UTSouthwesternO'Donnell Brain Institute

Updates in Myasthenia Gravis

Shaida Khan, D.O.

Associate Professor

Department of Neurology
UT Southwestern Medical Center
Chief of Service, Neurology, Parkland Hospital



Disclosures

- UCB pharma advisory board & consultant
- NIH DSMB
- Gather-ed

• Some medications discussed are off-label



Clinical presentation

Incidence: 14-40/100,000 in US

Subtype	AchR+	MuSK+	LRP4+	Seronegative	LEMS
Relative prevalence	80%	4%	2%	5%	4%

Gilhus, Lancet Neurol, Oct 2015

15% OMG, 85% generalized MG (gMG)

1st sx onset usually **ocular** (2/3 of pts)

- Pattern of ext weakness: proximal, extensors
- Fluctuating, fatigable

elderly

men

young

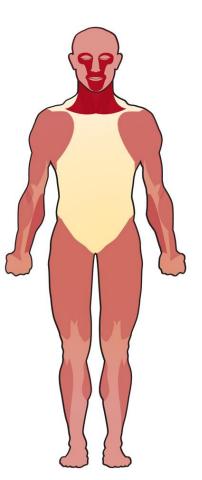
women

 Rarely distal weakness 1st sx – foot drop, wrist drop



Sanders D, Juel. V, J of Neuroimm, Sept 2008

Pt with MuSK+ MG



https://www.mda.org/disease/ myasthenia-gravis



Current MG immunotherapy treatments

Traditional Therapies

Thymectomy



Azathioprine

Prednisone

• Expert consensus & multiple RCT support *as* **1**st *line*

Mycophenolate Mofetil

Not supported by RCT, widely used

Cyclosporine/
Tacrolimus

- Not widely used, works faster
- †monitoring/side effect profile

Rituximab

 Refractory dz, BEAT-MG trial – no sig steroid-sparing effect for AchR+, helpful for MuSK+

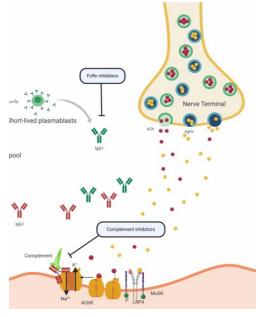
PLEX/IVIG

- Used for exacerbation/crisis
- Used for bridge/maintenance

Newer Therapies

Complement inhibitors					
	Antibody status	FDA approval	Maintenance schedule		
Eculizumab (IV)	AchR Ab (+)	2017	q 2 wks		
Ravalizumab (IV)	AchR Ab (+)	2022	q 8 wks		
Zilucoplan (SC)	AchR Ab (+)	2023	Daily		
Neonatal Fc Receptor Antagonists					
Efgartigimod (IV)	AchR Ab (+), seronegative	2021	Cycle: weekly x 4		
Efgartigimod alpha (SC)	AchR Ab (+), seronegative	2023	Cycle: weekly x 4		
Rozanolixizumab (SC)	AchR Ab (+), MuSK Ab (+), seronegative	2023	Cycle: weekly x 6		
Nipocalimab (IV)	AchR Ab (+), MuSK Ab (+)	2025 (12 yrs+)	Every other week		

Cemdisiran: *SC every 3 mon*, U.S. regulatory submission planned for 1st quarter of 2026, pending discussions with FDA

