

An expert clinical decision support system to guide appropriate use of intravenous fluid during a national emergency

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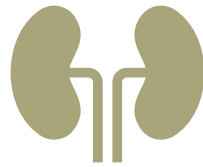
BMIN 5200 Final Project Presentation

December 12, 2024

Background



Intravenous fluids (IVF) are a mainstay of hospital care, used to treat a variety of conditions like shock, trauma



Also used for dialysis patients and in operating rooms for irrigation



Large hospital systems can use a lot of fluid

2600 liters/day at [University Hospitals Cleveland](#)

Two most commonly used IVF

LR

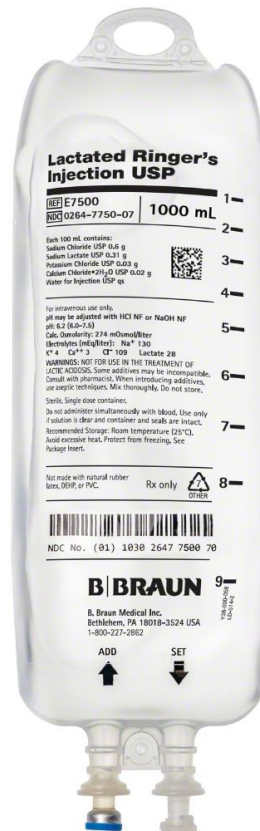


Image courtesy of:
<https://www.bbraunusa.com/en/products/b5/lactated-ringer-39sinjectionusp1000ml.html>

NS



Image courtesy of:
<https://www.calea.ca/catalogue/calea/index.php/virtuemart-live/i-v-supplies/solutions/solution-normal-saline-1l-detail>

Marketplace realities

- Not glamorous
- Low margin product
- Few companies make IVF in the U.S.
 - Baxter (60%)
 - B. Braun Medical (23%)
 - Fresenius and ICU Medical

Long before Helene, IV fluid shortages plagued hospitals; Baxter | IV Fluids Manufacturing

Some ER patients are half as likely to receive IV fluids since disruptions from Hurricane Helene

By Deidre McPhillips, CNN
5 minute read · Updated 12:14 PM EDT, Thu October 31, 2024



Hurricane Helene damaged Baxter's North Cove site in North Carolina in September, disrupting the largest source of IV fluids in the US. Julia Wall for The Washington Post/Getty Images

(CNN) — Patients visiting emergency departments for dehydration or nausea are half as likely to receive IV fluids now than they were before Hurricane Helene exacerbated supply shortages, according to an [analysis](#) of health records by Truveta Research.

Patients scramble for treatments as hospitals conserve IV fluids after storms

Hospitals delayed or canceled treatments after IV fluid maker Baxter International closed its North Carolina facility because of damage from Hurricane Helene.



SHOTS - HEALTH NEWS

Nationwide IV fluid shortage changing how hospitals manage patient hydration

NOVEMBER 19, 2024 · 8:00 AM ET
FROM KFF Health News
By Jackie Fortiér

3-Minute Listen + PLAYLIST



Problems

- Critical scarcity of IVF
- Clinicians need guidance about what IVF to order
- Hospitals need to conserve extremely limited supplies of IVF

ProblemsExpert System

- **Address the** critical scarcity of IVF
- Clinicians need guidance about what to order
 - **Provide ordering guidance to clinicians**
- Hospitals need to conserve extremely limited supplies of IVF
 - **Help hospitals conserve supply of IVF**

Materials and Methods

- Reviewed evidence about IVF types and volume recommendations for common conditions
 - Sometimes good evidence and clear guidance
 - Sometimes not
 - No guidance for how to adjust IVF in a national emergency
- Shock
- Rehydration
- Maintenance (temporarily nothing by mouth)
- Contrast radiology study
- Pancreatitis
- Diabetic ketoacidosis (DKA)

Design

- Expert system built with CLIPSPY, simple text-based user interface
- Intended for use by clinicians
- Principle: minimize clinician data entry to extent possible; speed is everything

Indication

IVF supply
level

Heart
failure
status, if
applicable



Sample scenarios

- A 24 year-old needing rehydration when supply status is green
- A 68 year-old having a radiology study that involves contrast when supply status is yellow
- A 52 year-old with a history of heart failure needing treatment for pancreatitis when supply status is red

