



# Optimizing Outcomes in Late-Onset Pompe Disease:

Integrating New Therapies, Whole-Person Markers for Disease Monitoring, and Shared Decision-making Into Practice

## Suggested Readings

### A New Era of Understanding Pompe Disease

Ausems MG, Lochman P, van Diggelen OP, et al. A diagnostic protocol for adult-onset glycogen storage disease type II. *Neurology*. 1999;52:851-853. doi:10.1212/wnl.52.4.851

Bolano-Diaz C, Diaz-Manera J. Therapeutic options for the management of Pompe disease: current challenges and clinical evidence in therapeutics and clinical risk management. *Ther Clin Risk Manag*. 2022;18:1099-1115. doi:10.2147/TCRM.S334232

Buckley AF, Desai AK, Ha CI, et al. Outside the fiber: endomysial stromal and capillary pathology in skeletal muscle may impede infusion therapy in infantile-onset Pompe disease. *J Neuropathol Exp Neurol*. 2023;82:345-362. doi:10.1093/jnen/nlad012

Carlier R-Y, Laforet P, Wary C, et al. Whole-body muscle MRI in 20 patients suffering from late onset Pompe disease: involvement patterns. *Neuromuscul Disord*. 2011;21:791-799. doi: 10.1016/j.nmd.2011.06.748

Carlier PG, Azzabou N, de Sousa PL, et al. Skeletal muscle quantitative nuclear magnetic resonance imaging follow-up of adult Pompe patients. *J Inherit Metab Dis*. 2015;38:565-572. doi:10.1007/s10545-015-9825-9

Cocanougher BT, Huggins E, Kishnani P. GSD II and two: a case series of Pompe disease with coexisting genetic diagnoses. Presented at: 19th Annual *WORLD Symposium*; February 22-26, 2023; Orlando, FL. Poster 174.

Fukuda T, Ewan L, Bauer M, et al. Dysfunction of endocytic and autophagic pathways in a lysosomal storage disease. *Ann Neurol*. 2006;59:700-708. doi:10.1002/ana.20807

Herbert M, Case LE, Rairikar M, et al. Early-onset of symptoms and clinical course of Pompe disease associated with the c.-32-13 T > G variant. *Mol Genet Metab*. 2019;126:106-116. doi:10.1016/j.ymgme.2018.08.009

Hobson-Webb LD, Jones HN, Kishnani PS. Oropharyngeal dysphagia may occur in late-onset Pompe disease, implicating bulbar muscle involvement. *Neuromuscul Disord*. 2013;23:319-323. doi:10.1016/j.nmd.2012.12.003

Jackson DG, Case LE, Huggins E, et al. Muscle ultrasound in patients with late-onset Pompe disease identified by newborn screening. *Mol Genet Metab Rep*. 2023;36:100989. doi:10.1016/j.ymgmr.2023.100989

Keeler AM, Liu D, Zieger M, et al. Airway smooth muscle dysfunction in Pompe (*Gaa*<sup>-/-</sup>) mice. *Am J Physiol Lung Cell Mol Physiol*. 2017;312:L873-L881. doi:10.1152/ajplung.00568.2016

Khan AA, Boggs T, Bowling M, et al. Whole-body magnetic resonance imaging in late-onset Pompe disease: clinical utility and correlation with functional measures. *J Inherit Metab Dis*. 2020;43:549-557. doi:10.1002/jimd.12190

Khan AA, Case LE, Herbert M, et al. Higher dosing of alglucosidase alfa improves outcomes in children with Pompe disease: a clinical study and review of the literature. *Genet Med*. 2020;22:898-907. doi:10.1038/s41436-019-0738-0

Kishnani PS, Beckemeyer AA, Mendelsohn NJ. The new era of Pompe disease: advances in the detection, understanding of the phenotypic spectrum, pathophysiology, and management. *Am J Med Genet Part C Semin Med Genet*. 2012;160C:1-7. doi:10.1002/ajmg.c.31324