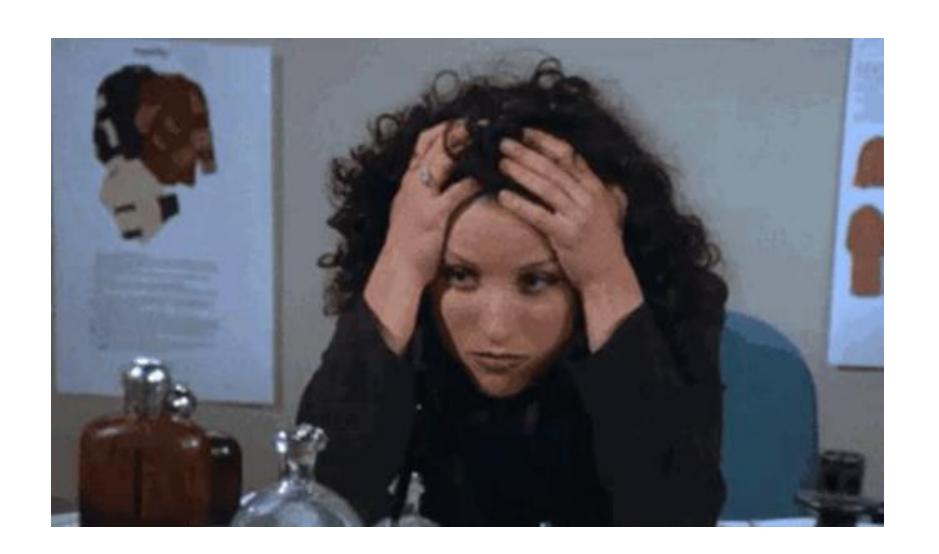


Fichtner et al, Front. Immunol, May 2020



MG drug pipeline

Agent / Therapy	Mechanism or Modality	Trial Phase & Details	Antibody / Pt Population	Estimated Timeline / Status
Cemdisiran	siRNA targeting complement factor C5 → reducing C5 / complement pathway activity	Phase 3 trial ("NIMBLE") in gMG	gMG (AChR+, general population)	Completed primary + key secondary endpoints; regulatory submission planned Q1 2026
Cemdisiran + Pozelimab	Dual complement inhibition (siRNA + antibody)	Part of same Phase 3 trial as above; combination arm	Same as above	Also met endpoints, nearly 99% inhibition of complement activity; comparative data vs monotherapy show monotherapy numerically better across endpoints
Iptacopan	Inhibitor of the alternative complement pathway via factor B inhibition	Phase 3 in AChR+ gMG on stable standard-of-care	AChR antibody+ gMG	Active/recruiting
Efgartigimod IV	FcRn blocker (antibody recycling dump)	"ADAPT SERON" - Phase 3	Seronegative gMG	Active & recruiting
Descartes-08	CAR T-cell therapy (engineered)	Phase 2b (Phase Ib/IIa) trial in gMG	gMG, heavily pretreated symptomatic patients	Reported sustained benefits through 12 mon post single 6-wk course; active & recruiting
Telitacicept	Dual targeting of BLyS/APRIL pathways → B cell / plasma cell modulation	Phase 3 trial in gMG	gMG (likely AChR+ or general)	Results shared in 2025; promising safety & efficacy
Uplizna (inebilizumab)	Anti-CD19 B cell depleter	Phase 3 ("MINT") trial in MG (AChR or MuSK Ab positive)	AChR+ or MuSK+ generalized MG	Active; looking at MG-ADL over 26/52 weeks
NMD670	Small molecule or novel immunomodulator (details less fully public)	Phase 2, dose-finding / proof-of-concept, multiple doses vs placebo	Adults with MG (AChR or MuSK positive)	Active & recruiting
MyClad (Oral Cladribine)	Immunosuppressant, lymphocyte depletion (a purine-analog)	Phase 3, randomized, placebo-controlled in gMG	gMG	Global trial; started dosing
RESET-MG (CABA-201)	Cell therapy (CABA-201) in gMG	Phase 1/2 open label; safety & efficacy evaluation	gMG, likely with standard criteria	Active & recruiting
MuSK-CAART	CAAR T therapy targeting MuSK autoantibody-producing B cells (Chimeric AutoAntigen Receptor T cells)	Phase 1 study (safety & dosing)	MuSK antibody-positive MG	Recruiting
CNP-106	Antigen-based / autoantigen encapsulated therapy. Possibly tolerization/resetting immune response rather than depletion	Phase 1b/2a (First-in-Human) study	gMG (adult 18-75)	Active & recruiting; safety, PD/efficacy endpoints
				UTSouthwestern Medical Center



MG goals of treatment

Individualized

- Good (consistent) disease control, minimal/no medication side effects
- Return to normal/near normal daily activities, work, social engagements

MGFA-Post Intervention Status (PIS)

- Minimal manifestation status (MMS) = no sx or functional limitation
 - Allows *mild* weakness on exam, can be on meds
- Remission (pharmacologic, complete stable): same, only allows eyelid closure weakness but no use of pyridostigmine

