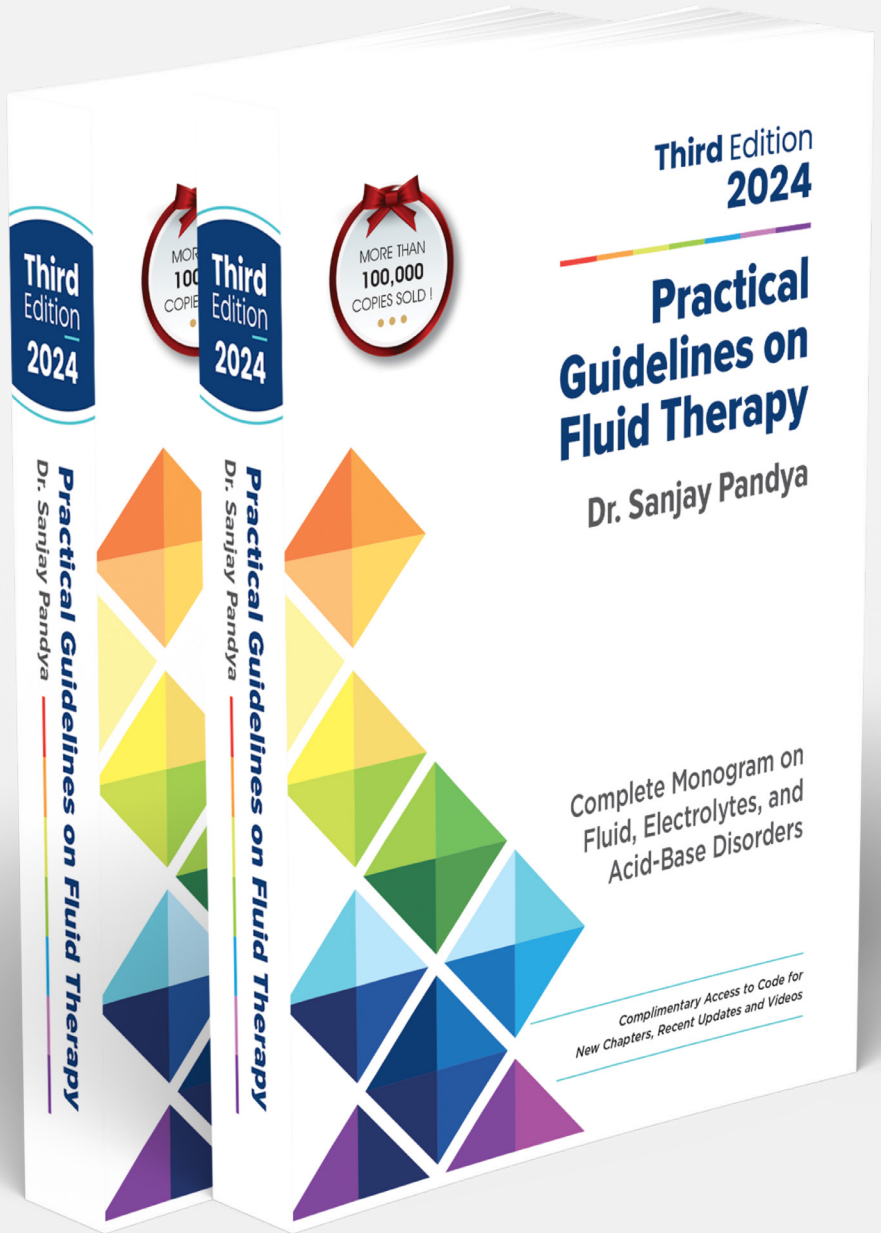
fluid therapy.org

Chapter 23:
Hyperkalemia



To get a copy of the book, visit: **www.fluidtherapy.org**

Fluid therapy.org

Table of Contents

23 Hyperkalemia

A serum potassium level greater than 5.5 mEq/L is considered hyperkalemia. The incidence of hyperkalemia is very low in the general population but increases in patients with chronic kidney disease (CKD), heart failure, diabetes and in patients receiving renin-angiotensin-aldosterone system inhibitor (RAASi) treatment [1–5]. Hyperkalemia is a potentially life-threatening electrolyte disorder associated with significantly increased hospitalizations, cardiovascular events, and all-cause mortality [6–9]. In addition, acute severe hyperkalemia is a potentially dangerous problem that can cause cardiac arrhythmias leading to cardiac arrest and death.

