IV Fluid Safety

full update April 2025

The FAQ below answers common questions about safely using IV fluids.

Clinical Question	Answer/Pertinent Information
What is meant by "isotonic" and "isosmotic?"	• Osmo***LAR***ity is the number of osmotically active particles **per L** of solution.[1] • Osmo***LAL***ity is the number of osmotically active particles **per kg** of solution.[1] • Osmo***LAL***ity is the same or slightly less than osmo***LAR***ity.[1] Generally, "osmolality" is used when talking about body fluids, and "osmolarity" when talking about IV fluids. • The normal osmolality of body fluids is 280 to 295 mOsm/kg.[16] • Isosmotic/isotonic fluids have an osmolarity that approximates the osmolality of human extracellular fluid (e.g., blood).[4,15,26] • "Hyperosmotic/hypertonic" or "hypoosmotic/hypotonic" solutions have osmolarities that are higher or lower, respectively, than the osmolality of blood (e.g., ≥375 mOsm/L or <250 mOsm/L, respectively).[7,26] • Osmolarity is often used as a synonym for "tonicity," but this is not always correct.[26] This is because tonicity depends on osmolarity and whether the solutes in the solution (e.g., glucose, sodium) will enter the cells.[26] ○ D5W is an example of an isosmotic solution that behaves like a hypotonic solution once administered.[26] • A cell will neither swell nor shrink in an isotonic solution, will swell in a hypotonic solution, and will shrink in a hypertonic solution.[26]
What is the approximate osmolarity of some common IV fluids?	The osmolarity of IV solutions is usually printed on the bag. The bag might also state that the solution is isotonic, hypertonic, or hypotonic/hemolytic. Here are some examples of approximate osmolarities of common IV fluids: **Isosmotic/Isotonic**: • 0.9% saline (NS): 308 mOsm/L[1] • LR: 275 mOsm/L[1] (The osmo***lal***ity of LR is 252 to 255 mOsm/kg due to incomplete dissociation of some ions, and so it is **slightly hypotonic**.[1,4]) • D5W: 252 mOsm/L[b] (acts as a **hypotonic** solution once administered because glucose enters cells and is unavailable to keep the water in the vascular space)[26] • Dextrose 5% in 0.225% saline (D5 1/4 NS): 329 mOsm/L

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<table>
<tr><th>Clinical Question</th><th colspan="3">Answer/Pertinent Information</th></tr>
<tr><td>Continued…
Approximate osmolarity of some common IV fluids, continued</td><td colspan="3">
• 5% albumin: 290 mOsm/L[1]

Hypoosmotic/Hypotonic:
• 0.45% saline: (half-normal saline; 1/2 NS): 154 mOsm/L[1]

Very Hypoosmotic/Hypotonic
• Sterile water: 0 mOsm/L[23]
• 0.225% saline (quarter normal saline; 1/4 NS): 77 mOsm/L[23]
• Sodium bicarbonate drip using 1 “amp” (50 mEq added to 1 L sterile water): 100 mOsm/L[31]

Hyperosmotic/Hypertonic:
• 3% saline: 1026 mOsm/L[1]
• Dextrose 5% in 0.9% saline (D5NS): 561 mOsm/L[1]
• Dextrose 5% in Lactated Ringer’s (D5LR): 525 mOsm/L[1]
• Dextrose 5% in 0.45% saline (D5 1/2 NS): 405 mOsm/L[1]
</td></tr>
<tr><td>What is considered an isotonic fluid, and when is it used?</td><td colspan="3">
• Examples of isotonic solutions include NS, LR, and D5W.[1,4,7]
  ○ LR is often considered isotonic, but it is actually slightly hypotonic (see above).
  ○ Although D5W is isotonic in the bag, once administered, the dextrose is metabolized, providing free water that mostly distributes out of the vascular space.[7,12] Therefore, unlike NS or LR, D5W is not useful for fluid resuscitation.[1,12]
• Isotonic, sodium-containing solutions are safer maintenance IV fluids than hypotonic solutions in regard to hyponatremia risk, especially in pediatrics.[2,5,15,25] However, use of isotonic solutions in children poses a risk of hypernatremia that is similar to the risk of hyponatremia conferred by hypotonic solutions.[24]
</td></tr>
<tr><td>How do the isotonic solutions (e.g., normal saline, Lactated Ringer’s) compare?
Continued…</td><td>Fluid/
cost per liter[a]</td><td>Balanced Fluids (not all-inclusive)
(LR [~$5], Isolyte S pH 7.4 [<$10], Normosol-R [~$5], Plasma-Lyte A [~$15])</td><td>Normal saline
(0.9% Sodium Chloride)(~$5)</td></tr>
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Clinical Question	**Answer/Pertinent Information**		