Labella B, Cotti Piccinelli S, Risi B, et al. A comprehensive update on late-onset Pompe disease. *Biomolecules*. 2023;13:1279. doi:10.3390/biom13091279

Labrousse P, Chien Y-H, Pomponio RJ, et al. Genetic heterozygosity and pseudodeficiency in the Pompe disease newborn screening pilot program. *Mol Genet Metab*. 2010;99:379-383. doi:10.1016/j.ymgme.2009.12.014

Laforêt P, Nicolino M, Eymard PB, et al. Juvenile and adult-onset acid maltase deficiency in France: genotype-phenotype correlation. *Neurology*. 2000;55:1122-1128. doi:10.1212/wnl.55.8.1122

Laforêt P, Petiot P, Nicolino M, et al. Dilative arteriopathy and basilar artery dolichoectasia complicating late-onset Pompe disease. *Neurology*. 2008;70:2063-2066. doi:10.1212/01.wnl.0000313367.09469.13

McNamara ER, Austin S, Case L, et al. Expanding our understanding of lower urinary tract symptoms and incontinence in adults with Pompe disease. *JIMD Rep*. 2015;20:5-10. doi:10.1007/8904\_2014\_381

Müller-Felber W, Horvath R, Gempel K, et al. Late onset Pompe disease: clinical and neurophysiological spectrum of 38 patients including long-term follow-up in 18 patients. *Neuromuscul Disord*. 2007;17:698-706. doi:10.1016/j.nmd.2007.06.002

Peruzzo P, Pavan E, Dardis A. Molecular genetics of Pompe disease: a comprehensive overview. *Ann Transl Med*. 2019;7:278. doi:10.21037/atm.2019.04.13

Prater SN, Patel TT, Buckley AF, et al. Skeletal muscle pathology of infantile Pompe disease during long-term enzyme replacement therapy. *Orphanet J Rare Dis*. 2013;8:90. doi:10.1186/1750-1172-8-90

Raben N, Roberts A, Poltz PH. Role of autophagy in the pathogenesis of Pompe disease. *Acta Myol.* 2007;26:45-48.

Raben N, Wong A, Ralston E, et al. Autophagy and mitochondria in Pompe disease: nothing is so new as what has long been forgotten. *Am J Med Genet C Semin Med Genet.* 2012;160C:13-21. doi:10.1002/ajmg.c.31317

Rairikar MV, Case LE, Bailey LA, et al. Insight into the phenotype of infants with Pompe disease identified by newborn screening with the common c.-32-13T>G "late-onset" GAA variant. *Mol Genet Metab.* 2017;122:99-107. doi:10.1016/j.ymgme.2017.09.008

Stevens D, Milani-Nejad S, Mozaffar T. Pompe disease: a clinical, diagnostic, and therapeutic overview. *Curr Treat Options Neurol.* 2022;24:573-588. doi:10.1007/s11940-022-00736-1

Thurberg BL, Maloney CL, Vaccaro C, et al. Characterization of pre- and post-treatment pathology after enzyme replacement therapy for Pompe disease. *Lab Invest.* 2006;86:1208-1220. doi:10.1038/labinvest.3700484

Young SP, Piraud M, Goldstein JL, et al. Assessing disease severity in Pompe disease: the roles of a urinary glucose tetrasaccharide biomarker and imaging techniques. *Am J Med Genet C Semin Med Genet.* 2012;160C:50-58. doi:10.1002/ajmg.c.31320

### **Evaluating the Utility of Next-generation LOPD-Modifying Therapy**

Amalfitano A, Bengur AR, Morse RP, et al. Recombinant human acid alpha-glucosidase enzyme therapy for infantile glycogen storage disease type II: results of a phase I/II clinical trial. *Genet Med.* 2001;3:132-138.