ETIOLOGY

The most common causes of hyperkalemia are renal dysfunction (acute or chronic), medication causing impaired potassium excretion, diabetes mellitus, cell lysis (rhabdomyolysis, tumor lysis syndrome, massive hemolysis), and pseudohyperkalemia [10]. The causes of hyperkalemia based on its mechanism of development are summarized in Table 23.1.

CKD is the most common risk factor for hyperkalemia, and hyperkalemia is the most common electrolyte disturbance in CKD [11, 12]. Furthermore, as CKD advances, the prevalence of hyperkalemia increases [3, 13].

A. Drug-induced hyperkalemia

Various drugs interfere with potassium homeostasis and can cause hyperkalemia by affecting renal potassium excretion, inhibiting the renin-angiotensin-aldosterone system, or promoting the transcellular potassium shift from intracellular fluid (ICF) to extracellular fluid (ECF) compartment (Table 23.2. Drug-induced hyperkalemia) [10, 14, 15].

REFERENCES

1. Nilsson E, Gasparini A, Ärnlöv J, et al. Incidence and determinants of hyperkalemia and hypokalemia in a large healthcare system. Int J Cardiol. 2017;245:277–284.
2. Betts KA, Woolley JM, Mu F, et al. The prevalence of hyperkalemia in the United States. Curr Med Res Opin. 2018;34(6):971–978.
3. Belmar Vega L, Galabia ER, Bada da Silva J, et al. Epidemiology of hyperkalemia in chronic kidney disease. Nefrologia (Engl Ed). 2019;39(3):277–286.
4. Kashihara N, Kohsaka S, Kanda E, et al. Hyperkalemia in real-world patients under continuous medical care in Japan. Kidney Int Rep. 2019;4(9):1248–60.
5. Palmer BF, Carrero JJ, Clegg DJ, et al. Clinical Management of Hyperkalemia. Mayo Clin Proc. 2021;96(3):744–762.
6. Kovesdy CP, Matsushita K, Sang Y, et al. CKD Prognosis Consortium. Serum potassium and adverse outcomes across the range of kidney function: a CKD Prognosis Consortium meta-analysis. Eur Heart J. 2018;39(17):1535–1542.
7. Hoppe LK, Muhlack DC, Koenig W, et al. Association of Abnormal Serum Potassium Levels with Arrhythmias and Cardiovascular Mortality: A Systematic Review and Meta-Analysis of Observational Studies. Cardiovasc Drugs Ther. 2018;32(2):197–21.
8. Cooper LB, Benson L, Mentz RJ et al. Association between potassium level and outcomes in heart failure with reduced ejection fraction: a cohort study from the Swedish Heart Failure Registry. Eur J Heart Fail 2020;22(8):1390–1398.
9. Hougen I, Leon SJ, Whitlock R, et al. Hyperkalemia and its Association with Mortality, Cardiovascular Events, Hospitalizations, and Intensive Care Unit Admissions in a Population-Based Retrospective Cohort. Kidney Int Rep. 2021;6(5):1309–1316.
10. Hunter RW, Bailey MA. Hyperkalemia: pathophysiology, risk factors and consequences. Nephrol Dial Transplant. 2019;34(Suppl 3):iii2–iii11.
11. Dunn JD, Benton WW, Orozco-Torrentera E, et al. The burden of hyperkalemia in patients with cardiovascular and renal disease. Am J Manag Care. 2015;21(15 Suppl):s307–15.
12. Seliger SL. Hyperkalemia in patients with chronic renal failure. Nephrol Dial Transplant. 2019;34(Suppl 3):iii12–iii18.
13. Einhorn LM, Zhan M, Hsu VD, et al. The frequency of hyperkalemia and its significance in chronic kidney disease. Arch Intern Med. 2009;169(12):1156–62.
14. Ben Salem C, Badreddine A, Fathallah N, et al. Drug-induced hyperkalemia. Drug Saf. 2014;37(9):677–92.
15. Palmer BF, Clegg DJ. Physiology and Pathophysiology of Potassium Homeostasis: Core Curriculum 2019. Am J Kidney Dis. 2019;74(5):682–695.
16. Adrogué HJ, Lederer ED, Suki WN, et al. Determinants of plasma potassium levels in diabetic ketoacidosis. Medicine (Baltimore) 1986;65(3):163–172.
17. Grande VJ, Macias Nunez JF, Miralles JM, et al. Hyporeninemic hypoaldosteronism in diabetic