IV Fluid Supply Level

Condition	Preferred fluid	GREEN	YELLOW	RED
		Therapy recommendation_Green	Therapy recommendation_Yellow	Therapy recommendation_Red
Shock	Ir, ns	30ml/kg Ir or ns bolus	30ml/kg Ir or ns bolus	Consider vasopressor therapy. Consider 15-30ml/kg Ir or ns bolus.
Adjust Shock for HF?	No	No	No	No
Rehydration	Ir, ns	20ml/kg Ir or ns bolus and reassess clinically.	20ml/kg Ir or ns bolus and reassess clinically Consider oral rehydration if possible.	20ml/kg Ir or ns bolus and reassess clinically Consider oral rehydration if possible.
Adjust Rehydration for HF?	Yes	15ml/kg Ir or ns bolus and reassess clinically.	15ml/kg Ir or ns bolus and reassess clinically. Consider oral rehydration if possible.	15ml/kg Ir or ns bolus and reassess clinically. Consider oral rehydration if possible.
Maintenance	Ir, ns	25ml/kg/day Ir for up to 1 day and then reassess clinically.	25ml/kg/day Ir for up to 1 day and then reassess clinically. Consider oral hydration if possible.	20ml/kg/day Ir for up to 1 day and then reassess clinically. Consider oral hydration if possible.
Adjust Maintenance for HF?	Yes	15ml/kg/day Ir for up to 1 day and then reassess clinically	15ml/kg/day Ir for up to 1 day and then reassess clinically	15ml/kg/day Ir for up to 1 day and then reassess clinically
Contrast	ns	1 ml/kg/hour ns starting 1 hour before contrast study and for 6 hours after contrast study	1 ml/kg/hour ns starting 1 hour before contrast study and for 6 hours after contrast study	0.5ml/kg/hr ns starting 1 hour before contrast study and for 6 hours after contrast study. Consider oral hydration if possible.
Adjust Contrast for HF?	No	No	No	No
Pancreatitis	Ir, ns	10ml/kg bolus Ir or ns then 1.5ml/kg/hr	10ml/kg bolus Ir or ns then 1.5ml/kg/hr and reassess clinically at 6 hours	5ml/kg bolus Ir or ns then 1ml/kg/hr and reassess clinically at 6 hours
Adjust Pancreatitis for HF?	Yes	10ml/kg bolus Ir or ns then 1.5ml/kg/hr and reassess clinically at 6 hours	10ml/kg bolus Ir or ns then 1.5ml/kg/hr and reassess clinically at 6 hours	5ml/kg bolus Ir or ns then 1ml/kg/hr and reassess clinically at 6 hours
DKA	Ir, ns	15-20 mL/kg of body weight per hour Ir or ns for the first 1-2 hours, then adjust based on clinical status	15-20 mL/kg of body weight per hour Ir or ns for the first 1-2 hours, then adjust based on clinical status	10-15 mL/kg of body weight per hour Ir or ns for the first 1-2 hours, then adjust based on clinical status
Adjust DKA for HF?	No	No	No	No

Forward chaining to save clinicians time

```
#Rule to check patients over 50 for possible HF, as HF may require more conservative fluid  
#Limited to indications for which ivf recommendation would be adjusted for HF  
DEFRULE_HF_READ = ""  
(defrule HF_READ ; does this patient have HF?  
  (logical  
    —»(patient (age_is ?age))  
    —»(test(>= ?age 50))  
    —»(or  
      (indication (fluid_indication rehydration))  
      (indication (fluid_indication maintenance))  
      (indication (fluid_indication pancreatitis))  
    )  
  )  
  =>  
  (read_assert hf)  
)  
""  
env.build(DEFRULE_HF_READ)
```

- Prompt HF question iff:
 - Patient at risk of HF AND
 - HF status would alter IVF recommendation
- Rule: Age \geq 50 and a relevant condition prompts HF question

Dynamic presentation of HF question, with IVF recommendation tailored for HF status

Enter patient name: Sharon

Enter patient age (in years): 78

What is the indication for IV fluid? (shock rehydration maintenance contrast pancreatitis dka): rehydration

What is the current IV fluid supply level? (green, yellow, or red): red

Does this patient have a history of or suspicion for heart failure? (yes/no): yes

For Sharon for condition rehydration recommend 15ml/kg 1r or ns bolus and reassess clinically. Consider oral rehydration if possible.