How do the isotonic solutions (e.g., normal saline, Lactated Ringer's) compare?	**Composition**[b]	**Balanced Fluids**
		Electrolytes (for products listed above):
		• calcium (only in **LR**): ~2.7 mEq/L
		• chloride: 98 to 110 mEq/L
		• magnesium (not in LR): ~3 mEq/L
		• sodium:
		  ○ LR: ~130 mEq/L
		  ○ others ~140 to 141 mEq/L
		• phosphate: ~0 to 1 mEq/L
		• potassium: ~4 to 5 mEq/L
		Buffers (may contain one or more of the following):
		• acetate (not LR): ~27 mEq/L
		• gluconate (not LR): ~23 mEq/L
		• lactate (LR): ~28 mEq/L
			Normal saline
			Electrolytes
			• chloride: ~154 mEq/L
			• sodium: ~154 mEq/L

	Preferred Indications or Potential Benefits	**Balanced Fluids** • Hyperchloremic metabolic acidosis.[29] • Generally preferred as an initial resuscitation fluid in sepsis, burns, trauma (not TBI), critical illness, pancreatitis, or surgical patients, or in diabetic ketoacidosis.[4,28,43,47,48] • May **prevent one major adverse kidney event in critically ill patients** (NNT = 91) compared to NS [Evidence Level B-1].[29] Other studies show no difference in kidney outcomes or mortality, perhaps due to differences in patient populations or definition of AKI.[36,37] • May improve survival, reduce kidney injury, and reduce the length of time vasopressors are required in **pediatric sepsis** compared to resuscitation with non-balanced fluids.[19,41] • **Pancreatitis**: LR may reduce severity vs NS, with mixed evidence on LOS and mortality.[43-46] • **DKA**: normalizes pH faster and reduces LOS compared to NS.[48]	**Normal saline** • NS is associated with lower mortality than balanced fluids in TBI. Balanced fluids' lower tonicity might worsen brain edema.[42] • Hypovolemic, hypochloremic metabolic alkalosis.[4,34] • Replacement of chloride from GI losses (e.g., diarrhea, excessive colostomy output, high output ileal stoma or fistula, jejunal stoma or fistula, pancreatic or biliary drainage).[8,34]

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Clinical Question	**Answer/Pertinent Information**		
Comparison of isotonic solutions (e.g., normal saline, Lactated Ringer's), continued	**When to Avoid Use, or Possible Complications**	**Balanced Fluids** • LR provides 114 mL of free water/L; therefore, excessive amounts can cause hypotonicity.[1] Volumes more than 3 L can provide enough free water to increase intracranial pressure.[1] o May be associated with increased mortality when used prior to hospital admissions for traumatic brain injury compared to NS [Evidence Level B-1].[18] • Avoid LR (even if infusing through different lines) **in neonates ≤28 days old receiving ceftriaxone** due to potential for calcium precipitation.[31] o Ceftriaxone and LR can be used together in patients older than 28 days as long as they are infused in separately and lines are properly flushed between infusions.[31]	**Normal saline** • May cause hyperchloremic metabolic acidosis.[20]
	Use in Patients with Kidney or Liver Impairment	**Balanced Fluids** • In **severe liver impairment** metabolism of buffers may be impaired. Alkalinizing effect of lactate may be impaired. Accumulation of gluconate or acetate may worsen alkalosis.[b]	**Normal Saline** • Consider limiting use of large volumes of NS in patients with **impaired kidney function**, especially with concomitant heart failure, due to risk of sodium retention.[b]
	Impact on Potassium Levels	**Balanced Fluids** • The small amount of potassium in balanced fluids was not associated with a higher incidence of severe hyperkalemia in critically ill patients [Evidence level B-1].[11] • In acidosis, buffers in these solutions may help prevent the extracellular potassium shift and resultant hyperkalemia.[11]	**Normal Saline** • Does not contain any potassium, but can cause hyperchloremic metabolic acidosis, which increases potassium by causing extracellular potassium shift.[11]