MG-ADL

Grade	0	1	2	3	Score
Talking	Normal	Intermittent slurring or nasal speech	Constant slurring or nasal, but can be understood	Difficult to understand speech	
Chewing	Normal	Fatigue with solid food	Fatigue with soft food	Gastric tube	
Swallowing	Normal	Rare episode of choking	Frequent choking necessitating changes in diet	Gastric tube	
Breathing	Normal	Shortness of breath with exertion	Shortness of breath at rest	Ventilator dependence	
Impairment of ability to brush teeth or comb hair	None	Extra effort, but no rest periods needed	Rest periods needed	Cannot do one of these functions	
Impairment of ability to arise from a chair	None	Mild, sometimes uses arms	Moderate, always uses arms	Severe, requires assistance	
Double vision	None	Occurs, but not daily	Daily, but not constant	Constant	
Eyelid droop	None	Occurs, but not daily	Daily, but not constant	Constant	
		1		Total Score:	Le

Initial presentation

Tx with Pyrido + IST

Improved

MMS, remission

De-escalation trial

Sustain for >1 year

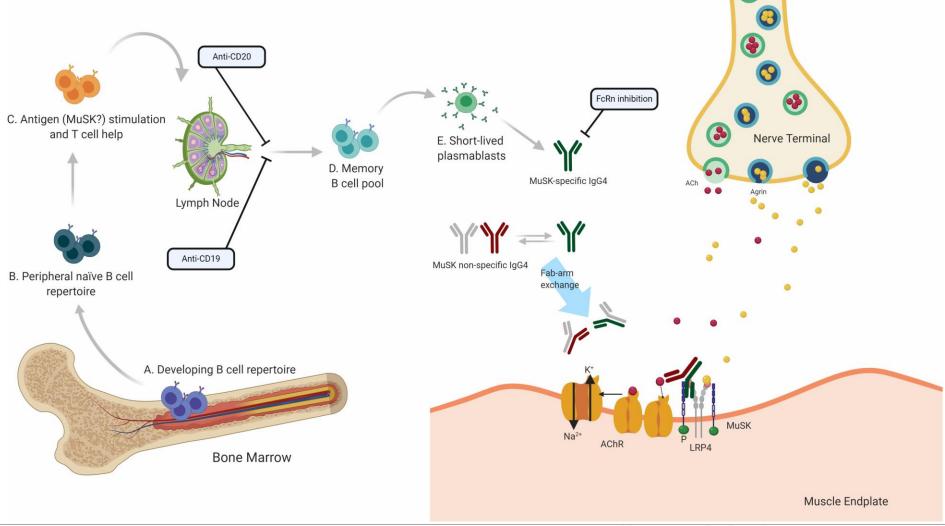


Targets of therapy – AChR+, seronegative Thymectomy Anti-CD20 FcRn inhibition C. Antigen (AChR?) stimulation Nerve Terminal and T cell help E. Short-lived plasmablasts Thymus D. Memory B cell pool F2. Long-lived Plasma cells, plasmablasts and memory cells Anti-CD19 B. Peripheral naïve B cell repertoire Complement Inhibitors Proteasome inhibitors Complement A. Developing B cell repertoire F1. Long-lived Plasma Bone Marrow Muscle Endplate

Neuromuscular Junction



Targets of therapy – MuSK+



C5 inhibitors

Clinical Trial > Lancet Neurol. 2017 Dec;16(12):976-986 doi: 10.1016/S1474-4422(17)30369-1. Epub 2017 Oct 20.

Safety and efficacy of eculizumab in antiacetylcholine receptor antibody-positive refractory generalised myasthenia gravis (REGAIN): a phase 3, randomised, double-blind, placebo-controlled, multicentre study

James F Howard Jr ¹, Kimiaki Utsugisawa ², Michael Benatar ³, Hiroyuki Murai ⁴, Richard J Barohn ⁵, Isabel Illa ⁶, Saiju Jacob ⁷, John Vissing ⁸, Ted M Burns ⁹, John T Kissel ¹⁰ Srikanth Muppidi ¹¹, Richard J Nowak ¹², Fanny O'Brien ¹³, Jing-Jing Wang ¹³, Renato Mantegazza ¹⁴; REGAIN Study Group

Eculizumab (Soliris)

- 26 wks, 125 pts
- IV Dosing loading x 4 weeks, 5th week higher dose, then **g 2 weeks**
- 4.2-point improvement in mean MG-ADL score from baseline → wk 26 in Ecu group vs 2.3-pt placebo (p=0.006)
- 4.6-point improvement in mean QMG
 score from baseline → wk 26 in Ecu group
 vs 1.6-pt placebo (p=0.0006)
- Most common adverse events: HA, URI

Clinical Trial > J Neurol. 2023 Aug;270(8):3862-3875. doi: 10.1007/s00415-023-11699-x. Epub 2023 Apr 27.

