (1-11)
Refractory to second-line or later-line therapy					
RR	20	21	20	40	25 (17-30)
CR rate	7	5	20	18	12 (8-20)
Relapse >12 mo post-ASCT					
RR	19	35	—	39	34 (24-45)
CR rate	6	10	—	20	15 (8-21)

\*Pooled response rate; †CR, complete response; PR, partial response; RR, refractory rate; CR, central response.

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Crump M, et al. Blood. 2017; 130 (16): 1800-09

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### Diffuse large B cell lymphoma: Relapsed or refractory disease

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Crump M, et al. Blood. 2017; 130 (16): 1800-09

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### DLBCL: FDA approved agents

	Axicabtagene Ciloleucel	Tisagenlecleucel	Lisocabtagene maraleucel
FDA Approval indication for 3 <sup>rd</sup> line and beyond	Yes, ZUMA-1	Yes, JULIET	Yes, TRANSCEND NHL001
FDA Approval indication for 2 <sup>nd</sup> line and beyond	Yes, ZUMA-7	No	Yes, TRANSFORM
FDA approval for refractory disease to 1 <sup>st</sup> line chemoimmunotherapy or relapse after 1 <sup>st</sup> line chemoimmunotherapy and are <b>not</b> eligible for HCT due to comorbidities or age	-	-	Yes, PILOT

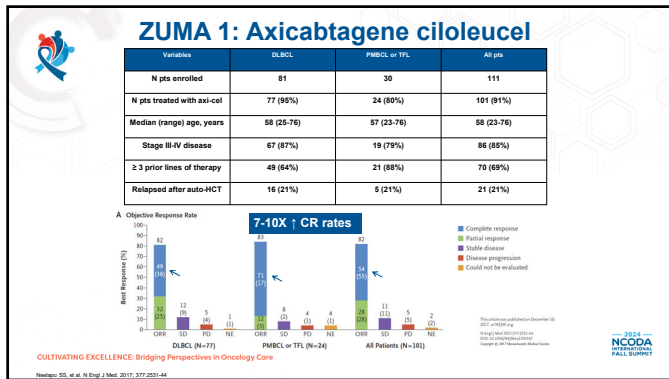
HCT, hematopoietic cell transplantation.

CULTIVATING EXCELLENCE: Bridging Perspectives in Oncology Care  
Neelapu SS, et al. N Engl J Med. 2017; 377:2531-44  
 Schuster et al. N Engl J Med. 2019; 380:45-56  
 Abramson JS, et al. Lancet. 2020; 396: 839-52  
 Locke F, et al. N Engl J Med. 2022; 386: 605-14  
 Blahop M, et al. N Engl J Med. 2022; 386(7): 629-39  
 Blahop M, et al. Lancet. 2022; 399: 2094-2098  
 Sehgal A, et al. Lancet. 2022; 23 (8): 1066-77

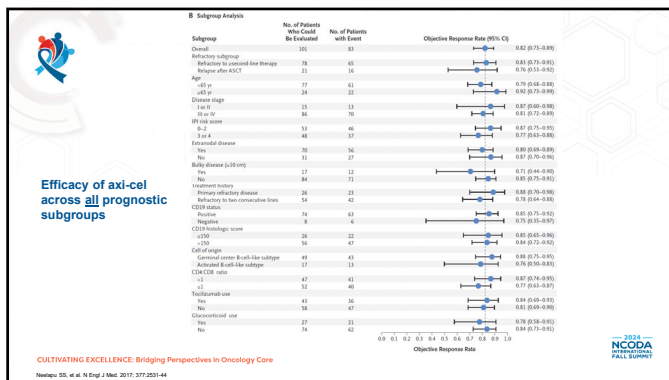
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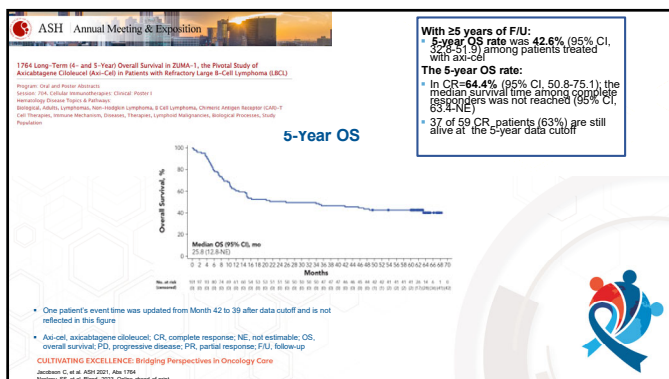




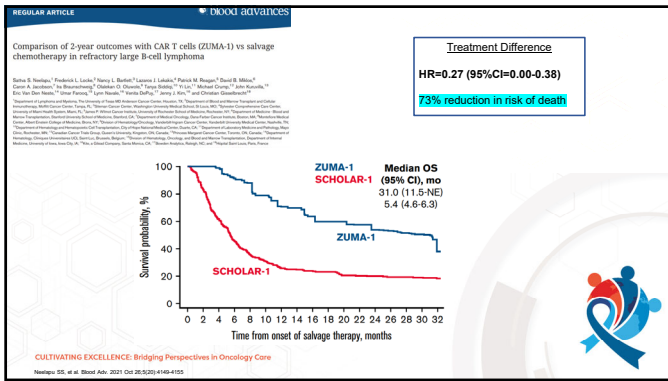
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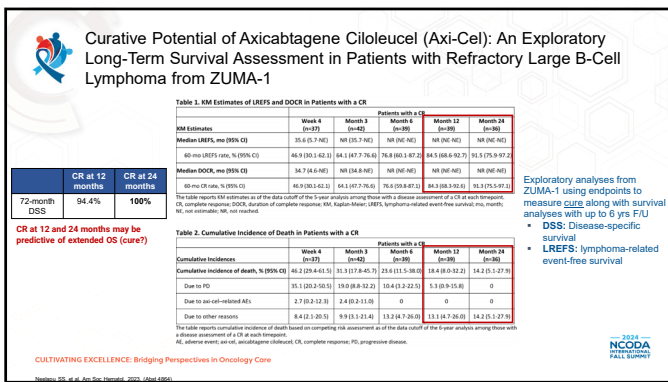
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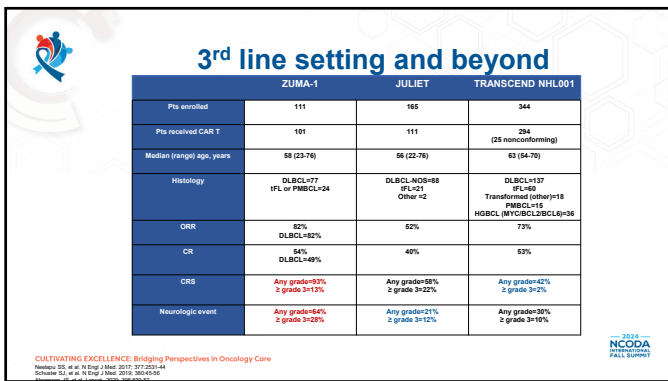
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### Hypoalbuminemia