patients with chronic renal failure. Am J Nephrol 1988;8(2):127–37.
18. Uribarri J, Oh MS, Carroll HJ. Hyperkalemia in diabetes mellitus. J Diabet Complications. 1990;4(1):3–7.
19. Umpierrez GE, Murphy MB, Kitabchi AE. Diabetic Ketoacidosis and Hyperglycemic Hyperosmolar Syndrome. Diabetes Spectrum 2002;15(1):28–36.
20. Hollander-Rodriguez JC, Calvert JF Jr. Hyperkalemia. Am Fam Physician. 2006;73(2):283–90.
21. Kitabchi AE, Umpierrez GE, Miles JM, et al. Hyperglycemic crises in adult patients with diabetes. Diabetes Care 2009;32(7):1335–1343.
22. Palmer BF, Clegg DJ. Electrolyte and Acid-Base Disturbances in Patients with Diabetes Mellitus. N Engl J Med. 2015;373(6):548–59.
23. Asirvatham JR, Moses V, Bjornson L. Errors in potassium measurement: a laboratory perspective for the clinician. N Am J Med Sci. 2013;5(4):255–259.
24. Wiederkehr MR, Moe OW. Factitious hyperkalemia. Am J Kidney Dis 2000;36(5):1049–53.
25. Ismail A, Shingler W, Seneviratne J, et al. In vitro and in vivo haemolysis and potassium measurement. BMJ 2005;330(7497):949.
26. Smellie WS. Spurious hyperkalaemia. BMJ. 2007;334(7595):693–5.
27. Krogager ML, Kragholm K, Thomassen JQ, et al. Update on management of hypokalaemia and goals for the lower potassium level in patients with cardiovascular disease: a review in collaboration with the European Society of Cardiology Working Group on Cardiovascular Pharmacotherapy. Eur Heart J Cardiovasc Pharmacother. 2021:pvab038.
28. Šálek T. Pseudohyperkalemia - Potassium released from cells due to clotting and centrifugation - a case report. Biochem Med (Zagreb). 2018;28(1):011002.
29. Sevastos N, Theodossiades G, Archimandritis AJ. Pseudohyperkalemia in serum: a new insight into an old phenomenon. Clin Med Res. 2008;6(1):30–32.
30. Jain AG, Tauseef A, Hasan SA, et al. Pseudo-hyperkalemia: To Treat or not to Treat. Cureus. 2018;10(11):e3570.
31. Mahto M, Kumar M, Kumar S, et al. Pseudohyperkalemia in Serum and Plasma: The Phenomena and Its Clinical Implications. Indian J Clin Biochem. 2021;36(2):235–238.
32. Avelar T. Reverse pseudohyperkalemia in a patient with chronic lymphocytic leukemia. Perm J. 2014;18(4):e150–152.
33. Montford JR, Linas S. How Dangerous Is Hyperkalemia? J Am Soc Nephrol 2017;28(11):3155–3165.
34. Martinez-Vea A, Bardají A, Garcia C, et al. Severe hyperkalemia with minimal electrocardiographic manifestations: a report of seven cases. J Electrocardiol. 1999;32(1):45–9.
35. Montague BT, Ouellette JR, Buller GK. Retrospective review of the frequency of ECG changes in hyperkalemia. Clin J Am Soc Nephrol. 2008;3(2):324–30.
36. Cohen R, Ramos R, Garcia CA, et al. Electrocardiogram manifestations in hyperkalemia. World Journal of Cardiovascular Diseases 2012;2:57–63.