Long-term efficacy and safety of ravulizumab in adults with anti-acetylcholine receptor antibodypositive generalized myasthenia gravis: results from the phase 3 CHAMPION MG open-label extension

Andreas Meisel ¹, Djillali Annane ², Tuan Vu ³, Renato Mantegazza ⁴, Masahisa Katsuno ⁵, Rasha Aguzzi ⁶, Glen Frick ⁶, Laura Gault ⁶, James F Howard Jr ⁷; CHAMPION MG Study Group Affiliations + expand PMID: 37103755 PMCID: PMC10134722 DOI: 10.1007/s00415-023-11699-x

Ravulizumab (Ultomiris)

- 26 weeks, 175 pts
- IV Dosing loading, maintenance dose day 15, then <u>q 8 weeks</u>
- Significantly improved score from baseline to wk 26 in both MG-ADL + QMG scores in Rava group
 - MG-ADL [-3.1 vs. -1.4; p<0.001]
 - QMG [-2.8 vs. -0.8; p<0.001]
- Improvements in both measures MG-ADL + QMG, occurred within 1 wk of initiation, sustained through wk 26

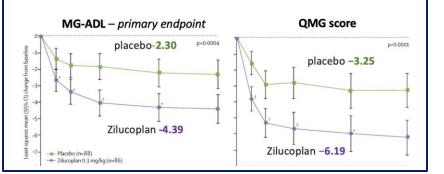
Clinical Trial > Lancet Neurol. 2023 May;22(5):395-406. doi: 10.1016/S1474-4422(23)00080-7.

Safety and efficacy of zilucoplan in patients with generalised myasthenia gravis (RAISE): a randomised, double-blind, placebo-controlled, phase 3 study

James F Howard Jr ¹, Saskia Bresch ², Angela Genge ³, Channa Hewamadduma ⁴, John Hinton ⁵, Yessar Hussain ⁶, Raul Juntas-Morales ⁷, Henry J Kaminski ⁸, Angelina Maniaol ⁹, Renato Mantegazza ¹⁰, Masayuki Masuda ¹¹, Kumaraswamy Sivakumar ¹², Marek Śmiłowski ¹³, Kimiaki Utsugisawa ¹⁴, Tuan Vu ¹⁵, Michael D Weiss ¹⁶, Małgorzata Zajda ¹⁷, Babak Boroojerdi ¹⁸, Melissa Brock ¹⁹, Guillemette de la Borderie ²⁰, Petra W Duda ²¹, Romana Lowcock ²², Mark Vanderkelen ²³, M Isabel Leite ²⁴; RAISE Study Team

Zilucoplan (Zilbrysq)

- 12 wks, 174 pts
- SC Dosing: 0.3 mg/kg once <u>daily</u> selfinjection. Small molecule peptide (3.5 kDa, 15-aa), 40x smaller than IgG
- Achieves significant clinical improvements
 within 1 wk → sustained 12 wks



Can a pt switch from IV to SC? Is it safe?



> Ther Adv Neurol Disord. 2025 Jul 5:18:17562864251347283. doi: 10.1177/17562864251347283 eCollection 2025.

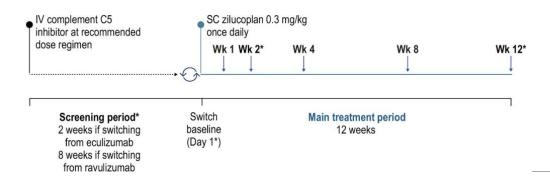
Switching to subcutaneous zilucoplan from intravenous complement component 5 inhibitors in generalised myasthenia gravis: a phase IIIb, openlabel study

Miriam Freimer ¹, Urvi Desai ², Raghav Govindarajan ³, Min K Kang ⁴, Shaida Khan ⁵, Bhupendra Khatri ⁶, Todd Levine ⁷, Samir Macwan ⁸, Perry B Shieh ⁹, Michael D Weiss ¹⁰, Jos Bloemers ¹¹, Babak Boroojerdi ¹², Eumorphia Maria Delicha ¹³, Andreea Lavrov ¹², Puneet Singh ¹⁴, James F Howard Jr ¹⁵

