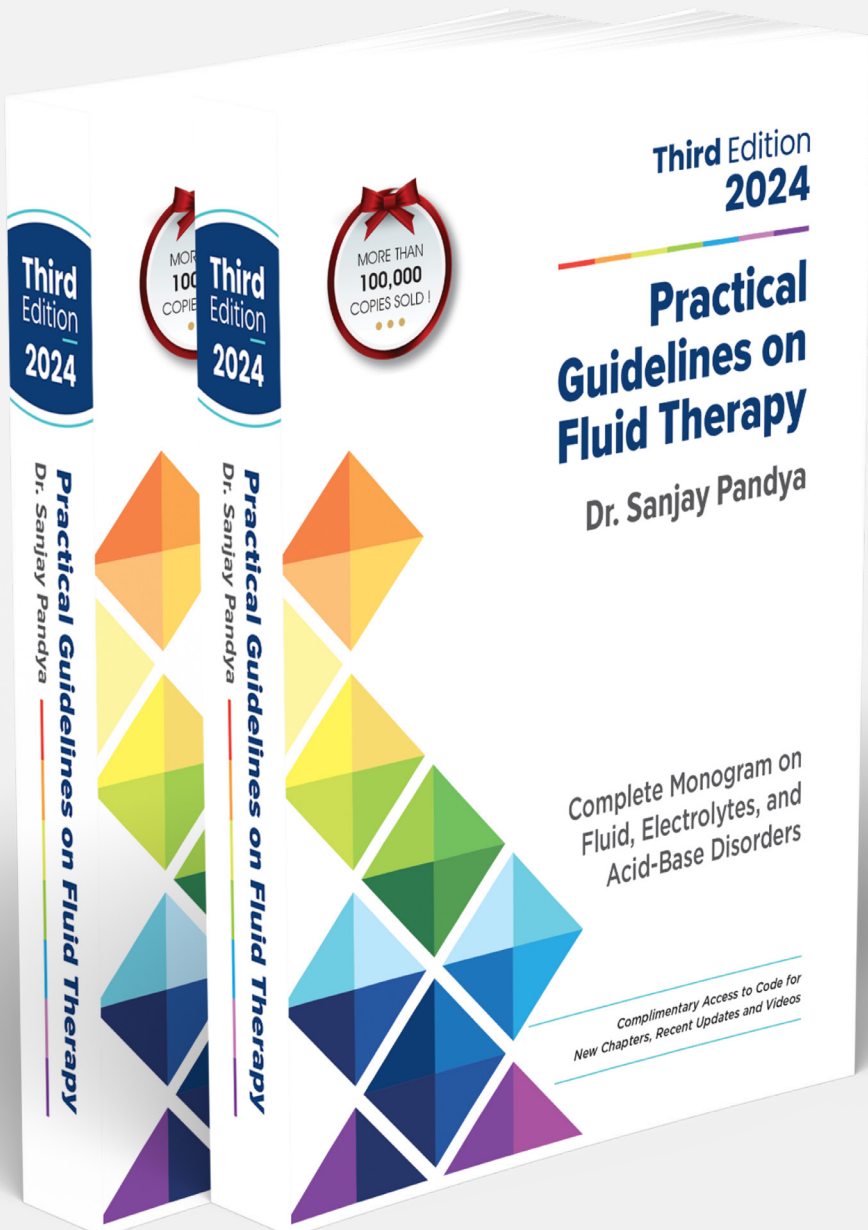




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Chapter 40:

Diabetic Ketoacidosis and Hyperosmolar
Hyperglycemic State



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40

Diabetic Ketoacidosis and Hyperosmolar Hyperglycemic State

DIABETIC KETOACIDOSIS

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Diabetic ketoacidosis (DKA) and hyperosmolar hyperglycemic state (HHS) are serious and potentially life-threatening metabolic complications of diabetes mellitus (DM). While DKA is a common hyperglycemic emergency with a low mortality rate, characterized by hyperglycemia and ketoacidosis, HHS, on the other hand, is less common, characterized by hyperglycemia and hyperosmolality without ketoacidosis, but has a high mortality rate.

DIABETIC KETOACIDOSIS

Diabetic ketoacidosis is a medical emergency that can be life-threatening if not treated promptly. DKA is one of the

common complications of type-I diabetes mellitus (IDDM) associated with significant fluid and electrolyte imbalance.