37. Ryuge A, Nomura A, Shimizu H, et al. Warning: the ECG may be normal in severe hyperkalemia. Intern Med. 2017;56(16):2243–2244.
38. Yoon D, Lim HS, Jeong JC, et al. Quantitative Evaluation of the Relationship between T-Wave-Based Features and Serum Potassium Level in Real-World Clinical Practice. Biomed Res Int. 2018;2018:3054316.
39. Diercks DB, Shumaik GM, Harrigan RA, et al. Electrocardiographic manifestations: Electrolyte abnormalities. J Emerg Med. 2004;27(2):153–160.
40. Littmann L, Gibbs MA. Electrocardiographic manifestations of severe hyperkalemia. J Electrocardiol. 2018;51(5):814–817.
41. Clase CM, Carrero JJ, Ellison DH, et al. Potassium homeostasis and management of dyskalemia in kidney diseases: conclusions from a Kidney Disease: Improving Global Outcomes (KDIGO) Controversies Conference. Kidney Int. 2020;97(1):42–61.
42. Sood MM, Sood AR, Richardson R. Emergency management and commonly encountered outpatient scenarios in patients with hyperkalemia. Mayo Clin Proc. 2007;82(12):1553–61.
43. Campese VM, Adenuga G. Electrophysiological and clinical consequences of hyperkalemia. Kidney Int Suppl. 2016;6(1):16–19.
44. Choi MJ, Ziyadeh FN. The utility of the transtubular potassium gradient in the evaluation of hyperkalemia. J Am Soc Nephrol. 2008;19(3):424–6.
45. Kamel KS, Halperin M. Intrarenal urea recycling leads to a higher rate of renal excretion of potassium: an hypothesis with clinical implications. Curr Opin Nephrol Hypertens 2011;20(5):547–54.
46. Halperin ML. Assessing the renal response in patients with potassium disorders: a shift in emphasis from the TTKG to the urine K+/creatinine ratio. Afr J Nephrol. 2017;20(1):22–24.
47. Kamel KS, Halperin ML. Use of Urine Electrolytes and Urine Osmolality in the Clinical Diagnosis of Fluid, Electrolytes, and Acid-Base Disorders. Kidney Int Rep. 2021;6(5):1211–1224.
48. Palmer BF, Clegg DJ. Diagnosis and treatment of hyperkalemia. Cleve Clin J Med. 2017;84(12):934–942.
49. Kamel KS, Halperin ML. Fluid, Electrolyte, and Acid-Base Physiology - A Problem-Based Approach (5th ed.). Philadelphia: Elsevier; 2017:445–446.
50. Lindner G, Burdmann EA, Clase CM, et al. Acute hyperkalemia in the emergency department: a summary from a Kidney Disease: Improving Global Outcomes conference. Eur J Emerg Med. 2020;27(5):329–337.
51. Alfonzo A, Harrison A, Baines R, et al. Clinical practice guidelines: Treatment of Acute Hyperkalemia in Adults. UK Renal Association July 2020.
52. Mount DB. Disorders of potassium balance. In: Brenner and Rector's The Kidney, 11th ed, Yu A, Chertow G, Luyckx V, et al (Eds), W.B. Saunders &