****1r preferred and use caution with iv fluids - heart failure patient****

Advantages/Disadvantages

Advantages

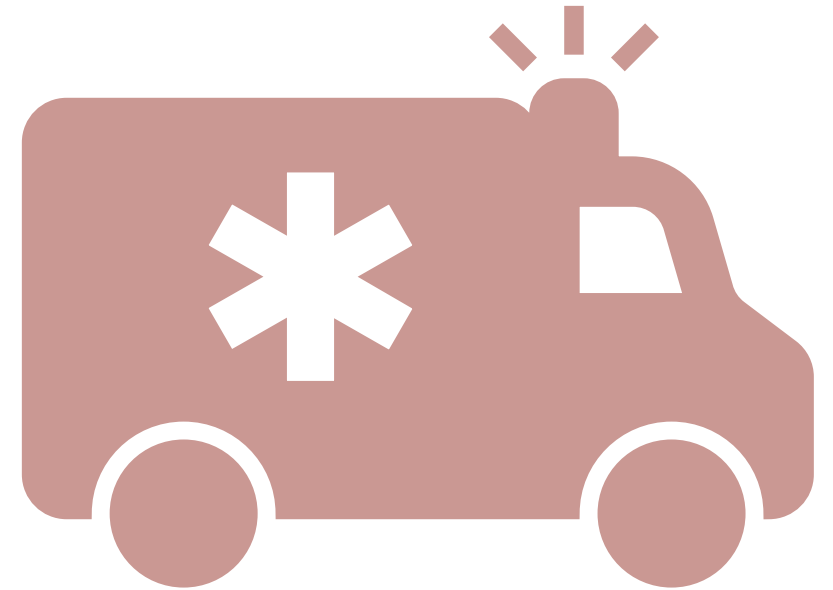
- Real-time IVF guidance for clinicians
- Evidence-based to extent possible
- Potential to integrate with EHR
 - Where clinicians do their work
 - Access key EHR data (kg, Cr), limit need for manual data entry
- Relatively simple to develop; rapid deployment

Disadvantages

- A prototype; not EHR-integrated. Would it be used?
- IVF recommendations may vary site to site, ? transferability of knowledge, scalability of expert system
- Lacks rationale for recommendations and ability to query rules like Shortliffe's MYCIN
- Needs ongoing maintenance by an expert
- Is it worth building in an emergency?

Conclusion

- A prototype expert system can meet key needs during an IVF emergency.
 - Guide clinicians to the right fluid orders enabling them to provide high-quality care
 - Enable hospitals to conserve scarce IVF supplies
- Holds potential to provide value in the current and future IVF crises