Bhengu L, Davidson A, du Toit P, et al. Diagnosis and management of Pompe disease. *S Afr Med J.* 2014;104:273-274. doi:10.7196/samj.7386

Chien Y-H, Lee NC, Chen CA, et al. Long-term prognosis of patients with infantile-onset Pompe disease diagnosed by newborn screening and treated since birth. *J Pediatr.* 2015;166:985-991.e1-2. doi:10.1016/j.jpeds.2014.10.068

Diaz-Manera J, Kishnani PS, Kushlaf H, et al. Safety and efficacy of avalglucosidase alfa versus alglucosidase alfa in patients with late-onset Pompe disease (COMET): a phase 3, randomised, multicentre trial. *Lancet Neurol.* 2021;20:1012-1026. doi:10.1016/S1474-4422(21)00241-6

Do HV, Khanna R, Gotschall R. Challenges in treating Pompe disease: an industry perspective. *Ann Transl Med.* 2019;7:291. doi:10.21037/atm.2019.04.15

Fratantoni JC, Hall CW, Neufeld EF. Hurler and Hunter syndromes: mutual correction of the defect in cultured fibroblasts. *Science.* 1968;162:570-572. doi:10.1126/science.162.3853.570

Gutschmidt K, Musumeci O, Díaz-Manera J, et al. STIG study: real-world data of long-term outcomes of adults with Pompe disease under enzyme replacement therapy with alglucosidase alfa. *J Neurol*. 2021;268:2482-2492. doi:10.1007/s00415-021-10409-9

Kishnani PS, Corzo D, Nicolino M, et al. Recombinant human acid [alpha]-glucosidase: major clinical benefits in infantile-onset Pompe disease. *Neurology*. 2007;68:99-109. doi:10.1212/01.wnl.0000251268.41188.04

Kishnani P, et al. Avalglucosidase alfa improves health-related quality of life (HRQoL) in patients with late-onset Pompe disease (LOPD) vs. alglucosidase alfa: patient-reported outcome measures (PROMs) from the phase 3 COMET trial. Presented virtually at: 18th Annual *WorldSymposium*; February 7-11, 2022. Abstract LB-37.

Kishnani P, et al. Efficacy and safety of avalglucosidase alfa in participants with late-onset Pompe disease after 145 weeks of treatment during the COMET trial. Presented at: 19th Annual *WORLDSymposium*; February 22-26, 2023; Orlando, FL. Abstract 202.

Kuperus E, Kruijshaar ME, Wens SCA, et al. Long-term benefit of enzyme replacement therapy in Pompe disease: a 5-year prospective study. *Neurology*. 2017;89:2365-2373. doi:10.1212/WNL.0000000000004711

Moreland RJ, Jin X, Zhang XK, et al. Lysosomal acid alpha-glucosidase consists of four different peptides processed from a single chain precursor. *J Biol Chem*. 2005;280:6780-6791. doi:10.1074/jbc.M404008200

Núñez-Peralta C, Alonso-Pérez J, Llauger J, et al. Follow-up of late-onset Pompe disease patients with muscle magnetic resonance imaging reveals increase in fat replacement in skeletal muscles. *J Cachexia Sarcopenia Muscle*. 2020;11:1032-1046. doi:10.1002/jcsm.12555

Patel TT, Banugaria SG, Case LE, et al. The impact of antibodies in late-onset Pompe disease: a case series and literature review. *Mol Genet Metab*. 2012;106:301-309. doi:10.1016/j.ymgme.2012.04.027

Puertollano R, Raben N. Pompe disease: how to solve many problems with one solution. *Ann Transl Med*. 2018;6:313. doi:10.21037/atm.2018.06.52

Regnery C, Kornblum C, Hanisch F, et al. 36 months observational clinical study of 38 adult Pompe disease patients under alglucosidase alfa enzyme replacement therapy. *J Inherit Metab Dis*. 2012;35:837-845. doi:10.1007/s10545-012-9451-8

Schooser B, Bilder DA, Dimmock D, et al. The humanistic burden of Pompe disease: are there still unmet needs? A systematic review. *BMC Neurol*. 2017;17:202. doi:10.1186/s12883-017-0983-2