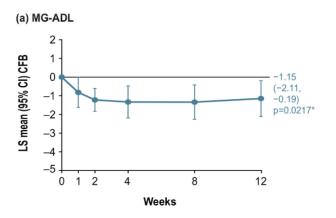
Affiliations + expand

PMID: 40620733 PMCID: PMC12228924 DOI: 10.1177/17562864251347283

- 26 pts clinically stable pts with gMG on IV C5 inhibitor who wanted to switch from IV to SC
 - 16 switched from Ecu, 10 from Rava

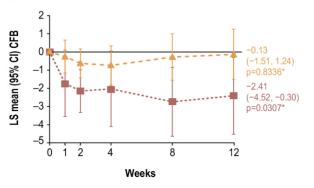


 TEAEs occurred in 19/26 (73%) pts, mostly mild in severity

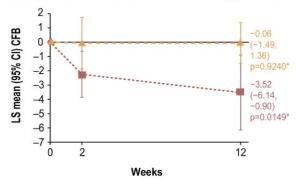


- At wk 12, MG-ADL & QMG scores improved from baseline (significant)
- Clinically meaningful improvement in mean MG-ADL & QMG scores observed at wk 12 from baseline among pts who switched from Rava

(b) MG-ADL (by prior IV complement C5 inhibitor; post hoc)



(d) QMG (by prior IV complement C5 inhibitor; post hoc)



At wk 12, **77%** (*n* = 20) **pts preferred SC injection** vs IV

Meningococcal vaccines

Recommendation for meningococcal vaccine at least 2 weeks prior to treatment for those receiving C5 inhibitor



SAMPLE VACCINATION SCHEDULE* VACCINE **PRIMARY VACCINATION BOOSTER VACCINATION MenACWY** 2 doses 1 dose every 5 years if risk remains (Menveo, at least 8 weeks apart MenQuadfi) 3 doses MenB-4C 1 dose 1 year following completion of primary 0, 1-2, and (Bexsero) series and every 2 to 3 years if risk remains 6 months apart OR 3 doses MenB-FHbp 1 dose 1 year following completion of primary 0. 1-2. and series and every 2 to 3 years if risk remains (Trumenba) 6 months apart

https://alexiononesource.com/

If drug must be started immediately, provide abx & administer vaccines as soon as possible

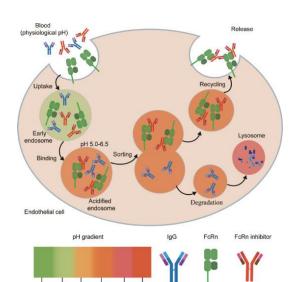


Safety and efficacy of nipocalimab in adults with generalised myasthenia gravis (Vivacity-MG3): a phase 3, randomised, double-blind, placebo-controlled study

Carlo Antozzi ¹, Tuan Vu ², Sindhu Ramchandren ³, Richard J Nowak ⁴,
Constantine Farmakidis ⁵, Vera Bril ⁶, Jan De Bleecker ⁷, Huan Yang ⁸, Eduard Minks ⁹,
Jin-Sung Park ¹⁰, Mariusz Grudniak ¹¹, Marek Smilowski ¹², Teresa Sevilla ¹³, Sarah Hoffmann ¹⁴,
Kumaraswamy Sivakumar ¹⁵, Yasushi Suzuki ¹⁶, Eriene Youssef ¹⁷, Panna Sanga ¹⁷,
Keith Karcher ¹⁸, Yaowei Zhu ¹⁷, John J Sheehan ¹⁹, Hong Sun ¹⁷; Vivacity-MG3 Study Group

Affiliations + expand

PMID: 39862879 DOI: 10.1016/S1474-4422(24)00498-8



Designed to binds to FcRn, reducing circulating IgG Ab levels, blocks IgG recycling

Nipocalimab

- MG-ADL score ≥6, Ab positive (AChR/MuSK/LRP4)
- Nipocalimab vs placebo IV infusions q 2 wks for 24 wks (added to standard-of-care therapy)
- 196 pts (98 in Nipo group, 98 in placebo group)
 - 153 were **Ab+** (77 in Nipo group & 76 in placebo)
- Primary endpoint: mean change in MG-ADL from baseline to wks 22, 23, & 24
- -4.70 in the Nipo group vs -3.25 in placebo (difference 1.45 [95% CI -2.38 to -0.52]; *p=0.0024*)
- Adverse events was similar btwn groups
- SAE reported for 9 (9%) of 98 pts in the nipocalimab group,
 14% of pts in the placebo group, 3 had a fatal outcome
 - Nipocalimab: MG crisis; placebo: cardiac arrest & MI