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Clinical Question	Answer/Pertinent Information

What are the concerns with hypotonic solutions, or D5W?	• Hypotonic saline or isotonic D5W may result in hyponatremia due to insufficient provision of sodium.[2,13]
	  o Risk of hyponatremia is highest within the first 24 hours.[25]
	• Hypotonic and sodium-free solutions provide free water.[1,2] This reduces plasma osmolality and reduces serum sodium.[1,2] If serum sodium falls quickly the body cannot compensate, and the resultant osmotic gradient causes water to enter the brain, causing cerebral edema.[1,2] This can result in brainstem herniation with compression of the midbrain, and death.[2]
	  o Patients at particular risk include post-op patients, ICU patients, children, and patients with conditions or medications that promote antidiuretic hormone secretion or otherwise reduce serum sodium (e.g., diuretics; opioids; proton pump inhibitors; heparin; inhalational anesthetics; desmopressin; pain; nausea; stress; dehydration; pneumonia; central nervous system infections; or adrenal, kidney, or hepatic insufficiency).[2]
	  o Children are at particular risk because their ability to maintain water balance is not robust, and they are more likely to develop syndrome of inappropriate antidiuretic hormone secretion (SIADH) post-op. Children develop cerebral edema at higher sodium levels than adults and have little extra room in their cranium to accommodate brain swelling.[2]
	• Because they are hypotonic, sterile water and 1/4 NS can cause hemolysis, kidney failure, and death.[23]

What can be done to reduce harm associated with hypotonic solutions?	• Some hospitals have policies prohibiting or restricting use of solutions with osmolarity <154 mOsm/L.
	• STERILE WATER WITHOUT ADDITIVES IS NOT FOR DIRECT INFUSION.[3]
	  • It is recommended that institutions:
	  o remove sterile water for injection from computer order entry systems so that prescribers cannot order it.[3]
	  o in the pharmacy, do not allow sterile water to leave the sterile compounding area.[3]
	  o stock sterile water only in 2 L bags, bottles, or vials to help distinguish it from 1 L bags of fluids for direct IV administration.[3,10]
	  o label sterile water for use as respiratory humidification with "For Respiratory Equipment-Not for Use" on the bag and on the end of the tubing closest to the patient.[22]
	• Prohibit compounding of <0.45% saline (less than half-normal saline; <1/2 NS) except in specific circumstances (e.g., certain neonatal intensive care patients).[23,49,50]
	• Prohibit use of 1/4 NS and instead use Dextrose 5% in 0.225% saline (D5 1/4 NS).
	  o Ease concerns about dextrose in the solution; the risk of hyperglycemia is low and manageable, and less than the risks of administering a hypotonic solution.[23] Each 100 mL provides only 17 kcals of glucose.
	• Standardize orders for sodium bicarbonate drips so that very hypotonic solutions (e.g., sodium bicarbonate 50 mEq/L sterile water) are avoided.
	• Reserve IV treatment of hypernatremia for patients who cannot take fluids orally or enterally, or for those who are hemodynamically unstable.[23]