Company, Philadelphia 2020.p.573.

53. Fenton F, Smally AJ, Laut J. Hyperkalemia and digoxin toxicity in a patient with kidney failure. Ann Emerg Med 1996;28(4):440–441.
54. Levine M, Nikkanen H, Pallin DJ. The effects of intravenous calcium in patients with digoxin toxicity. J Emerg Med 2011;40(1):41–46.
55. Crnobrnja L, Metlapalli M, Jiang C, et al. The Association of Insulin-dextrose Treatment with Hypoglycemia in Patients with Hyperkalemia. Sci Rep. 2020;10(1):22044.
56. Moussavi K, Fitter S, Gabrielson SW, et al. Management of Hyperkalemia with Insulin and Glucose: Pearls for the Emergency Clinician. J Emerg Med. 2019;57(1):36–42.
57. Tee SA, Devine K, Potts A, et al. Iatrogenic hypoglycaemia following glucose-insulin infusions for the treatment of hyperkalaemia. Clin Endocrinol (Oxf) 2021;94(2):176–182.
58. LaRue HA, Peksa GD, Shah SC. A comparison of insulin doses for the treatment of hyperkalemia in patients with renal insufficiency. Pharmacotherapy 2017;37(12):1516–1522.
59. McNicholas BA, Pham MH, Carli K, et al. Treatment of hyperkalemia with a low-dose insulin protocol is effective and results in reduced hypoglycemia. Kidney Int Rep 2018;3(2):328–336.
60. Wheeler DT, Schafers SJ, Horwedel TA, et al. Weight-based insulin dosing for acute hyperkalemia results in less hypoglycemia. J Hosp Med. 2016;11(5):355–7.
61. Harel Z, Kamel KS. Optimal Dose and Method of Administration of Intravenous Insulin in the Management of Emergency Hyperkalemia: A Systematic Review. PLoS One. 2016;11(5):0154963.
62. Coca A, Valencia AL, Bustamante J, et al. Hypoglycemia following intravenous insulin plus glucose for hyperkalemia in patients with impaired renal function. PLoS ONE. 2017;12:0172961.
63. Li T, Vijayan A. Insulin for the treatment of hyperkalemia: a double-edged sword?. Clin Kidney J. 2014;7(3):239–241.
64. Viera AJ, Wouk N. Potassium Disorders: Hypokalemia and Hyperkalemia. Am Fam Physician. 2015;92(6):487–95.
65. Allon M, Copkney C. Albuterol and insulin for treatment of hyperkalemia in hemodialysis patients. Kidney Int. 1990;38(5):869–872.
66. Mahoney BA, Smith WA, Lo DS, et al. Emergency interventions for hyperkalaemia. Cochrane Database Syst Rev. 2005;2005(2):CD003235.
67. Dépret F, Peacock WF, Liu KD, et al. Management of hyperkalemia in the acutely ill patient. Ann Intensive Care. 2019;9(1):32.
68. Liou HH, Chiang SS, Wu S, et al. Hypokalemic effects of intravenous infusion or nebulization of salbutamol in patients with chronic renal failure: comparative study. Am J Kidney Dis. 1994;23(2):266–271.
69. Mount DB. Disorders of potassium balance. In: Brenner and Rector's The Kidney, 11th ed, Yu A, Chertow G, Luyckx V, et al (Eds), W.B. Saunders & Company, Philadelphia 2020.p.574.