Schooser B, Stewart A, Kanters S, et al. Survival and long-term outcomes in late-onset Pompe disease following alglucosidase alfa treatment: a systematic review and meta-analysis. *J Neurol*. 2017;264:621-630. doi:10.1007/s00415-016-8219-8

Schooser B. Pompe disease: what are we missing? *Ann Transl Med*. 2019;7:292. doi:10.21037/atm.2019.05.29

Schoaser B, Roberts M, Byrne BJ, et al. Safety and efficacy of cipaglucosidase alfa plus miglustat versus alglucosidase alfa plus placebo in late-onset Pompe disease (PROPEL): an international, randomised, double-blind, parallel-group, phase 3 trial. *Lancet Neurol.* 2021;20:1027-1037. doi:10.1016/S1474-4422(21)00331-8

Schoaser B, et al. Long-term efficacy and safety of cipaglucosidase alfa/miglustat in ambulatory patients with Pompe disease: a phase III open-label extension study (ATB200-07). Presented at: 19th Annual WORLDSymposium; February 22-26, 2023; Orlando, FL. Abstract LB-59.

Semplicini C, De Antonio M, Taouagh N, et al. Long-term benefit of enzyme replacement therapy with alglucosidase alfa in adults with Pompe disease: prospective analysis from the French Pompe Registry. *J Inherit Metab Dis.* 2020;43:1219-1231. doi:10.1002/jimd.12272

Stepien KM, Hendriksz CJ, Roberts M, et al. Observational clinical study of 22 adult-onset Pompe disease patients undergoing enzyme replacement therapy over 5 years. *Mol Genet Metab.* 2016;117:413-418. doi:10.1016/j.ymgme.2016.01.013

Thurberg BL, Maloney CL, Vaccaro C, et al. Characterization of pre- and post-treatment pathology after enzyme replacement therapy for Pompe disease. *Lab Invest.* 2006;86:1208-1220. doi:10.1038/labinvest.3700484

van der Meijden JC, Kruijshaar ME, Harlaar L, et al. Long-term follow-up of 17 patients with childhood Pompe disease treated with enzyme replacement therapy. *J Inherit Metab Dis.* 2018;41:1205-1214. doi:10.1007/s10545-018-0166-3

van der Ploeg AT, Kroos MA, Willemsen R, et al. Intravenous administration of phosphorylated acid alpha-glucosidase leads to uptake of enzyme in heart and skeletal muscle of mice. *J Clin Invest.* 1991;87:513-518. doi:10.1172/JCI115025

van der Ploeg AT, Clemens PR, Corzo D, et al. A randomized study of alglucosidase alfa in late-onset Pompe's disease. *N Engl J Med.* 2010;362:1396-1406. doi:10.1056/NEJMoa0909859

van der Ploeg AT, Barohn R, Carlson L, et al. Open-label extension study following the Late-Onset Treatment Study (LOTS) of alglucosidase alfa. *Mol Genet Metab.* 2012;107:456-461. doi:10.1016/j.ymgme.2012.09.015

Van Hove JL, Yang HW, Wu JY, et al. High-level production of recombinant human lysosomal acid alpha-glucosidase in Chinese hamster ovary cells which targets to heart muscle and corrects glycogen accumulation in fibroblasts from patients with Pompe disease. *Proc Natl Acad Sci U S A.* 1996;93:65-70. doi:10.1073/pnas.93.1.65

Wenk J, Hille A, von Figura K. Quantitation of Mr 46000 and Mr 300000 mannose 6-phosphate receptors in human cells and tissues. *Biochem Int.* 1991;23:723-731.

Xu S, Lun Y, Frascella M, et al. Improved efficacy of a next-generation ERT in murine Pompe disease. *JCI Insight.* 2019;4:e125358. doi:10.1172/jci.insight.125358

Zhou Q, Stefano JE, Harrahy J, et al. Strategies for Neoglycan conjugation to human acid  $\alpha$ -glucosidase. *Bioconjug Chem.* 2011;22:741-751. doi:10.1021/bc1005416