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Clinical Question	Answer/Pertinent Information
When might a sodium-free (D5W) or lower-sodium solution be appropriate?	• For dilution of drugs, when compatible (**D5W**), to prevent hypernatremia in critical care patients [Evidence Level B-3].[30] • To keep peripheral venous catheters patent (i.e., KVO rate) (**D5W**) to prevent hypernatremia in critical care patients.[27] • For treatment of hypovolemic hypernatremia (**D5W**), **after** initial fluid resuscitation.[4,23] • For treatment of diabetic ketoacidosis (**1/2 NS**), **after** initial fluid resuscitation.[9] • For treatment of isovolemic hypernatremia (**D5W**).[33] • Replacement of certain GI losses (e.g., vomiting, nasogastric tube output, diarrhea) or insensible losses (**1/2 NS**).[8,34] • As a maintenance IV fluid in a stable adult (**D5 12 NS**).[32]
What are some concepts regarding safe use of hypertonic solutions?	• Examples of hypertonic solutions include 3% saline, and dextrose concentrations >5% (e.g., D10W, D50W).[7] • Hypertonic solutions can cause phlebitis.[17] The peripheral vs central administration cut-off is generally considered 900 mOsm/L.[17] • Emerging evidence suggests that peripheral administration of 3% sodium chloride for neurological emergencies or severe symptomatic hyponatremia has an acceptable risk of complications (e.g., phlebitis, thrombosis, infiltration).[6,39,40] ○ If a peripheral line is used for administration, experts recommend using the largest peripheral vein available (avoiding a flexion site if feasible) and monitoring the site for redness, swelling, pain, and tenderness.[14] Canadian labeling suggests changing the site every 24 hours.[21] • Keep in mind that like D5W, D10W is a sodium-free source of free water, and although hypertonic, it is not useful for fluid resuscitation because most of the water distributes out of the vascular space.[12] • To minimize errors with hypertonic saline, it has been suggested that hospitals stick with commercially available concentrations (as opposed to compounding) and standardize dosing for specific uses. Special storage, use of warning stickers, and pharmacist oversight are also suggested.[17] • The safety of hypertonic (3%) saline for fluid resuscitation is unclear.[4]

What steps can be taken to ensure that patients don't receive unnecessary IV fluids?	• Determine if fluids can be given orally or enterally.[8]
	• The purpose of maintenance IV fluids/electrolytes is to replacement of insensible losses, maintenance of normal volume status, and ensure kidney function.[38] Needs in adults are generally 25 to 30 mL/kg/day, but should be individulaized.[8,38]
	• Follow daily weights and fluid balance to guide discontinuation or adjustment of fluids.[38]
	• Look for all sources of fluids and subtract these in the daily requirement, including:[35]
	  ○ enteral or parenteral nutrition
	  ○ continuous infusions (e.g., pressors, sedatives)
	  ○ piggybacks(e.g., larger volumes or given frequently)
	• If the patient is getting excess fluids, consider:[35]
	  ○ switching IV meds to the oral, subcutaneous, or IM route (e.g., IV heparin to apixaban or enoxaparin).
	  ○ concentrating continuous infusions.
	  ○ switching from IV infusions to IV push (e.g., antibiotics).

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Abbreviations: AKI = acute kidney injury; D5W = dextrose 5% in water; D10W = dextrose 10% in water; DKA = diabetic ketoacidosis; GI = gastrointestinal; IV = intravenous; KVO = keep vein open; LOS = length of stay; LR = Lactated Ringer's; NNT = number needed to treat; NS = normal saline; TBI = traumatic brain injury

a. US wholesale acquisition cost (WAC). Medication pricing by Elsevier, accessed April 2025.
b. Information from US product labeling unless otherwise indicated: Dextrose solution (Baxter Healthcare, November 2024), Dextrose solution (B. Braun Medical, March 2024), Lactated Ringer's (Baxter, March 2025); Isolyte S pH 7.4 (July2018); Normosol-R (October 2018); Plasma-Lyte A (August 2019); sodium chloride 0.9% injection (Baxter, March 2018).

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In accordance with our goal of providing Evidence-Based information, we are citing the **LEVEL OF EVIDENCE** for the clinical recommendations we publish.