**OS and Albumin**  
Log-rank p-value = 0.001

**Impact of hypoalbuminemia on the prognosis of relapsed/refractory B-cell lymphoma treated with axicabtagene ciloleucel**

**CAR T-cell therapy overcomes the adverse prognosis of hypoalbuminemia**

**PFS**  
P=0.1

**OS**

**N=81 patients**

**CULTIVATING EXCELLENCE: Bridging Perspectives in Oncology Care**  
Datta S, et al. Ann Hematol. 2014; 93: 1305-12  
Mandy W, et al. Eur J Haematol. 2014; 107: 48-51

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### Five Year Outcomes of Patients with Large B-Cell Lymphoma Treated with Standard-of-Care Axicabtagene Ciloleucel: Results from the US Lymphoma CAR-T Cell Consortium

**42% would not have met eligibility criteria for ZUMA-1**

- 17 US academic centers
- 297 pts underwent leukapheresis with intent to manufacture axi-cel
- 275 infused, OS and PFS calculated from infusion date
- Median FU of 53 months, median OS was 34.9 months and median PFS was 8.7 months
- 5-year OS **40.3%** (95% CI 34.2 - 46.4%)
- 5-year PFS and **28.5%** (95% CI 23 - 34.2%)

**MVA for OS:** Male, LDH > ULN, ECOG of 2-4, elevated bilirubin > 1.5 mg/dL

**MVA for PFS:** Male, LDH > ULN, ECOG of 2-4, elevated bilirubin > 1.5 mg/dL, ≥3 prior Rx

**Real World Data**

**5-year cum relapse risk= 55.2%**  
**5-year risk NRM=16.2%**

**CULTIVATING EXCELLENCE: Bridging Perspectives in Oncology Care**  
Sengul JY, et al. Ann Soc Hematol. 2023 (Apr 10/22)

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### Moving CAR T-cell therapy to 2<sup>nd</sup> line

- 3 randomized studies:**
  - ZUMA-7:** Axi-cel vs. SOC (Axi-cel better)
  - TRANSFORM:** Liso-cel vs. SOC (Liso-cel better)
  - BELINDA:** Tisagenlecleucel vs. SOC (no difference)

**SOC: standard of care**

**CULTIVATING EXCELLENCE: Bridging Perspectives in Oncology Care**  
Lundh P, et al. N Engl J Med. 2022; 386: 665-674  
Kamdar M, et al. Lancet. 2022; 399: 2224-2233  
Chihara M, et al. N Engl J Med. 2022; 387: 2071-2082

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ORIGINAL ARTICLE

### Survival with Axicabtagene Ciloleucel in Large B-Cell Lymphoma

J.R. Westin, O.O. Oluwole, M.J. Keenan, D.B. Miklos, M.A. Presler, A. Chhabra, A.P. Bhanoo, A. Suredh, C.A. Jacobson, G. Tannir, T. van Hecken, M. Lindeman, M. Hwang, L.A. Leskin, S. Chaganti, M. Dickinson, K. Durrant, P.M. Hegazi, J. Hodi, K.W. Song, P.A. Ruffell, M.C. Robinson, Y. Yang, S. Vardhanchandran, S. Fison, P. Cheng, S.A. Shukani, M. Schupp, C. Tu, and P.L. Locke, for the ZUMA-7 Investigators and Site Members\*

**ZUMA 7: shows OS advantage (vs. SOC)**

**Figure 1: Overall Survival.** Shows an Kaplan-Meier estimate of overall survival among the patients who were randomly assigned to receive axicabtagene ciloleucel (Axi-Cel) or standard care. At a median follow-up of 43.2 months, death was reported in 83 patients in the Axi-Cel group and in 89 patients in the standard care group. The stratified two-sided P value was calculated by means of log-rank testing. Tick marks indicate data censoring. 95% denotes not estimable, and NR, not reached.

CULTIVATING EXCELLENCE: Bridging Perspectives in Oncology Care  
Westin JR, et al. N Engl J Med. 2023; Jun 5. doi: 10.1056/NEJMoa2301965.  
View abstract | PDF

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### ZUMA-7 subgroup analysis

**B Subgroup Analysis**

Subgroup	Axi-Cel no. of patients with events/deaths	Standard Care no. of patients with events/deaths	Hazard Ratio for Event or Death (95% CI)
Overall	186/180	144/179	0.49 (0.31-0.71)
Age			
<65 yr	81/129	96/132	0.49 (0.36-0.67)
≥65 yr	105/51	48/47	0.28 (0.16-0.46)
Response to First-Line Therapy at Randomization			
Primary refractory disease	81/111	106/113	0.41 (0.32-0.51)
Relapsed ≥12 mo after initiation or completion of first-line therapy	105/47	38/48	0.34 (0.20-0.55)
Second-line age-adjusted CR			
≥0 or 1	14/98	71/108	0.41 (0.28-0.58)
2 or 3	14/82	71/79	0.39 (0.27-0.55)
Prognostic marker according to central laboratory			
HGBL, double or triple-hit	15/61	21/25	0.38 (0.14-0.94)
Double-expressor lymphoma	35/57	50/62	0.42 (0.27-0.67)
Molecular subgroup according to central laboratory			
Central cancer B-cell-like	64/109	80/99	0.41 (0.29-0.57)
Activated B-cell-like	11/28	8/9	0.38 (0.09-1.72)
Unclassified	8/17	12/14	
Disease type according to investigator			
DLBCL, not otherwise specified	48/130	97/116	0.37 (0.27-0.52)
Legionell transformation from follicular lymphoma	80/19	26/27	0.31 (0.16-0.57)
HGBL, including rearrangement of MYC with BCL2 or BCL6 or both	21/43	16/27	0.47 (0.24-0.90)
Disease type according to central laboratory			
DLBCL	79/126	95/120	0.44 (0.32-0.60)
HGBL, including rearrangement of MYC with BCL2 or BCL6 or both	15/31	23/28	0.34 (0.14-0.93)
	0/0	0/1	0.2 (0.02-1.7)