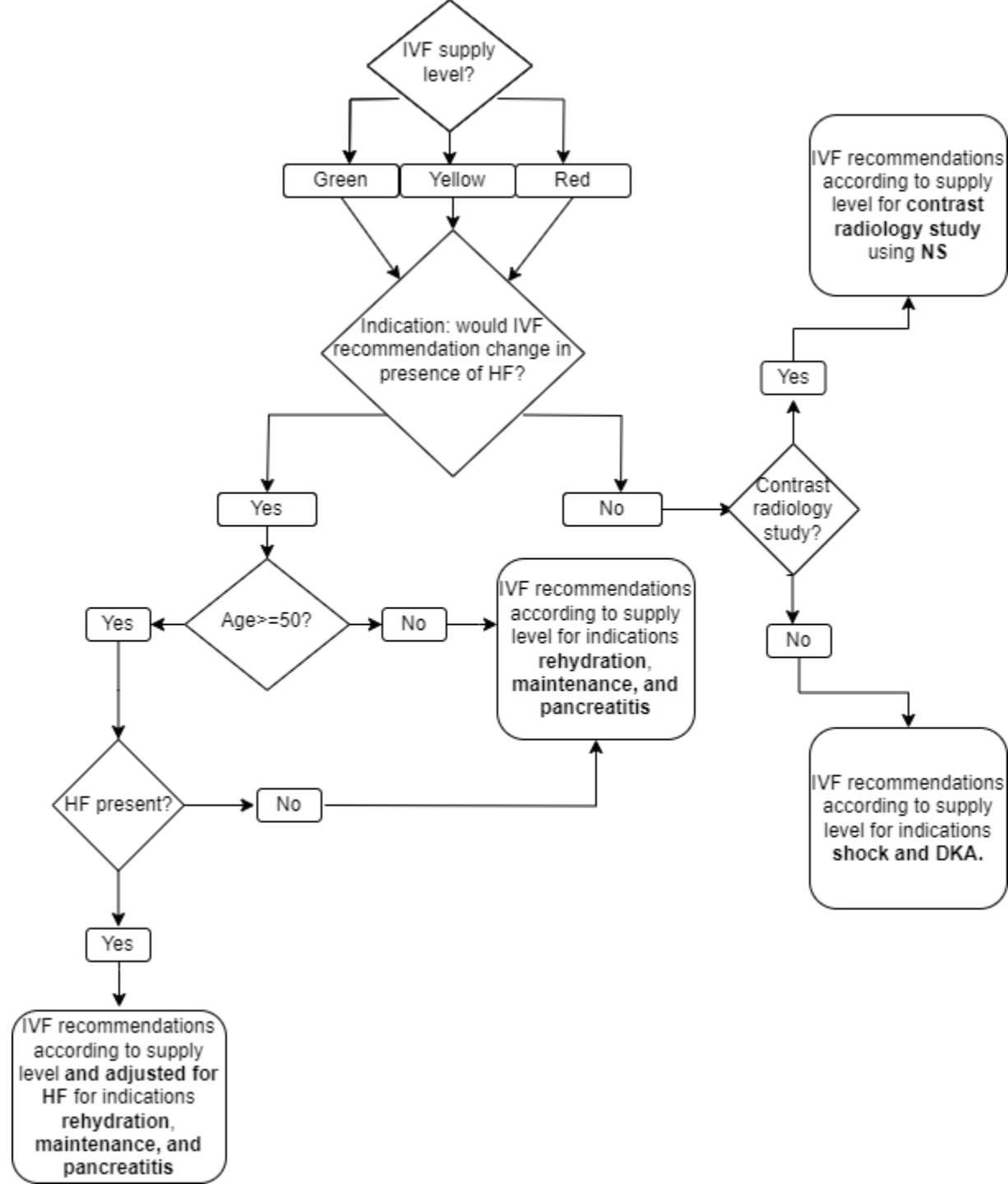
Comments and questions

For more information:

<https://github.com/mcgreevj/BMIN-5200>

Appendix





PennChart

Epic

Hyperspace®
February 2024

Featuring
EpicCare

🔔 Important Message

Monday October 7, 2024 11:09 AM

Due to the recent hurricane impact on the Baxter facility in North Carolina, we are experiencing a nationwide shortage of IV solutions affecting all types and sizes. We have actively deployed a clinician team to review supplies on hand and we recommend the following strategies to assist in conserving our supply.

Conservation Strategies

- Use oral hydration whenever possible
 - o When possible, utilize oral medications for electrolytes, antimicrobials and iron
- Evaluate clinical need of IV hydration frequently; at a minimum each

Continue

Last login Mon Nov 25, 2024 3:41 PM EST.

User interface with sample responses and IVF recommendation

```
Enter patient name: Tony
Enter patient age (in years): 35
What is the indication for IV fluid? (shock rehydration maintenance contrast pancreatitis dka): shock
What is the current IV fluid supply level? (green, yellow, or red): green
```

Given the indication selected, you may choose a fluid type.

```
Enter the desired IV fluid type (either lr or ns): lr
```

```
_____
For Tony for condition shock recommend 30ml/kg lr or ns bolus
**lr is preferred**
_____
```

```
print_facts(env)

(hf (hf_status unknown))
(patient (name_is "Tony") (age_is 35))
(indication (fluid_indication shock))
(supply (supply_status green))
(fluid (fluid_type lr))
Total facts: 5
```

 **Fact base**