DEFINITION

Diabetic ketoacidosis is characterized by the triad of [1, 2]:

1. Hyperglycemia: Blood glucose concentration of >200 mg/dL or 11.0 mmol/L.
2. Metabolic acidosis: Venous pH <7.3 and serum bicarbonate <18 mmol/L [1] (or 15 mmol/L [2]).
3. Ketonemia or ketonuria: Capillary ketones >3 mmol/L or urine ketones ++ ("moderate or large").

If a facility to measure blood beta-hydroxybutyrate (BOHB) concentration

is available, it is a more precise and sensitive test to diagnose DKA [3].

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REFERENCES

1. Glaser N, Fritsch M, Priyambada L, et al: ISPAD Clinical practice consensus guidelines 2022: diabetic ketoacidosis and hyperglycemic hyperosmolar state. *Pediatr Diabetes*. 2022;23(7):835–56.
2. JBDS. JBDS-IP Joint British Diabetes Societies Inpatient Care Group. The Management of Diabetic Ketoacidosis in Adults, March 2023 Update: JBDS Guidelines [Internet]. London: ABCD; 2023 Mar. Available from: https://abcd.care/sites/abcd.care/files/site_uploads/JBDS_Guidelines_Current/JBDS_02_DKA_Guideline_with_QR_code_March_2023.pdf.
3. Tremblay ES, Millington K, Monuteaux MC, et al. Plasma β -Hydroxybutyrate for the Diagnosis of Diabetic Ketoacidosis in the Emergency Department. *Pediatr Emerg Care*. 2021;37(12):e1345–e1350.
4. Dhatariya K. Blood Ketones: Measurement, Interpretation, Limitations, and Utility in the Management of Diabetic Ketoacidosis. *Rev Diabet Stud*. 2016;13(4):217–225.
5. Rawla P, Vellipuram AR, Bandaru SS, et al. Euglycemic diabetic ketoacidosis: a diagnostic and therapeutic dilemma. *Endocrinol Diabetes Metab Case Rep*. 2017;2017:17–0081.
6. Nasa P, Chaudhary S, Shrivastava PK, et al. Euglycemic diabetic ketoacidosis: A missed diagnosis. *World J Diabetes*. 2021;12(5):514–523.
7. Kitabchi AE, Umpierrez GE, Miles JM, et al. Hyperglycemic crises in adult patients with diabetes. *Diabetes Care*. 2009;32(7):1335–1343.
8. Kitabchi AE, Umpierrez GE, Murphy MB, et al. Hyperglycemic crises in adult patients with diabetes: a consensus statement from the American Diabetes Association. *Diabetes Care*. 2006;29(12):2739–48.
9. English P, Williams G. Hyperglycaemic crises and lactic acidosis in diabetes mellitus. *Postgrad Med J*. 2004;80(943):253–261.
10. DeFronzo RA, Hompesch M, Kasichayanula SK, et al. Characterization of renal glucose reabsorption in response to dapagliflozin in healthy subjects and subjects with type 2 diabetes. *Diabetes Care* 2013;36(10):3169–3176.
11. Arora S, Cheng D, Wyler B, et al. Prevalence of hypokalemia in ED patients with diabetic ketoacidosis. *Am J Emerg Med* 2012;30(3):481–4.
12. Adrogué HJ, Lederer ED, Suki WN, et al. Determinants of plasma potassium levels in diabetic ketoacidosis. *Medicine (Baltimore)* 1986;65(3):163–172.
13. Conte G, Dal Canton A, Imperatore P, et al. Acute increase in plasma osmolality as a cause of hyperkalemia in patients with renal failure. *Kidney Int*. 1990;38(2):301–7.
14. Umpierrez GE, Murphy MB, Kitabchi AE. Diabetic Ketoacidosis and Hyperglycemic Hyperosmolar Syndrome. *Diabetes Spectrum* 2002;15(1):28–36.
15. Dhatariya KK, Nunney I, Higgins K, et al. A national survey of the management of diabetic ketoacidosis in the UK in 2014. *Diabet Med*. 2016;33(2):252–260.
16. Pasquel FJ, Lansang MC, Dhatariya K, et al. Management of diabetes and hyperglycaemia in the hospital. *Lancet Diabetes Endocrinol*. 2021;9(3):174–188.
17. Mein SA, Schwartzstein RM, Richards JB. Sugar, Sodium, and Water: A Recipe for Disaster. *Ann Am Thorac Soc*. 2020;17(8):1016–1020.
18. van der Vaart A, Waanders F, van Beek AP, et al. Incidence and determinants of hypophosphatemia in diabetic ketoacidosis: an observational study. *BMJ Open Diabetes Res Care*. 2021;9(1):e002018.
19. Choi HS, Kwon A, Chae HW, et al. Respiratory failure in a diabetic ketoacidosis patient with severe hypophosphatemia. *Ann Pediatr Endocrinol Metab*. 2018;23(2):103–106.
20. Kuppermann N, Ghetti S, Schunk JE, et al. Clinical trial of fluid infusion rates for pediatric diabetic ketoacidosis. *New England Journal of Medicine* 2018;378(24):2275–2287.