Axi-Cel Better Standard Care Better

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Locke PL, et al. N Engl J Med. 2023;2023(04):040-049

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### Improved Overall Survival with Axicabtagene Ciloleucel Vs Standard of Care in Second-Line Large B-Cell Lymphoma Among the Elderly: A Subgroup Analysis of ZUMA-7

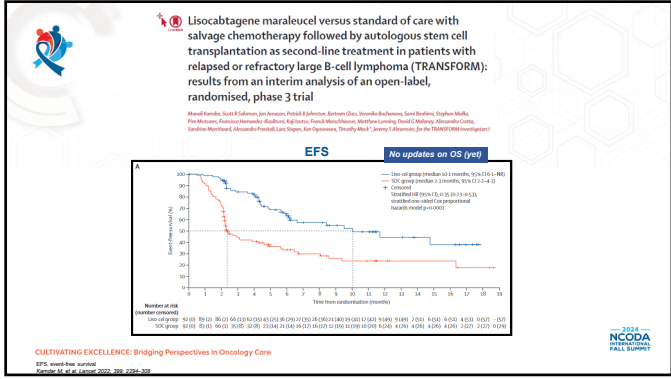
- 109 patients were included in analysis
- Axi-cel= 51; pts ≥65 yrs (≥70 y=26, max age=80 yrs)
- SOC= 58; pts ≥65 yrs (≥70 y=27, max age=81 yrs)

**Figure 1: Overall Survival of Axi-Cel vs Standard of Care Patients Aged ≥65 Years.** Shows an Kaplan-Meier estimate of overall survival among elderly patients who were randomly assigned to receive axicabtagene ciloleucel (Axi-Cel) or standard care. At a median follow-up of 43.2 months, death was reported in 26 patients in the Axi-Cel group and in 32 patients in the standard care group. The stratified two-sided P value was calculated by means of log-rank testing. Tick marks indicate data censoring. 95% denotes not estimable, and NR, not reached.

**Figure 2: Overall Survival of Axi-Cel vs Standard of Care Patients Aged ≥70 Years.** Shows an Kaplan-Meier estimate of overall survival among elderly patients who were randomly assigned to receive axicabtagene ciloleucel (Axi-Cel) or standard care. At a median follow-up of 43.2 months, death was reported in 11 patients in the Axi-Cel group and in 16 patients in the standard care group. The stratified two-sided P value was calculated by means of log-rank testing. Tick marks indicate data censoring. 95% denotes not estimable, and NR, not reached.

CULTIVATING EXCELLENCE: Bridging Perspectives in Oncology Care  
Hossein MZ, et al. Ann Oncol. 2023;34(10):1793

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**QUESTION 1**

Mr. J.M. is a 65 y/o old man who was diagnosed with stage IV diffuse large B cell lymphoma. He received front-line treatment with chemimmunotherapy and achieved a complete remission. Unfortunately, his disease relapsed within 9 months. Which of the following treatment options are **correct**?

- He can be treated with axicabtagene ciloleucei based on results of ZUMA-7 showing superior EFS compared to standard of care
- He can be treated with lisocabtagene maraleucei based on results of TRANSFORM showing superior EFS compared to standard of care
- He can be treated with tisagenlecleucel based on results of BELINDA showing superior EFS compared to standard of care
- A and B
- All of the above

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**Mantle Cell Lymphoma**

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# Follicular Lymphoma

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## Follicular Lymphoma: ZUMA-5

**New Anti-Bispecific Chimeric (Ax-Cel) B Cell Patients with Relapsed/Refractory Follicular Non-Hodgkin's Lymphoma: 4-Year Follow-up From the Phase 2 ZUMA-5 Trial**

Updated outcomes from ZUMA-5 after ≥4 years median follow-up

- 159 pts entered (127 FL; 31 MZL) and 152 treated with axi-cel (124 FL; 28 MZL)
- Median F/U 52.5 months (range, 20.3-69.4; FL: 53.7, MZL: 43.8)
- Median progression-free survival= 57.3 months (95%CI=34.9-NE)
  - 4-year PFS=52%
- Median overall survival (OS)= Not reached
  - 4-year OS=72%

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## Tisagenlecleucel in Adult Relapsed or Refractory Follicular Lymphoma: The Phase 2 ELARA Trial

N=87  
 Median prior therapies of 4 (2-13)  
 FLIPI high >=89.8%  
 Median F/U 9.9 months

Median OS not reached

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### Tisagenlecleucel in Adult Relapsed or Refractory Follicular Lymphoma: The Phase 2 ELARA Trial

**Table 2 | Best overall response in the EAS and per-protocol population\***

Parameter	Per-protocol set, n = 85		EAS, n = 94	
	Local assessment	IRC assessment	Local assessment	IRC assessment
Best overall response, n (%)				
CR	64 (75.3); 95% CI, 64.7-84.0	62 (72.9); 95% CI, 62.2-82.0	68 (72.3); 95% CI, 62.2-81.1	65 (69.1); 95% CI, 58.5-78.3
PR	14 (16.5)	12 (14.1)	17 (18.1)	16 (17.0)
SD	2 (2.4)	3 (3.5)	3 (3.2)	3 (3.2)
PD	5 (5.9)	8 (9.4)	6 (6.4)	9 (9.6)
LNK				1 (1.1)
Overall response rate (CR + PR), n (%)	78 (91.8); 95% CI, 83.8-96.6	74 (87.1); 95% CI, 78.0-93.4	85 (90.4); 95% CI, 82.6-95.5	81 (86.2); 95% CI, 77.5-92.4

\*The per-protocol set is a subset of patients in the primary analysis efficacy set with no major protocol deviations, LNK, unknown.

**CULTIVATING EXCELLENCE: Bridging Perspectives in Oncology Care**  
Frontier Natl. Natl. Med. 2021; Dec 17. doi: 10.1038/s41591-021-14622-0  
 Online ahead of print.