Level	Definition	Study Quality
A	Good-quality patient-oriented evidence.*	1. High-quality randomized controlled trial (RCT) 2. Systematic review (SR)/Meta-analysis of RCTs with consistent findings 3. All-or-none study
B	Inconsistent or limited-quality patient-oriented evidence.*	1. Lower-quality RCT 2. SR/Meta-analysis with low-quality clinical trials or of studies with inconsistent findings 3. Cohort study 4. Case control study
C	Consensus; usual practice; expert opinion; disease-oriented evidence (e.g., physiologic or surrogate endpoints); case series for studies of diagnosis, treatment, prevention, or screening.	

***Outcomes that matter to patients** (e.g., morbidity, mortality, symptom improvement, quality of life).

[Adapted from Ebell MH, Siwek J, Weiss BD, et al. Strength of Recommendation Taxonomy (SORT): a patient-centered approach to grading evidence in the medical literature. Am Fam Physician 2004;69:548-56. https://www.aafp.org/pubs/afp/issues/2004/0201/p548.html.]

References

1. Tommasino C. Fluids and the neurosurgical patient. Anesthesiol Clin North Am. 2002 Jun;20(2):329-46, vi.
2. ISMP. Plain D5W or hypotonic saline solutions post-op could result in acute hyponatremia and death in healthy children. October 1, 2009. https://www.medscape.com/viewarticle/710427 (Accessed April1, 2025).
3. Sterile water should not be given "freely." Pennsylvania Patient Safety Advisory. 2008;5(2):52-6. https://patientsafety.pa.gov/ADVISORIES/Pages/200806_53.aspx. (Accessed April 1, 2025).
4. Myburgh JA, Mythen MG. Resuscitation fluids. N Engl J Med. 2013 Sep 26;369(13):1243-51.
5. Moritz ML, Ayus JC. Hospital-acquired hyponatremia--why are hypotonic parenteral fluids still being used? Nat Clin Pract Nephrol. 2007 Jul;3(7):374-82.
6. Khasiyev F, Hakoun A, Christopher K, et al. Safety and Effect on Intracranial Pressure of 3% Hypertonic Saline Bolus Via Peripheral Intravenous Catheter for Neurological Emergencies. Neurocrit Care. 2024 Aug;41(1):202-207.
7. Crawford A, Harris H. I.V. fluids What nurses need to know. Nursing. 2011 May;41(5):30-8; quiz 38-9.
8. National Institute for Health and Care Excellence. Intravenous fluid therapy in adults in hospital. December 10, 2013. Updated May 5, 2017. https://www.nice.org.uk/guidance/cg174/chapter/1-Recommendations#routine-maintenance-2. (Accessed April 1, 2025).
9. Gosmanov AR, Gosmanova EO, Dillard-Cannon E. Management of adult diabetic ketoacidosis. Diabetes Metab Syndr Obes. 2014 Jun 30;7:255-64.
10. ISMP. 2024-2025 ISMP Targeted medication safety best practices for hospitals. https://www.ismp.org. (Accessed April 1, 2025).
11. Toporek AH, Semler MW, Self WH, et al. Balanced Crystalloids versus Saline in Critically Ill Adults with Hyperkalemia or Acute Kidney Injury: Secondary Analysis of a Clinical Trial. Am J Respir Crit Care Med. 2021 May 15;203(10):1322-1325.
12. Huskisson L. Intravenous volume replacement: which fluid and why? Arch Dis Child. 1992 May;67(5):649-53.
13. Dickerson RN, Maish GO 3rd, Weinberg JA, et al. Safety and efficacy of intravenous hypotonic 0.225%