21. University Hospitals of Leicester. Management of Diabetic Ketoacidosis (DKA) in Adults Guideline (V4 approved by Policy and Guideline Committee on 27 February 2023 Trust ref: B66/2011) [Guidelines]. NHS; 2023. Available from: [https://secure.library.leicestershospitals.nhs.uk/PAGL/Shared%20Documents/Diabetic%20Ketoacidosis%20\(DKA\)%20in%20Adults%20UHL%20Guideline.pdf](https://secure.library.leicestershospitals.nhs.uk/PAGL/Shared%20Documents/Diabetic%20Ketoacidosis%20(DKA)%20in%20Adults%20UHL%20Guideline.pdf).
22. Fluid and insulin therapy in children and young people with diabetic ketoacidosis: An update to the NICE NG18 guideline. *Journal of Diabetes Nursing* 2021;25:JDN171. Available from: <https://www.nice.org.uk/guidance/ng18/chapter/Recommendations#fluid-and-insulin-therapy>.
23. Diabetes (type 1 and type 2) in children and young people: diagnosis and management. London: National Institute for Health and Care Excellence (NICE); 2022 Jun 29. (NICE Guideline, No. 18.) Available from: <https://www.ncbi.nlm.nih.gov/books/NBK555102/>.
24. South Australia (SA) Health. Clinical practice guideline on diabetic ketoacidosis (DKA) in children. Adelaide: SA Health; 2019. Available from: https://www.sahealth.sa.gov.au/wps/wcm/connect/04ac0b8040d0430e975ebf40b897efc8/Diabetic+Ketoacidosis+%28DKA%29+in+Children+and+Adolescents_Paed_v2_1.pdf?MOD=AJPERES&CACHEID=ROOT-WORKSPACE-04ac0b8040d0430e975ebf40b897efc8-obYYWor.
25. Diabetes Canada Clinical Practice Guidelines Expert Committee; Goguen J, Gilbert J. Hyperglycemic Emergencies in Adults. *Can J Diabetes*. 2018;42(1):S109–S114.
26. Myburgh JA, Mythen MG. Resuscitation fluids. *N Engl J Med*. 2013;369(13):1243–51.
27. Oliver WD, Willis GC, Hines MC, et al. Comparison of PlasmaLyte A and sodium chloride 0.9% for fluid resuscitation of patients with diabetic ketoacidosis. *Hosp Pharm* 2018;53(5):326–330.
28. Yung M, Letton G, Keeley S. Controlled trial of Hartmann's solution versus 0.9% saline for diabetic ketoacidosis. *J Paediatr Child Health*. 2017;53(1):12–17.
29. Mahler S, Conrad S, Wang H, et al. Resuscitation with balanced electrolyte solution prevents hyperchloremic metabolic acidosis in patients with diabetic ketoacidosis. *Am J Emerg Med*. 2011;29(6):670–674.
30. Ramanan M, Attokaran A, Murray L. SCOPE-DKA Collaborators and Queensland Critical Care Research Network (QCCRN). Sodium chloride or PlasmaLyte-148 evaluation in severe diabetic ketoacidosis (SCOPE-DKA): a cluster, crossover, randomized, controlled trial. *Intensive Care Med*. 2021;47(11):1248–1257.
31. Self W, Evans C, Jenkins C, et al. Clinical Effects of Balanced Crystalloids vs Saline in Adults With Diabetic Ketoacidosis. *JAMA Netw Open*. 2020;3(11):e2024596.
32. Van Zyl D, Rheeder P, Delpont E. Fluid management in diabetic-acidosis Ringer's lactate versus normal saline: a randomized controlled trial. *QJM*. 2012;105(4):337–343.
33. Chua HR, Schneider A, Bellomo R. Bicarbonate in diabetic ketoacidosis – a systematic review. *Ann Intensive Care* 2011;1(1):23.
34. Bergmann KR, Abuzzahab MJ, Nowak J, et al. Resuscitation with Ringer's lactate compared with normal saline for pediatric diabetic ketoacidosis. *Pediatr Emerg Care* 2021;37(5):e236–e242.
35. Jahangir A, Jahangir A, Siddiqui FS, et al. Normal Saline Versus Low Chloride Solutions in Treatment of Diabetic Ketoacidosis: A Systematic Review of Clinical Trials. *Cureus*. 2022;14(1):e21324.
36. Catahay JA, Polintan ET, Casimiro M, et al. Balanced electrolyte solutions versus isotonic saline in adult patients with diabetic ketoacidosis: A systematic review and meta-analysis. *Heart Lung*. 2022;54:74–79.
37. Alghamdi NA, Major P, Chaudhuri D, et al. Saline Compared to Balanced Crystalloid in Patients With Diabetic Ketoacidosis: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Crit Care Explor*. 2022;4(1):e0613.
38. Zardoost P, Khan Z, Wehrum HL, et al. Hyponatremia in Diabetic Ketoacidosis: A Rare Metabolic Derangement Requiring a Cautionary Approach in Fluid Resuscitation. *Cureus* 2023;15(3):e36689.
39. Dressler DD. Normal Saline vs. Balanced Crystalloid for Diabetic Ketoacidosis. *NEJM JOURNAL Watch*. 2022 Jul 26. Visit: <https://www.jwatch.org/na55108/2022/07/26/normal-saline-vs-balanced-crystalloid-diabetic>.
40. Aldhaefi M, Aldardeer NF, Alkhani N, et al. Updates in the Management of Hyperglycemic Crisis. *Front Clin Diabetes Healthc*. 2022;2:820728.
41. Effects of Balanced Crystalloids vs. Saline in Adults with Diabetic Ketoacidosis [Internet]. *Anaesthesia News*. 2021. Available from: <https://anaesthesianews.wordpress.com/2021/12/12/effects-of-balanced-crystalloids-vs-saline-in-adults-with-diabetic-ketoacidosis/>.
42. Farkas J. Diabetic Ketoacidosis (DKA). *emcrit.org*. 2021. Available from: <https://emcrit.org/ibcc/dka/>.
43. Gripp K, Trottier ED, Thakore S, et al. Current recommendations for management of paediatric diabetic ketoacidosis. *Canadian Paediatric Society* 2022.
44. BSPED Guideline for the Management of Children and Young People under the age of 18 years with Diabetic Ketoacidosis - 2021 [Internet]. *British Society for Paediatric Endocrinology and Diabetes*; 2021. Available from: <https://www.bsped.org.uk/clinical-resources/bsped-dka-guidelines/>.
45. Forestell B, Battaglia F, Sharif S, et al. Insulin Infusion Dosing in Pediatric Diabetic Ketoacidosis: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Crit Care Explor*. 2023;5(2):e0857.
46. Kilpatrick ES, Butler AE, Ostlundh L, et al. Controversies Around the Measurement of Blood Ketones to Diagnose and Manage Diabetic Ketoacidosis. *Diabetes Care*. 2022;45(2):267–272.

