What About the Bolus?

Burn Resuscitation in Pediatric and Adult Patients

Habiba Hashimi MD
Evans Haynes Burn Center

Demographics

40,000 annual hospital admissions, 1/3 are pediatric patients

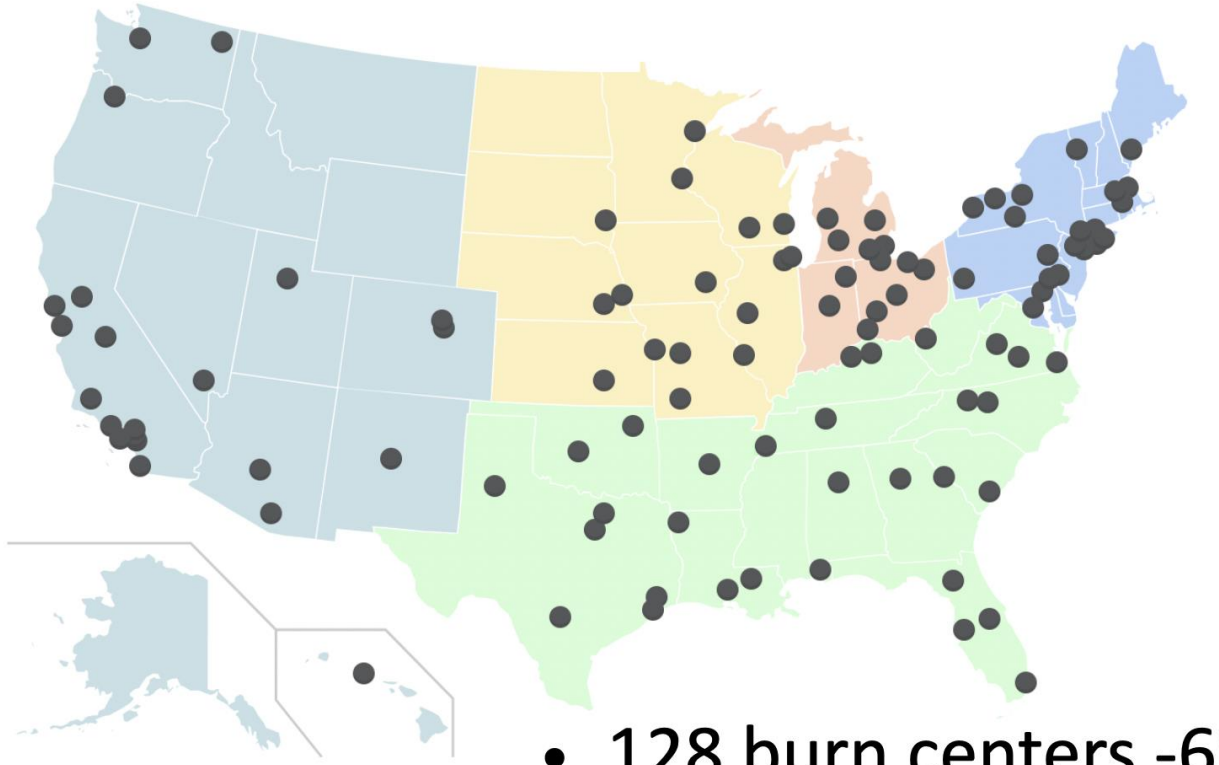
House fires are the leading cause

- Children under 5 are at a higher risk

Scald Burns are the most common mechanism of injury among pediatric patients

- 71% of all burn injuries nationwide

Flame burns are the dominant cause of burns in adolescents and are associated with increased severity and need for hospitalization compared to other burns.



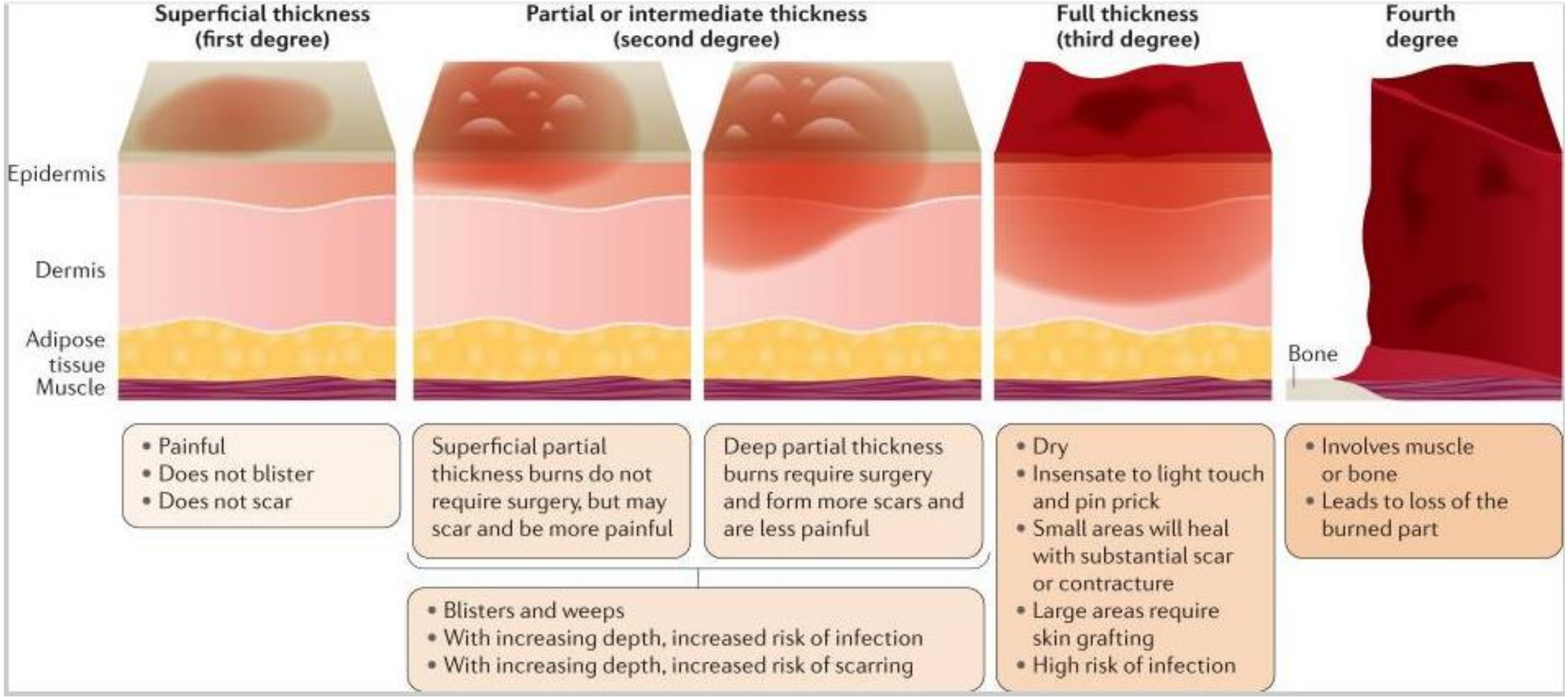
- 128 burn centers -60% of all burn admissions
- (avg of 200 admissions per hospital)