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sodium chloride infusion for the treatment of hypernatremia in critically ill patients. Nutr Clin Pract. 2013 Jun;28(3):400-8.
14. Metheny, Norma A. PhD, RN, FAAN; Moritz, Michael L. MD. Administration of 3% Sodium Chloride Via a Peripheral Vein: A Literature Review. Journal of Infusion Nursing 44(2):p 94-102, March/April 2021.
15. Wang J, Xu E, Xiao Y. Isotonic versus hypotonic maintenance IV fluids in hospitalized children: a meta-analysis. Pediatrics. 2014 Jan;133(1):105-13.
16. How PP, Lau AH Fluid and electrolyte disorders. In: Zeind CS, Carvalho MG, Cheng JW, et al., editors. Applied Therapeutics: the Clinical Use of Drugs. 12th ed. Philadelphia, PA: Wolters Kluwer Health, 2023:602-31.
17. Patanwala AE, Amini A, Erstad BL. Use of hypertonic saline injection in trauma. Am J Health Syst Pharm. 2010 Nov 15;67(22):1920-8.
18. Rowell SE, Fair KA, Barbosa RR, et al. The Impact of Pre-Hospital Administration of Lactated Ringer's Solution versus Normal Saline in Patients with Traumatic Brain Injury. J Neurotrauma. 2016 Jun 1;33(11):1054-9.
19. Mhanna A, Beran A, Srour O, et al. Balanced crystalloids versus isotonic saline in pediatric sepsis: a comprehensive systematic review and meta-analysis. Proc (Bayl Univ Med Cent). 2024 Feb 8;37(2):295-302.
20. Self WH, Semler MW, Wanderer JP, et al. Balanced Crystalloids versus Saline in Noncritically Ill Adults. N Engl J Med. 2018 Mar 1;378(9):819-828.
21. Product monograph for 3% and 5% sodium chloride injection, USP. Baxter Corporation. Mississauga, ON L5N 0C2. July 2018.
22. ISMP. Best practice #10 FAQ. August 29, 2016. https://www.ismp.org. (Accessed July 29, 2022).
23. Erstad BL, Huckleberry YC. Extremely hypo-osmolar intravenous solutions to treat hypernatremia: the time has come to stop. Am J Health Syst Pharm 2022 Jun 23;79(13):1122-1125.
24. Hasim N, Bakar MAA, Islam MA. Efficacy and Safety of Isotonic and Hypotonic Intravenous Maintenance Fluids in Hospitalised Children: A Systematic Review and Meta-Analysis of Randomised Controlled Trials. Children (Basel). 2021 Sep 8;8(9):785.
25. Hall AM, Ayus JC, Moritz ML. Things We Do For No Reason: The Default Use of Hypotonic Maintenance Intravenous Fluids in Pediatrics. J Hosp Med. 2018 Sep;13(9):637-640.
26. Silverthorn DU. Isosmotic is not always isotonic: the five-minute version. Adv Physiol Educ. 2016 Dec;40(4):499-500.
27. Choo WP, Groeneveld AB, Driessen RH, Swart EL. Normal saline to dilute parenteral drugs and to keep catheters open is a major and preventable source of hypernatremia acquired in the intensive care unit. J Crit Care. 2014 Jun;29(3):390-4.
28. Ostermann M, Randolph AG. Resuscitation Fluid Composition and Acute Kidney Injury in Critical Illness. N Engl J Med. 2022 Mar 3;386(9):888-889.
29. Semler MW, Self WH, Wanderer JP, et al. Balanced Crystalloids versus Saline in Critically Ill Adults. N Engl J Med. 2018 Mar 1;378(9):829-839.
30. Aoyagi Y, Yoshida T, Uchino S, et al. Saline versus 5% dextrose in water as a drug diluent for critically ill patients: a retrospective cohort study. J Intensive Care. 2020 Sep 11;8:69.
31. Clinical Pharmacology powered by Clinical Key. Tampa, FL: Elsevier; 2025. https://www.clinicalkey.com. (Accessed April 1, 2025).
32. Sanchez J, Lichtenberg R. Does my patient need maintenance fluids? Cleve Clin J Med. 2019 Oct;86(10):653-655.
33. Kraft MD, Btaiche IF, Sacks GS, Kudsk KA. Treatment of electrolyte disorders in adult patients in the intensive care unit. Am J Health Syst Pharm. 2005 Aug 15;62(16):1663-82.
34. Hawkins WA, Smith SE, Newsome AS, et al. Fluid Stewardship During Critical Illness: A Call to Action. J Pharm Pract. 2020 Dec;33(6):863-873.
35. Hawkins WA, Butler SA, Poirier N, et al. From theory to bedside: Implementation of fluid stewardship in a medical ICU pharmacy practice. Am J Health Syst Pharm. 2022 Jun 7;79(12):984-992.
36. Finfer S, Micallef S, Hammond N, et al. Balanced Multielectrolyte Solution versus Saline in Critically Ill Adults. N Engl J Med. 2022 Mar 3;386(9):815-826.
37. Zampieri FG, Machado FR, Biondi RS, et al. Effect of Intravenous Fluid Treatment With a Balanced Solution vs 0.9% Saline Solution on Mortality in Critically Ill Patients: The BaSICS Randomized Clinical Trial. JAMA. 2021 Aug 10;326(9):1–12.
38. Carr JR, Hawkins WA, Newsome AS, et al. Fluid Stewardship of Maintenance Intravenous Fluids. J Pharm Pract. 2021 Apr 8:8971900211008261.
39. Madieh J, Hasan B, Khamayseh I, et al. The safety of intravenous peripheral administration of 3% hypertonic saline: A systematic review and meta-analysis. Am J Med Sci. 2023 Aug;366(2):135-142.
40. Brown CS, Rabinstein AA, Zhao Y, Wieruszewski ED. Safety of peripheral 3% hypertonic saline bolus administration for neurologic emergency. Am J Emerg Med. 2023 Jul;69:83-86.
41. Emrath ET, Fortenberry JD, Travers C, et al. Resuscitation With Balanced Fluids Is Associated With Improved Survival in Pediatric Severe Sepsis. Crit Care Med. 2017 Jul;45(7):1177-1183.
42. Diz JC, Luna-Rojas P, Díaz-Vidal P, et al. Effect of Treatment With Balanced Crystalloids Versus Normal Saline on the Mortality of Critically Ill Patients With and Without Traumatic Brain Injury: A Systematic Review and Meta-Analysis. Anesth Analg. 2025 Jan 20.
43. Tenner S, Vege SS, Sheth SG, et al. American College of Gastroenterology Guidelines: Management of Acute Pancreatitis. Am J Gastroenterol. 2024 Mar 1;119(3):419-437.
44. Farrell PR, DesPain AW, Farmer P, et al. Faster discharge with lactated ringers than normal saline in first 72 h of acute pancreatitis: A multicenter randomized trial. J Pediatr Gastroenterol Nutr. 2024 Feb;78(2):360-368.

