Solubility Study of Zinc and Phosphates in PN and IV Fluid

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What is that Brown Precipitate?
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Background

- Home Parenteral Nutrition (HPN) consumers admitted for sepsis
- Blood cultures and urine cultures
What is that Brown Precipitate?

- PN switched to Dextrose 5% + PN ingredients until blood cultures are negative
  - Insulin removed
  - Calcium gluconate removed
  - Infused over 24 hours
What is that Brown Precipitate?

- Brown precipitate seen on filter in several IVs
- No record of any history of precipitate in HPN fluids
What is that Brown Precipitate?

- Filter with precipitate sent for analysis via electron microscope
- What is your guess as to what it was?
What is that Brown Precipitate?

- Dextrose 5% 1000 mL
- Magnesium sulfate 36 mEq
- Sodium phosphates 24 mmol
- Potassium chloride 40 mEq
- Sodium acetate 55 mEq
- MVI Adult 10 ml
- Multitrace-4 Conc. 1 ml
- Copper 0.8 mg
- Selenium 120 mcg
- Zinc 10 mg
- Famotidine 40 mg
- Octreotide 600 mcg
What is that Brown Precipitate?

- **ZINC PHOSPHATE**

- Like calcium, which precipitates more readily with phosphates in IV fluids, zinc does as well.

- As divalent cations, both have limited solubility with phosphates.
What is that Brown Precipitate?

- The conventional synthesis method of zinc phosphate consists in its preparation from an aqueous solution using zinc sulfate and sodium dihydrogen phosphate according to the following reaction:

\[
3\text{ZnSO}_4\cdot7\text{H}_2\text{O} + 2\text{Na}_2\text{HPO}_4\cdot2\text{H}_2\text{O} \rightarrow \\
\text{Zn}_3(\text{PO}_4)_2\cdot4\text{H}_2\text{O} + \text{H}_2\text{SO}_4 + 2\text{Na}_2\text{SO}_4 + 21\text{H}_2\text{O}
\]
What is that Brown Precipitate?

- Zinc phosphate has a solubility product (Ksp) of $9.0 \times 10^{-33}$
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- **Hypothesis:** By changing the concentrations of zinc and phosphates, we can find the maximum amounts that may be added together to avoid precipitation.

- **Aim:** This study will help decide the maximum levels of zinc (as chloride or sulfate) and phosphates that can be admixed in both parenteral nutrition (PN) and IV fluids with electrolytes.
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- Zinc (15 mg) and sodium phosphates (24 mmol) were admixed in a solution of 5% dextrose with electrolytes and resulted in a precipitation in the filter. When repeated, the precipitate reoccurred.
  - When the same solution was admixed without zinc, the precipitate did not occur.
  - When the same solution was admixed without phosphates, the precipitate did not occur.
- No precipitate appeared in a PN formula with same ingredients.
Zinc phosphate solubility

- Original IV Formula: 1000 ml
  - Dextrose 5%: 50 g
  - Magnesium sulfate: 36 mEq
  - Sodium phosphates: 24 mmol
  - Potassium chloride: 40 mEq
  - Sodium acetate: 55 mEq
  - MVI Adult: 10 ml (contains riboflavin phosphate)
  - Multitrace-4 Conc.: 1 ml
  - Copper: 0.8 mg
  - Selenium: 120 mcg
  - Zinc: 10 mg
  - Famotidine: 40 mg
  - Octreotide: 600 mcg
Zinc phosphate solubility

- D5lytes with 15 mg zinc and
  - 12 mmol phosphorus (as sodium phosphates)
  - 6 mmol phosphorus (as sodium phosphates)

- Continue down in 3 mmol increments until precipitate disappears. Then increase by 1 mmol until precipitate appears.
Zinc phosphate solubility

- D5lytes with 24 mmol phosphorus and
  - 10 mg zinc
  - 5 mg zinc

- Continue down in 2 mg increments until precipitate disappears. Then increase by 1 mg until precipitate appears.
Zinc phosphate solubility

- HPN with 15 mg zinc and
  - 27 mmol phosphorus (as sodium phosphates)
  - 30 mmol phosphorus (as sodium phosphates)

- Continue up in 3 mmol increments until precipitate disappears. Then decrease by 1 mmol until precipitate appears.
Zinc phosphate solubility

- HPN with 24 mmol phosphorus and
  - 17 mg zinc
  - 19 mg zinc

- Continue up in 2 mg increments until precipitate disappears. Then decrease by 1 mg until precipitate appears.
Zinc phosphate solubility in IV Fluid

D5lytes: Zinc + Phosphates precipitation

- Zinc (mg)
- Sodium phosphate (mmol)

Series 1
Zinc phosphate solubility in PN

![Graph showing solubility of Zinc phosphate in PN](image)
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- **Results:**
  - All mixtures of zinc and phosphates tested in D5lytes precipitated.
  - All mixtures of zinc and phosphates tested in PN did not precipitate.
  - The tested pH of the IV fluid and the PN mixtures was similar.
Conclusion

- When switching from HPN to D5 + PN lytes:
  - Remove insulin
  - Remove calcium
  - REMOVE ZINC
References