47. Ma OJ, Rush MD, Godfrey MM, et al. Arterial blood gas results rarely influence emergency physician management of patients with suspected diabetic ketoacidosis. *Acad Emerg Med.* 2003;10(8):836–41.
48. Menchine M, Probst MA, Agy C, et al. Diagnostic accuracy of venous blood gas electrolytes for identifying diabetic ketoacidosis in the emergency department. *Acad Emerg Med.* 2011;18(10):1105–1108.
49. Byrne AL, Bennett M, Chatterji R, et al. Peripheral venous and arterial blood gas analysis in adults: are they comparable? A systematic review and meta-analysis. *Respirology.* 2014;19(2):168–175.
50. Prasad H, Vempalli N, Agrawal N, et al. Correlation and agreement between arterial and venous blood gas analysis in patients with hypotension-an emergency department-based cross-sectional study. *Int J Emerg Med.* 2023;16(1):18.
51. Milanese A, Weinreb JE. Hyperglycemic Hyperosmolar State. [Updated 2018 Aug 1]. In: Feingold KR, Anawalt B, Blackman MR, et al, editors. *Endotext* [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK278976/>.
52. Mustafa OG, Haq M, Dashora U, et al. Management of Hyperosmolar Hyperglycaemic State (HHS) in Adults: An updated guideline from the Joint British Diabetes Societies (JBDS) for Inpatient Care Group. *Diabet Med.* 2023;40(3):e15005.
53. Zeitler P, Haqq A, Rosenbloom A, et al. Hyperglycemic hyperosmolar syndrome in children: pathophysiological considerations and suggested guidelines for treatment. *Rev J Pediatr.* 2011;158(1):9–14.

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