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45. Chen H, Lu X, Xu B, et al. Lactated Ringer Solution Is Superior to Normal Saline Solution in Managing Acute Pancreatitis: An Updated Meta-analysis of Randomized Controlled Trials. J Clin Gastroenterol. 2022 Feb 1;56(2):e114-e120.
46. Antoniak D, Twohig P, Olson K, et al. Lactated Ringer's or Normal Saline for Initial Resuscitation in Patients Hospitalized With Acute Pancreatitis: A Retrospective Database Analysis. Pancreas. 2023 Mar 1;52(3):e203-e209.
47. Evans L, Rhodes A, Alhazzani W, et al. Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock 2021. Crit Care Med. 2021 Nov 1;49(11):e1063-e1143.
48. Umpierrez GE, Davis GM, ElSayed NA, et al. Hyperglycemic Crises in Adults With Diabetes: A Consensus Report. Diabetes Care. 2024 Aug 1;47(8):1257-1275.
49. ISMP Canada. ISMP Canada Safety Bulletin. Reducing the Risk of Hospital-Acquired Hyponatremia: Intravenous Fluid Management and Monitoring. 2024 June 18;24(6). https://ismpcanada.ca. (April 8, 2025).
50. Acarregui MJ. Fluid and electrolyte management in the newborn. May 18, 2022. In: Iowa Neonatology Handbook. https://uihc.org/childrens/educational-resources/fluid-management-nicu-handbook. (Accessed April 8, 2025).

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