FcRN inhibitors

Efgartigimod (Vyvgart)

- Human IgG1 ab Fc-fragment
- 167 pts
 - 129 (77%) AchR ab+, 6 MuSK ab+
- 26 wks IV Dosing
 - 10 mg/kg weekly x 4 wks, repeated based on clinical response

68%

of AChR-Ab+ pts treated with efgart achieved primary endpoint compared w 29.7% on placebo (p<0.0001) 14%

of AChR-Ab+ pts pts
responded to efgart on
QMG score compared w
14% on placebo
(p<0.0001)

40%

of AChR-Ab+ pts treated with efgart achieved minimal symptom expression (MG-ADL 0 or 1), vs 11% placebo

Mean MG-ADL = 9

Efgartigimod alpha (Vyvgart Hytrulo)

- 6 mL <u>injection</u> over **30 90 sec**
- Clinical trial bridging study: Efgart IV & Efgart alfa SC (non-inferiority study)
- Essentially, outcomes same btwn both studies (MG-ADL, QMG, MSE) as well as SE
 - Injection site reaction (38% in SC group vs 1.8% in IV group)

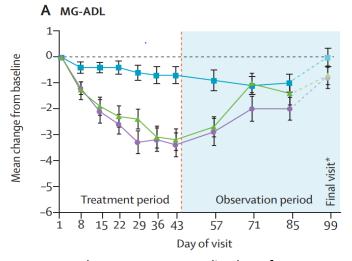
Overall Population MG-ADL (ADAPT-SC) Weaks Overall Population MG-ADL (ADAPT-SC) Baseline 1 2 3 4 5 6 7 8 10 Weeks

Adverse events: HA, nasopharyngitis

Rozanolixizumab (Rystiggo)

Humanized IgG4 ab Fc-fragment

- 200 pts
 - 179 (90%) AchR ab+, **21 (11%) MuSK** ab+
- SC infusions weekly x 6
 - Rozanolixizumab 7 mg/kg,
 Rozanolixizumab 10 mg/kg, or placebo



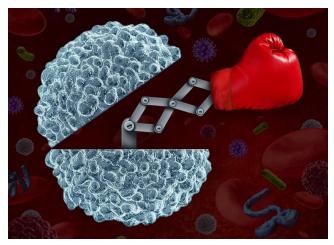
Adverse events: HA, diarrhea, fever

Emerging Therapies

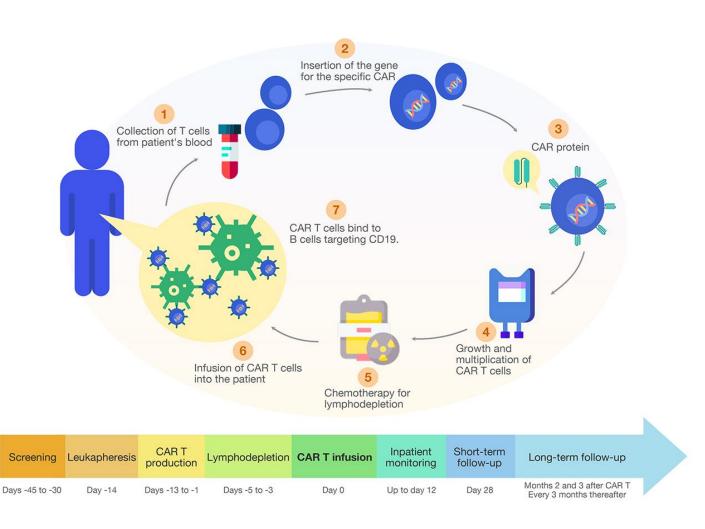
LYMPHOCYTE TARGETING THERAPIES

CAR-T

- Evolving
- Modifies pt's T-cells to target & eliminate the autoantibody-producing B cells driving the disease
- Suggested as a possible <u>cure</u>