70. McClure RJ, Prasad VK, Brocklebank JT. Treatment of hyperkalaemia using intravenous and nebulised salbutamol. Arch Dis Child 1994;70(2):126–128.
71. Batterink J, Cessford TA, Taylor RAI. Pharmacological interventions for the acute management of hyperkalaemia in adults. Cochrane Database Syst Rev 2015;CD010344.
72. Allon M, Dunlay R, Copkney C. Nebulised albuterol for acute hyperkalaemia in patients on haemodialysis. Ann Intern Med 1989;110(6):426–429.
73. Sterns RH, Grieff M, Bernstein PL. Treatment of hyperkalemia: something old, something new. Kidney Int. 2016;89(3):546–554.
74. Bianchi S, Aucella F, De Nicola L, et al. Management of hyperkalemia in patients with kidney disease: a position paper endorsed by the Italian Society of Nephrology. J Nephrol. 2019;32(4):499–516.
75. Montassier E, Legrand M, Rossignol P, et al. Hyperkalemia in the emergency department: Consider the use of nebulized salbutamol. Am J Emerg Med. 2019;37(5):1004.
76. Lim AKH, Crnobrnja L, Metlapalli M, et al. The Effect of Patient Factors and Cotreatments on the Magnitude of Potassium Lowering with Insulin-Glucose Treatment in Patients with Hyperkalemia. Epidemiologia. 2021;2(1):27–35.
77. Weisberg LS. Management of severe hyperkalemia. Crit Care Med. 2008;36(12):3246–3251.
78. Chalisey A, Ross C, Weavers N. Joint Trust Guideline for the management of hyperkalaemia in adults, James Paget University Hospitals and Norfolk and Norwich University Hospitals. 2018.
79. Geng S, Green EF, Kurz MC, et al. Sodium bicarbonate administration and subsequent potassium concentration in hyperkalemia treatment. Am J Emerg Med. 2021;50:132–135.
80. Farkas J. Hyperkalemia. The Internet Book of Critical Care. June 20, 2021. Visit: https://emcrit.org/ibcc/hyperkalemia/#Rx_severe_hyperkalemia:_Temporizing_measures.
81. Esposito P, Conti NE, Falqui V, et al. New Treatment Options for Hyperkalemia in Patients with Chronic Kidney Disease. J Clin Med. 2020;9(8):2337.
82. Rakisheva A, Marketou M, Klimenko A, et al. Hyperkalemia in heart failure: Foe or friend? Clin Cardiol 2020;43(7):666–7.
83. Rosano GMC, Tamargo J, Kjeldsen KP, et al. Expert consensus document on the management of hyperkalaemia in patients with cardiovascular disease treated with renin angiotensin aldosterone system inhibitors: coordinated by the working group on cardiovascular pharmacotherapy of the European Society of Cardiology. Eur Heart J Cardiovasc Pharmacother. 2018;4(3):180–8.
84. Watson M, Abbott KC, Yuan CM. Damned if you do, damned if you don't: potassium binding resins in hyperkalemia. Clin J Am Soc Nephrol. 2010;5(10):1723–1726.
85. Chaitman M, Dixit D, Bridgeman MB. Potassium-