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### TRANSCEND FL: Phase 2 Study Results of Lisocabtagene Maraleucel (Liso-Cel) in Patients (Pts) with Relapsed/Refractory (R/R) Follicular Lymphoma (FL)


- R/R FL: 3L\* and 2L pts with progression within 24 months (POD24) of Dx and/or modified Groupe d'Etude des Lymphomes Foliculaires (GELF) criteria
- Liso-cel (100 x10<sup>6</sup> CAR+ T cells) after LD chemotherapy
- 1<sup>y</sup> endpoint ORR per IRC by PET/CT
- N of patients who underwent leukapheresis=139
  - N infused= 130
  - N evaluable for efficacy=124
  - Median age= 62 (23-80) years
  - High-risk FLIPI=57%
  - Median (range) prior lines of therapy= 3 (2-10)

**FDA grants accelerated approval to lisocabtagene maraleucel for follicular lymphoma**

On May 19, 2024, the Food and Drug Administration (FDA) granted accelerated approval to Lisocabtagene maraleucel (Liso-Cel) for the treatment of relapsed and refractory (R/R) follicular lymphoma (FL). Liso-Cel is a chimeric antigen receptor (CAR) T-cell therapy that targets CD19 on B cells. Liso-Cel is a first-in-class, off-the-shelf CAR T-cell therapy. Liso-Cel is a chimeric antigen receptor (CAR) T-cell therapy that targets CD19 on B cells. Liso-Cel is a first-in-class, off-the-shelf CAR T-cell therapy.

- Median F/U=18.9 (0.3-28.2) months
- Evaluable 3L\* pts=101
- ORR= 97%**
- CR=94.1%**

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March 2024; 7: 4. doi: 10.1001/ncoda.2023.0017-000  
 POC: <https://www.fda.gov/oc/press-releases/2024/03/19-fda-grants-accelerated-approval-lisocabtagene-maraleucel-follicular-lymphoma>. Accessed 7, October 2024.



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## Chronic Lymphocytic Leukemia

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CAR T-cell in CLL vs. other low grade lymphoid malignancies			
CAR T-cell product	CLL (TRANSCEND CLL004) <sup>1</sup> (N=23)	Follicular lymphoma (ZUMA 5) <sup>2</sup> (N=124)	Follicular lymphoma (ELARA) <sup>3</sup> (N=89)
CAR T-cell product	Lisocabtagene Maraleucel	Axicabtagene Ciloleucel	Tisagenlecleucel
Study type	Phase 1	Phase 2	Phase 2
ORR	82%	94%	87.1%
CR	45% ↓	79%	72.9%
PR	36%	15%	14.1%

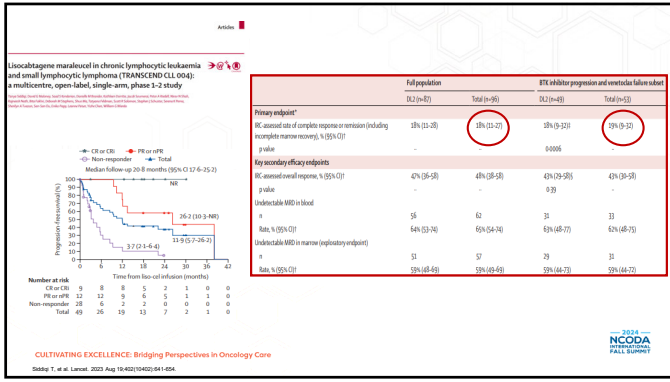
\*per protocol

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1. Steiner T, et al. Blood. 2022; 138(12):1794-1800  
 2. Swoboda KJ, et al. Lancet Oncol. 2022; 23(8):1041-1053  
 3. Paschos JP, et al. Blood. 2021; 137(20):2811-2821




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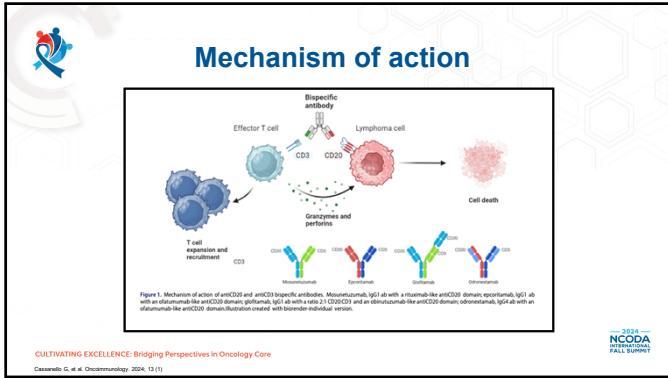
## Bispecifics in B-cell Lymphomas



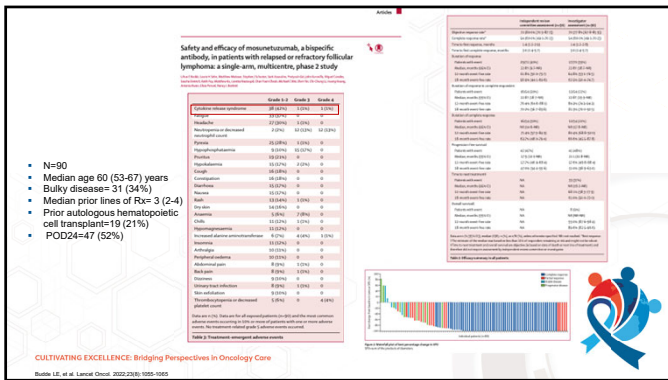
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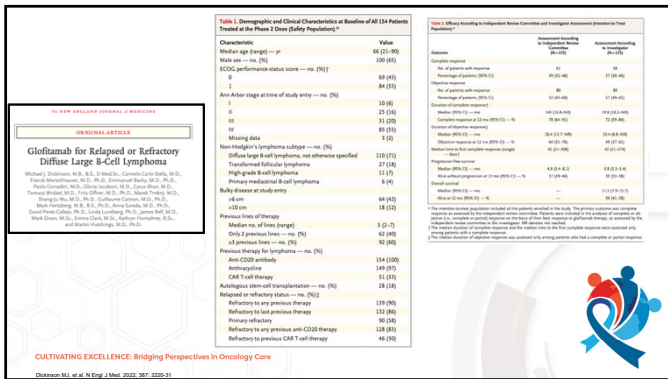
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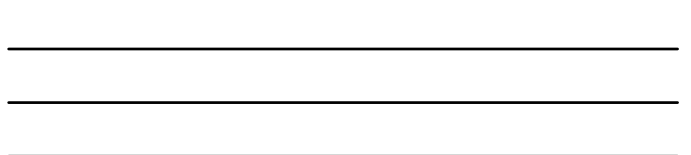
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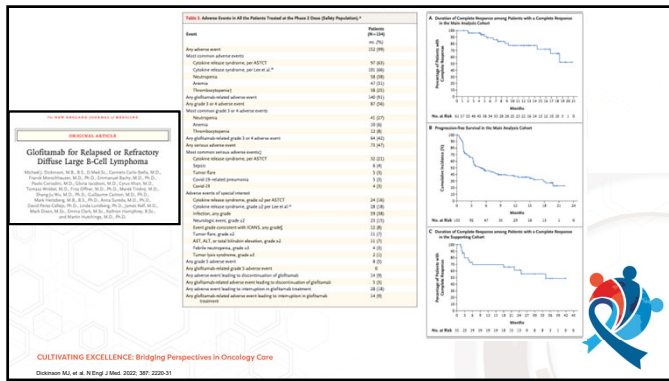