www.nature.com/articles/d41591-023-00062-2





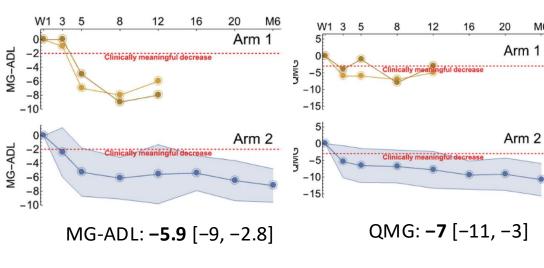
Emerging Therapies

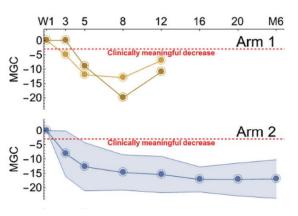
Safety and Efficacy of Autologous RNA Chimeric Antigen Receptor T-cell (rCAR-T) Therapy in Myasthenia Gravis: a prospective, multicenter, openlabel, non-randomised phase 1b/2a study

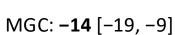
<u>Volkan Granit</u> ^{1,*}, <u>Michael Benatar</u> ^{1,*}, <u>Metin Kurtoglu</u> ², <u>Miloš D Miljković</u> ², <u>Nizar Chahin</u> ³, <u>Gregory Sahagian</u> ⁴, <u>Marc H Feinberg</u> ⁵, <u>Adam Slansky</u> ⁶, <u>Tuan Vu</u> ⁷, <u>Christopher M Jewell</u> ², <u>Michael S Singer</u> ², <u>Murat V Kalayoglu</u> ², <u>James F Howard Jr</u> ^{8,**}, <u>Tahseen Mozaffar</u> ^{9,**}; MG-001 Study Team

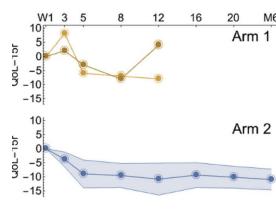
- ▶ Author information ▶ Copyright and License information
- PMCID: PMC10416207 NIHMSID: NIHMS1913712 PMID: 37353278
- Primary objective: establish safety & tolerability
- ❖ Secondary objectives: MG disease severity & biomarkers
- 14 pts
- Weekly infusions x 6 wks
- Common adverse events: HA, n/v, fever resolved within 24 hrs of infusion
- No dose-limiting toxicity, cytokine release syndrome, or neurotoxicity
 - 1 influenza, 1 drug-induced urticaria, 1 NSTEMI but deemed unrelated
- No pt showed evidence of functional immunosuppression (i.e. disappearance of therapeutic levels of vaccine titers)
- No opportunistic infections, no pts needed empiric Abx

Mean improvements from baseline to wk 12







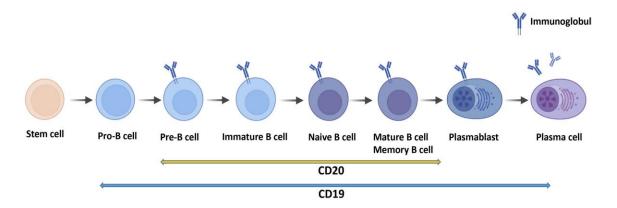


MG-QoL-15r: **-9** [-15, -3]

B cell depletion

MINT trial

- AchR or MuSK+ pts
- Inebilizumab monoclonal antibody that depletes CD19+
 B cells (broad B-cell lineage marker)



Depletes **plasmablasts** → **plasma cells** (plasma cells lack CD20, so Rituximab doesn't target this cell line)

Rituximab targets CD20, mature B cells only

Clinical Trial > N Engl J Med. 2025 Jun 19;392(23):2309-2320. doi: 10.1056/NEJMoa2501561. Epub 2025 Apr 8.

A Phase 3 Trial of Inebilizumab in Generalized Myasthenia Gravis

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Richard J Nowak <sup>1</sup>, Michael Benatar <sup>2</sup>, Emma Ciafaloni <sup>3</sup>, James F Howard Jr <sup>4</sup>, M Isabel Leite <sup>5</sup>, Kimiaki Utsugisawa <sup>6</sup>, John Vissing <sup>7</sup>, Mikhail Rojavin <sup>8</sup>, Qing Li <sup>8</sup>, Fengming Tang <sup>8</sup>, Yanping Wu <sup>8</sup>, Nishi Rampal <sup>8</sup>, Sue Cheng <sup>8</sup>; MINT Investigators
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PMID: 40202593 DOI: 10.1056/NEJMoa2501561