binding agents for the clinical management of hyperkalemia. P T. 2016;41(1):43–50.

86. Lepage L, Dufour AC, Doiron J, et al. Randomized clinical trial of sodium polystyrene sulfonate for the treatment of mild hyperkalemia in CKD. Clin J Am Soc Nephrol. 2015;10(12):2136–2142.
87. Mistry M, Shea A, Giguère P, et al. Evaluation of Sodium Polystyrene Sulfonate Dosing Strategies in the Inpatient Management of Hyperkalemia. Ann Pharmacother 2016;50(6):455–62.
88. Dardik A, Moesinger RC, Efron G, et al. Acute abdomen with colonic necrosis induced by Kayexalate-sorbitol. South Med J. 2000;93(5):511–3.
89. McGowan CE, Saha S, Chu G, et al. Intestinal necrosis due to sodium polystyrene sulfonate (Kayexalate) in sorbitol. South Med J. 2009;102(5):493–497.
90. Harel Z, Harel S, Shah PS, et al. Gastrointestinal adverse events with sodium polystyrene sulfonate (Kayexalate) use: a systematic review. Am J Med. 2013;126(3):264.e9–24.
91. US Food and Drug Administration. Kayexalate (sodium polystyrene sulfonate, USP) powder approval letter (2009). US Food and Drug Administration website. https://www.accessdata.fda.gov/drugsatfda_docs/appletter/2009/011287s022ltr.pdf. Accessed September 6, 2021.
92. Laureati P, Xu Y, Trevisan M, et al. Initiation of sodium polystyrene sulphonate and the risk of gastrointestinal adverse events in advanced chronic kidney disease: a nationwide study. Nephrol Dial Transplant. 2020;35(9):1518–1526.
93. Noel JA, Bota SE, Petrcich W, et al. Risk of hospitalization for serious adverse gastrointestinal events associated with sodium polystyrene sulfonate use in patients of advanced age. JAMA Intern Med. 2019;179(8):1025–1033.
94. Meaney CJ, Beccari MV, Yang Y, et al. Systematic Review and Meta-Analysis of Patiromer and Sodium Zirconium Cyclosilicate: A New Armamentarium for the Treatment of Hyperkalemia. Pharmacotherapy. 2017;37(4):401–411.
95. National Institute for Health and Care Excellence. Sodium zirconium cyclosilicate for treating hyperkalaemia. 2019. https://www.nice.org.uk/guidance/ta599/chapter/1-Recommendations (accessed 8 September 2021).
96. Rafique Z, Liu M, Staggers KA, et al. Patiromer for Treatment of Hyperkalemia in the Emergency Department: A Pilot Study. Acad Emerg Med 2020;27(1):54–60.
97. Peacock WF, Rafique Z, Vishnevskiy K, et al. Emergency Potassium Normalization Treatment Including Sodium Zirconium Cyclosilicate: A Phase II, Randomized, Double-blind, Placebo-controlled Study (ENERGIZE). Acad Emerg Med 2020;27(6):475–486.
98. National Institute for Health and Care Excellence. Patiromer for treating hyperkalaemia. National Institute for Health and Care Excellence 2020. https://www.nice.org.uk/guidance/ta623/chapter/1-Recommendations (Accessed 8 September 2021).
99. Campbell P, McKeveney P, Donegan K, et al. Practical guidance for the use of potassium binders in the management of hyperkalaemia in patients with heart failure and/or chronic kidney disease. Br J Hosp Med (Lond). 2021;82(4):1–11.
100. Morales E, Cravedi P, Manrique J. Management of Chronic Hyperkalemia in Patients with Chronic Kidney Disease: An Old Problem with News Options. Front Med (Lausanne). 2021;8:653634.
101. Shrestha DB, Budhathoki P, Sedhai YR, et al. Patiromer and Sodium Zirconium Cyclosilicate in Treatment of Hyperkalemia: A Systematic Review and Meta-Analysis. Curr Ther Res Clin Exp. 2021;95:100635.
102. Hoy SM. Sodium Zirconium Cyclosilicate: A Review in Hyperkalaemia [published correction appears in Drugs. 2019;79(5):591]. Drugs. 2018;78(15):1605–1613.
103. Spinowitz BS, Fishbane S, Pergola PE, et al. Sodium Zirconium Cyclosilicate among Individuals with Hyperkalemia: A 12-Month Phase 3 Study. Clin J Am Soc Nephrol. 2019;14(6):798–809.
104. Mount DB. Disorders of potassium balance. In: Brenner and Rector's The Kidney, 11th ed, Yu A, Chertow G, Luyckx V, et al (Eds), W.B. Saunders & Company, Philadelphia 2020.p.577.
105. Holleck JL, Roberts AE, Marhoffer EA, et al. Risk of Intestinal Necrosis with Sodium Polystyrene Sulfonate: A Systematic Review and Meta-analysis. J Hosp Med. 2021;16(8):489–494.
106. Statland JM, Fontaine B, Hanna MG, et al. Review of the Diagnosis and Treatment of Periodic Paralysis. Muscle Nerve. 2018;57(4):522–530.
107. Renal Association Clinical Practice Guidelines - Treatment of Acute Hyperkalaemia in Adults - July 2020. (https://ukkidney.org/sites/renal.org/files/RENAL%20ASSOCIATION%20HYPERKALAEMIA%20GUIDELINE%202020.pdf). Accessed on 19 August 2021.
108. Berbenetz NM, Mrkobrada M. Mineralocorticoid receptor antagonists for heart failure: systematic review and meta-analysis. BMC Cardiovasc Disord. 2016;16(1):246.

KidneyEducation 

Join the Mission to Fight Kidney Diseases

Explore the world's largest multilingual website created by a global team of over 100 nephrologists.

www.KidneyEducation.com

» Read online or download the 200-page book "Save Your Kidneys" in 40 languages—completely free.

» This comprehensive resource offers valuable information on preventing and managing common kidney problems, tailored for kidney patients and their families.

» It's an authentic guide, prepared by nephrologists and free from any external funding.