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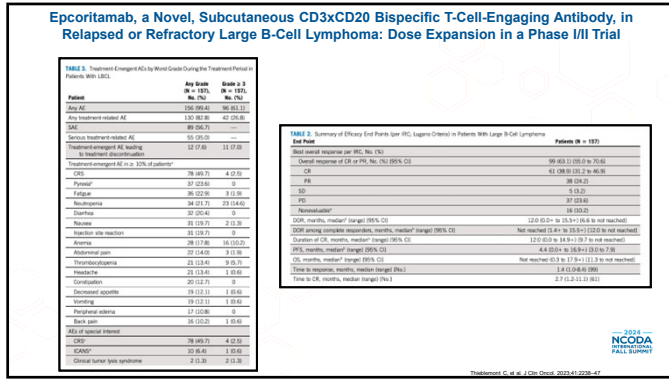


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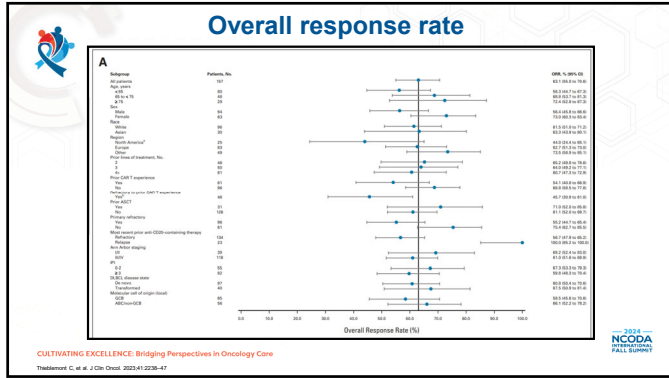




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## Challenges Associated with Delivery of Care with CAR T-Cell and Bispecific Therapies

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## Challenges associated with Rx delivery

<p><b>CAR T-Cell Therapy</b></p> <ul style="list-style-type: none"> <li>• Cost (approx. \$ 450,000)           <ul style="list-style-type: none"> <li>○ Parts without labor</li> </ul> </li> <li>• Complex logistics           <ul style="list-style-type: none"> <li>○ Limited number of centers</li> </ul> </li> <li>• Manufacturing takes time           <ul style="list-style-type: none"> <li>○ 14-28 days</li> </ul> </li> <li>• Short-term toxicities           <ul style="list-style-type: none"> <li>○ CRS, neurotoxicity</li> </ul> </li> <li>• Long-term toxicities           <ul style="list-style-type: none"> <li>○ Pancytopenia, 2<sup>nd</sup> malignancies</li> </ul> </li> </ul>	<p><b>Bispecifics</b></p> <ul style="list-style-type: none"> <li>• Cost (albeit apparently less costly)           <ul style="list-style-type: none"> <li>○ Epcoritamab 9 cycles=\$120,000               <ul style="list-style-type: none"> <li>▪ But usually prescribed until disease progression</li> </ul> </li> </ul> </li> <li>• No data on 2<sup>nd</sup> line setting</li> <li>• Transitioning pts from the inpatient to outpatient setting</li> <li>• Management of side effects in the community setting           <ul style="list-style-type: none"> <li>○ CRS, neurotoxicity</li> </ul> </li> </ul>
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Chen C, et al. J Clin Oncol. 2023;41(16):2406-2414. doi:10.1200/JCO.2022.41.16.2406

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## QUESTION 2

Which of the following statements is **incorrect**:

- a. Axicabtagene ciloleucel is approved in the second line setting in patients with diffuse large B-cell lymphoma
- b. Epcoritamab is a bispecific therapy approved in the second line setting in patients with diffuse large B-cell lymphoma
- c. T-cell cancers have been reported after CAR T-cell therapy
- d. Bispecifics are off-the shelf, providing an advantage for faster administration

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## Short-Term Toxicities

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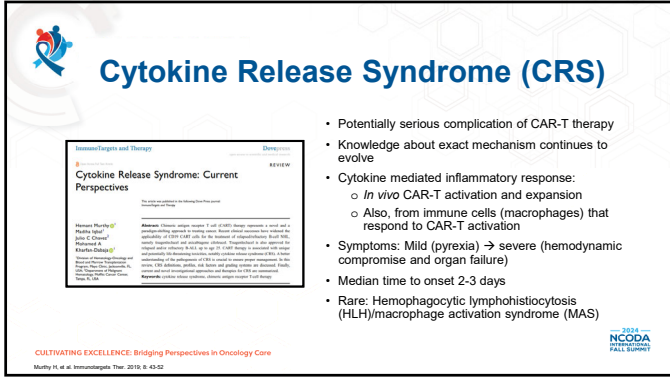
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## Cytokine Release Syndrome (CRS)

Immunofactors and Therapy

REVIEW

### Cytokine Release Syndrome: Current Perspectives

The review published in *Immunology Perspectives*

Authors: Thomas W. Heston, MD, PhD, Dana-Farber Cancer Institute; David C. Scharf, MD, Dana-Farber Cancer Institute; Michael A. Caligiuri, MD, Dana-Farber Cancer Institute; and others.