Collaborators, Affiliations + expand

- 238 participants (119 per group)
- 300 mg IV on days 1 & 15 for all, & additionally on day 183 for AChR+
 - 52 wks AchR+, 26 wks for MuSK+
- Steroid tapered starting wk 4, target 5 mg/day by wk 24
- Inebilizumab group: greater MG-ADL drop vs placebo (-4.2 vs. -2.2; adjusted difference, -1.9) at wk 26
- Greater reduction in QMG score vs placebo (-4.8 vs. -2.3; adjusted difference, -2.5)
- Most common adverse events: HA, cough, nasopharyngitis, infusion-related reactions, UTI



B cell depletion

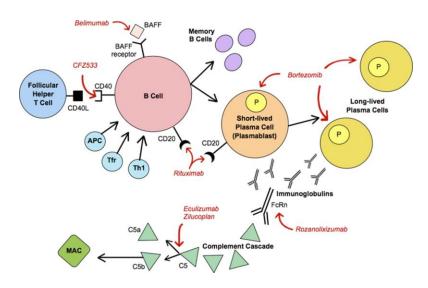
Clinical Trial > Eur J Neurol. 2024 Aug;31(8):e16322. doi: 10.1111/ene.16322. Epub 2024 May 10.

A multicenter, randomized, open-label, phase 2 clinical study of telitacicept in adult patients with generalized myasthenia gravis

Jian Yin ¹, Mingming Zhao ¹, Xianhao Xu ¹, Meini Zhang ², Zucai Xu ³, Zunbo Li ⁴, Xinyue Qin ⁵, Zhuyi Li ⁶, Chongbo Zhao ⁷, Hongyu Zhou ⁸, Ying Ma ⁹, Wenfeng Cao ¹⁰, Guoping Wang ¹¹ Yongzhong Lin 12, Jizhong Zhang 13, Xu Zhang 14, Hongbin Cai 15, Weidong Qian 16 Yiqi Wang ¹⁷, Xinghu Zhang ¹⁸, Guangzhi Liu ¹⁹, Jiawei Wang ²⁰, Wei Qiu ²¹, Liangiu Min ²², Jing Li 23, Hui Deng 24, Lan Chu 25, Yifan Zhang 25, Jianmin Fang 26

Affiliations + expand

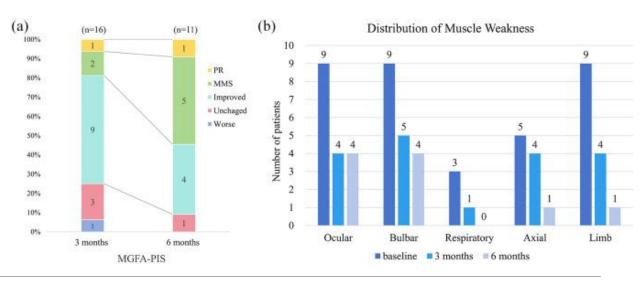
PMID: 38726639 PMCID: PMC11235933 DOI: 10.1111/ene.16322



Novel recombinant fusion protein targeting BAFF/APRIL -

Telitacicept

- Add on for refractory MG
- Effects seen at 3 mon, more at 6 mon significant reduction in both OMG & MG-ADL scores at 6 mon
 - More protracted therapeutic effect
- Enduring effect might be attributed to pharmacodynamics of BLyS-telitacicept complex --- prolonged formation & elimination times, continuing therapeutic effects well beyond active dosing period
- Able to reduce Prednisone dosage







A Phase 1 Study of Anitocabtagene Autoleucel for the Treatment of Subjects With Non-oncology Plasma Cell-related Diseases

ClinicalTrials.gov ID NCT06626919

Sponsor ① Arcellx, Inc.

Information provided by

Arcellx, Inc. (Responsible Party)

Last Update Posted 1 2025-08-01



Recruiting **i**

A Study of Telitacicept for the Treatment of Generalized Myasthenia Gravis (RemeMG)

Sponsor 1 RemeGen Co., Ltd.

Information provided by • RemeGen Co., Ltd. (Responsible Party)

Last Update Posted 1 2025-07-15



DISCUSSION

- **So many options** which class do I choose?
- What role do the "newer" agents have?
- Complement vs FcRN which one, when?
- Combo treatments?
- Predictive biomarkers for disease activity and/or treatment response?
 - Currently, treatment based only on clinical status + responses to treatment
- COST





Perpetual solace



Gena Brodie