- Potentially serious complication of CAR-T therapy
- Knowledge about exact mechanism continues to evolve
- Cytokine mediated inflammatory response:
  - *In vivo* CAR-T activation and expansion
  - Also, from immune cells (macrophages) that respond to CAR-T activation
- Symptoms: Mild (pyrexia) → severe (hemodynamic compromise and organ failure)
- Median time to onset 2-3 days
- Rare: Hemophagocytic lymphohistiocytosis (HLH)/macrophage activation syndrome (MAS)

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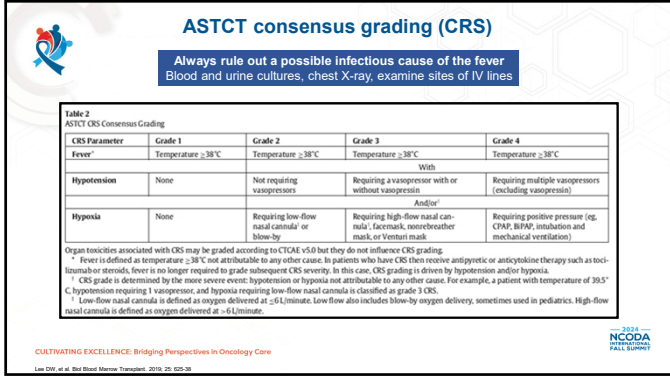
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## ASTCT consensus grading (CRS)

Always rule out a possible infectious cause of the fever  
Blood and urine cultures, chest X-ray, examine sites of IV lines

CRS Parameter	Grade 1	Grade 2	Grade 3	Grade 4
<b>Fever</b> <sup>1</sup>	Temperature $\geq 38^\circ\text{C}$	Temperature $\geq 38^\circ\text{C}$	Temperature $\geq 38^\circ\text{C}$	Temperature $\geq 38^\circ\text{C}$
<b>Hypotension</b>	None	Not requiring vasopressors	Requiring a vasopressor with or without vasopressin	Requiring multiple vasopressors (excluding vasopressin)
<b>Hypoxia</b>	None	Requiring low-flow nasal cannula <sup>2</sup> or blow-by	And/or <sup>3</sup> Requiring high-flow nasal cannula <sup>2</sup> , facemask, nonrebreather mask, or Venturi mask	Requiring positive pressure (eg, CPAP, BiPAP, intubation and mechanical ventilation)

Organ toxicities associated with CRS may be graded according to CTCAE v5.0 but they do not influence CRS grading.

<sup>1</sup> Fever is defined as temperature  $\geq 38^\circ\text{C}$  not attributable to any other cause. In patients who have CRS they receive antipyretic or anticytokine therapy such as tocilizumab or steroids, fever is no longer required to grade subsequent CRS severity. In this case, CRS grading is driven by hypotension and/or hypoxia.

<sup>2</sup> CRS grade is determined by the most severe event: hypotension or hypoxia not attributable to any other cause. For example, a patient with temperature of  $39.5^\circ\text{C}$ , hypotension requiring 1 vasopressor, and hypoxia requiring low-flow nasal cannula is classified as grade 3 CRS.

<sup>3</sup> Low-flow nasal cannula is defined as oxygen delivered at  $\leq 6\text{ L/minute}$ . Low flow also includes blow-by oxygen delivery, sometimes used in pediatrics. High-flow nasal cannula is defined as oxygen delivered at  $> 6\text{ L/minute}$ .

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## Neurotoxicity

- Generally, manifests as a toxic encephalopathy
  - Confusion, disorientation, difficulty finding words, etc.
  - In more severe cases, seizures, elevated intracranial pressure, cerebral edema
- May last few hours to several days
- It is generally reversible, although deaths have been reported
- Biphasic presentation
  - Phase 1: Days 0-5, may have concurrent CRS
  - Phase 2: After day +5, by then CRS has generally subsided
    - Onset can be later with certain CAR T-cells


**ASTCT Consensus Grading (ICE score\*)**

ICE

- Orientation:** orientation to year, month, city, hospital: 4 points
- Naming:** ability to name 3 objects (eg, point to clock, pen, button): 3 points
- Following commands:** ability to follow simple commands (eg, "Show me 2 fingers" or "Close your eyes and stick out your tongue"): 1 point
- Writing:** ability to write a standard sentence (eg, "Our national bird is the bald eagle"): 1 point
- Attention:** ability to count backwards from 100 by 10: 1 point

\*ICE: Immune Effector Cell-Associated Encephalopathy score

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Lee DW, et al. *Biol Blood Marrow Transplant*. 2019; 25: 625-30




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## ASTCT consensus Grading (ICANS\*)

Neurotoxicity Domain	Grade 1	Grade 2	Grade 3	Grade 4
<b>ICE score<sup>1</sup></b>	7-9	3-6	0-2	0 (patient is unresponsive and unable to perform ICE)
<b>Depressed level of consciousness<sup>2</sup></b>	Awake/alert spontaneously	Awake/alert to voice	Awake/alert only to tactile stimulus	Patient is unresponsive or requires vigorous or repeated tactile stimuli to arouse. Slurred or coma
<b>Seizure</b>	N/A	N/A	Any clinical seizure focal or generalized that involves eyelids or masticatory muscles or microconvulsive seizures on EEG that require with intervention.	Life-threatening prolonged seizure (> 5 min); or repetitive clinical or electrical seizures without return to baseline in between
<b>Motor findings<sup>3</sup></b>	N/A	N/A	N/A	Deep focal motor weakness such as hemiparesis or paraparesis
<b>Elevated ICP<sup>4</sup>/cerebral edema</b>	N/A	N/A	N/A	Diffuse cerebral edema on neuroimaging; decerebrate or decorticate posturing; or central (nerve 11 palsy; or papilloedema; or Cushing's triad

ICANS grade is determined by the most severe event (ICE score, level of consciousness, seizure, motor findings, raised ICP/cerebral edema) not attributable to any other cause; for example, a patient with an ICE score of 1 who has a generalized seizure is classified as grade 3 ICANS.  
 N/A indicates not applicable.  
 1. A patient with an ICE score of 0 may be classified as grade 3 ICANS if awake with global aphasia, but a patient with an ICE score of 0 may be classified as grade 4 ICANS if unresponsive.  
 2. Depressed level of consciousness should be attributable to no other cause (eg, no sedating medications).  
 3. Tremors and myoclonus associated with immune effector cell therapies may be graded according to CTCAE v5.0, but they do not influence ICANS grading.  
 4. Intracranial hemorrhage with or without associated edema is not considered a neurotoxicity feature and is excluded from ICANS grading. It may be graded according to CTCAE v5.0.

\*ICANS: Immune effector cell-associated neurotoxicity syndrome

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Lee DW, et al. *Biol Blood Marrow Transplant*. 2019; 25: 625-30




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## Future Implications with CAR T-Cell Therapy Failure and Bispecific Use after Long-Term Toxicity Exposure

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### Long-term toxicities

#### Cytopenia (CAR-to-penia)

- Duration of cytopenias post CAR T-cell therapy is variable, ranging from 14 to 180 days, sometimes longer
- Significant percentage experience persistent cytopenias lasting >30 days

- Infections
- Transfusion dependence
- Prolonged hospitalization
- Increased medical costs

CULTIVATING EXCELLENCE: Bridging Perspectives in Oncology Care  
Zhu F et al. Cell Therapies. 2022 Jan-Dec;25(10):1937-1954  
DOI: 10.1016/j.clt.2021.09.011



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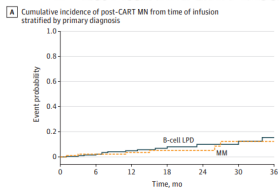
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### Features and Factors Associated with Myeloid Neoplasms after Chimeric Antigen Receptor T-Cell Therapy

**Incidence of myeloid neoplasm is comparable between LPD and MM**

- At 1-year=4%
- At 2-year=6%
- At 3-year=9%



CULTIVATING EXCELLENCE: Bridging Perspectives in Oncology Care  
Gomez M et al. JAMA Oncol. 2024;10(1):52-59



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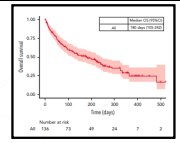
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### CAR T-cell therapy failure


- Dismal prognosis in general
  - Median overall survival after failing axicabtagene ciloleucel approximately 6 months

**TO THE EDITOR**  
**Outcomes of patients with large B-cell lymphoma progressing after axicabtagene ciloleucel therapy**

Singal F, Sengul F, Sengul S, et al. JAMA Oncol. 2021;17(11):1632-30



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Singal FJ et al. Blood. 2021;137(13):1632-30



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### Allogeneic Transplant following CAR T-cell Therapy for Large B-cell Lymphoma

• N=88  
 • Median age 54 (19-72) years  
 • 18 US centers

**Table 3. Multivariate analysis outcomes after allogeneic hematopoietic cell transplantation\***

	HR	95% CI	P
<b>Overall survival</b>			
Receptivity	0	0	0.93
ORR	0.94	1.02-0.83	
CR	0.76	0.70-0.83	
<b>Line of therapy between CAR-T and aBMT†</b>			
CR	1.16	0.76-1.77	0.52
ORR	0.82	0.63-1.07	
<b>Response status prior to aBMT</b>			
CR	4.92	1.81-12.9	0.01
ORR	1.02	0.73-1.43	
<b>Progression-free survival</b>			
Receptivity	HR	95% CI	P
ORR	1.16	0.76-1.77	0.52
CR	0.76	0.70-0.83	
<b>Line of therapy between CAR-T and aBMT†</b>			
CR	1.16	0.76-1.77	0.52
ORR	0.76	0.70-0.83	
<b>Response status prior to aBMT</b>			
CR	2.61	1.25-5.47	0.01
ORR	0.88	0.66-1.18	
<b>Non-relapse mortality</b>			
Receptivity	HR	95% CI	P
ORR	0.75	0.64-0.88	
CR	0.52	0.34-0.79	
<b>Line of therapy between CAR-T and aBMT†</b>			
CR	4.73	0.38-58.3	<0.001
ORR	1.02	0.59-1.75	
<b>Response status prior to aBMT</b>			
CR	4.92	1.81-12.9	0.01
ORR	0.87	0.62-1.23	
<b>Conditioning regimen</b>			
CR	0.25	0.17-0.37	
ORR	0.52	0.31-0.83	

\*CR, complete remission; ORR, overall response rate; aBMT, allogeneic hematopoietic cell transplantation; HR, hazard ratio. †CR, complete remission; ORR, overall response rate. The progression between CR prior response to CAR T-cell therapy and aBMT or CR prior response to CAR T-cell therapy.

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### What about bispecifics (CD3\*CD20) in the setting of post CAR T-cell failure

	Epcoritamab <sup>1</sup>	Glofitamab <sup>2</sup>
n CAR T failed/N total	61/157 (38.9%)	51/155 (31%)
ORR	54.1%	Not reported
CR	34.4%	35%
Median DOR	9.7 months	Not reported

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### Secondary Cancers after Chimeric Antigen Receptor T-Cell Therapy

As of 12-31-2023, the FDA had become aware of 22 cases of T-cell cancers that occurred after CAR-T product treatment. Such cancers include: T-cell lymphoma, T-cell LGL, PTCL, and CTCL.

Among 14 cases with data, cancers manifested within 2 years after CAR T cells (range, 1 to 19 months), with roughly half occurring within the 1<sup>st</sup> year

Some are still under investigation. In 3 cases for which genetic sequencing was performed, the CAR transgene was detected in the malignant clone

With > 27,000 doses of the 6 approved products having been administered in the USA, the overall rate of T-cell cancers is low (22/27,000=0.081%)

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**Do cutting-edge CAR-T-cell therapies cause cancer? What the data say**

Regulators have identified around 30 cases of cancer linked to this blockbuster treatment. But is CAR-T too hot? The heat is on for answers.

- The FDA has since documented more cases
- As of March 25<sup>th</sup>, 2024, the agency had received 33 reports of such lymphomas among some 30,000 people who had been treated (**33/30,000= 0.11%**)
- It now requires all CAR-T therapies to carry a boxed warning on the drug's packaging, which mentions that such cancers have occurred
- The European Medicines Agency has launched its own investigation

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### CAR T-cell therapy vs. Bispecifics (DLBCL)

	CAR T-cell	Bispecifics	Winner
Indications	2 <sup>nd</sup> line, 3 <sup>rd</sup> line	3 <sup>rd</sup> line	CAR T
Pre-treatment requirements	Complex (leukapheresis, LD)	<b>Simpler (off-the-shelf)</b>	Bispecifics
Rx. frequency	Single infusion	Multiple (months)	CAR T
Administration	Specialized centers	<b>Community setting possible</b>	Bispecifics
Lymphodepletion	Needed	<b>Not needed</b>	Bispecifics
CNS efficacy	Present, but limited	?	CAR T
IP vs. OP	Mostly IP (but doable OP)	<b>OP</b>	Bispecifics
Toxicities	+++	+	Bispecifics
Cost	+++	<b>++ (for up to 9 months)</b>	Bispecifics
Follow-up	Longer (5 <sup>+</sup> yrs)	Short	CAR T

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### QUESTION 3

Which of the following statements is incorrect?

- The incidence of neurotoxicity is higher with bispecifics compared to CAR T-cell
- The incidence of neurotoxicity is lower with bispecifics compared to CAR T-cell
- Bispecifics are off-the-shelf products whereas CAR T-cell require long-term manufacturing time of 14-28 days
- Bispecifics are more feasible for administration in the community setting

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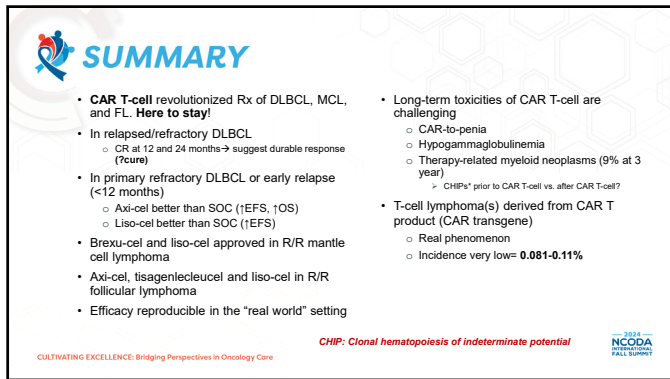
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**SUMMARY**

- **CAR T-cell** revolutionized Rx of DLBCL, MCL, and FL. **Here to stay!**
- In relapsed/refractory DLBCL
  - CR at 12 and 24 months → suggest durable response (7cure)
- In primary refractory DLBCL or early relapse (<12 months)
  - Axi-cel better than SOC (1EFS, 1OS)
  - Liso-cel better than SOC (1EFS)
- Brexu-cel and liso-cel approved in R/R mantle cell lymphoma
- Axi-cel, tisagenlecleucel and liso-cel in R/R follicular lymphoma
- Efficacy reproducible in the "real world" setting
- Long-term toxicities of CAR T-cell are challenging
  - CAR-to-penia
  - Hypogammaglobulinemia
  - Therapy-related myeloid neoplasms (9% at 3 year)
    - CHIPs\* prior to CAR T-cell vs. after CAR T-cell?
- T-cell lymphoma(s) derived from CAR T product (CAR transgene)
  - Real phenomenon
  - Incidence very low= **0.081-0.11%**

*CHIP: Clonal hematopoiesis of indeterminate potential*

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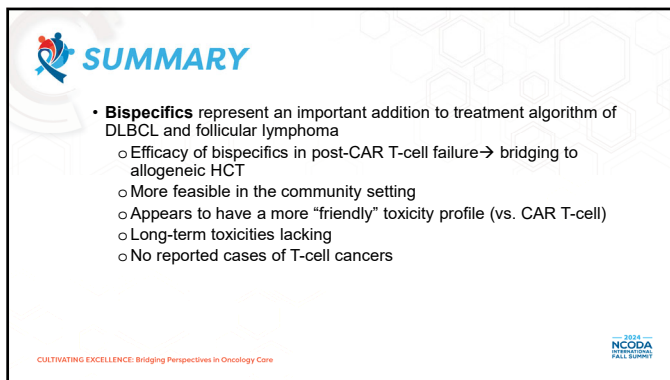
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**SUMMARY**

- **Bispecifics** represent an important addition to treatment algorithm of DLBCL and follicular lymphoma
  - Efficacy of bispecifics in post-CAR T-cell failure → bridging to allogeneic HCT
  - More feasible in the community setting
  - Appears to have a more "friendly" toxicity profile (vs. CAR T-cell)
  - Long-term toxicities lacking
  - No reported cases of T-cell cancers

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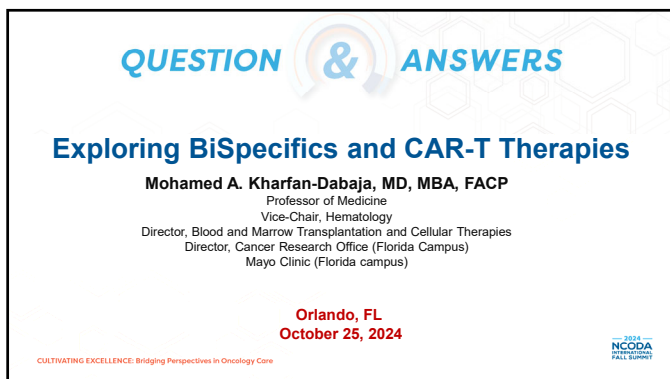
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**QUESTION & ANSWERS**

**Exploring BiSpecifics and CAR-T Therapies**

**Mohamed A. Kharfan-Dabaja, MD, MBA, FACP**  
 Professor of Medicine  
 Vice-Chair, Hematology  
 Director, Blood and Marrow Transplantation and Cellular Therapies  
 Director, Cancer Research Office (Florida Campus)  
 Mayo Clinic (Florida campus)

**Orlando, FL**  
**October 25, 2024**

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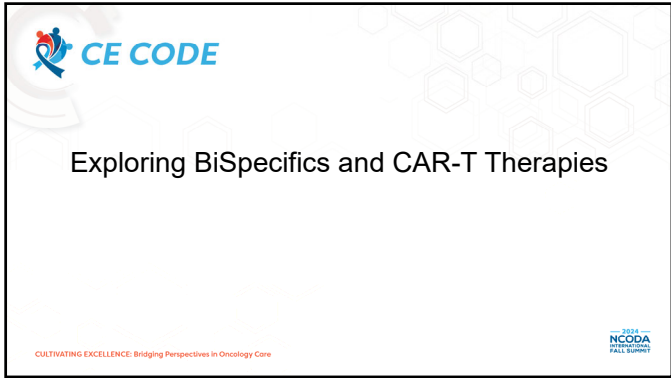
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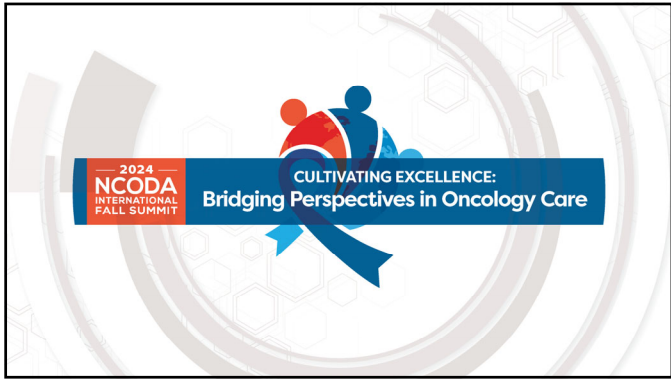
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