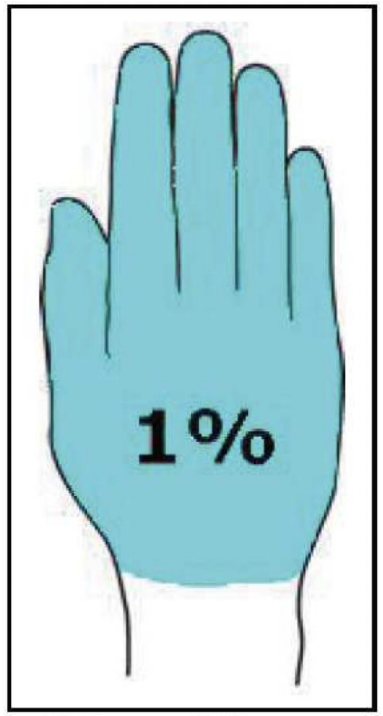
What are the American Burn Association burn center transfer criteria?

	Immediate Consultation with Consideration for Transfer	Consultation Recommendation
Thermal Burns	• Full thickness burns • Partial thickness ≥10% TBSA* • Any deep partial or full thickness burns involving the face, hands, genitalia, feet, perineum, or over any joints • Patients with burns and other comorbidities • Patients with concomitant traumatic injuries • Poorly controlled pain	• Partial thickness burns <10% TBSA* • All potentially deep burns of any size
Inhalation Injury	• All patients with suspected inhalation injury	• Patients with signs of potential inhalation such as facial flash burns, singed facial hairs, or smoke exposure
Pediatrics (≤14 years, or <30 kg)	• All pediatric burns may benefit from burn center referral due to pain, dressing change needs, rehabilitation, patient/caregiver needs, or non-accidental trauma	
Chemical Injuries	• All chemical injuries	
Electrical Injuries	• All high voltage (≥1,000V) electrical injuries • Lightning injury	• Low voltage (<1,000V) electrical injuries should receive consultation and consideration for follow-up in a burn center to screen for delayed symptom onset and vision problems

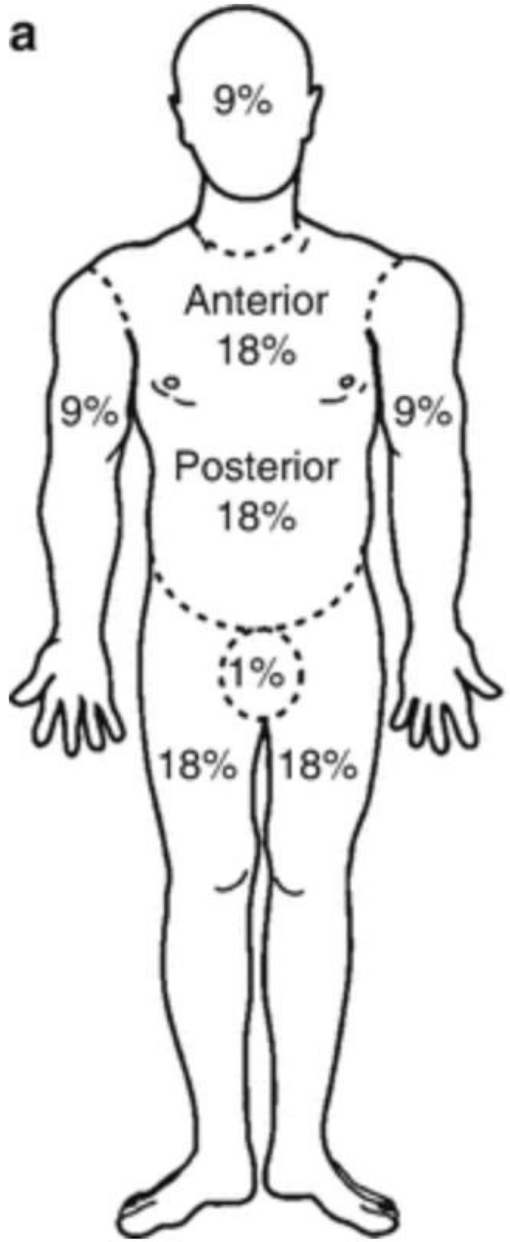
Case 1

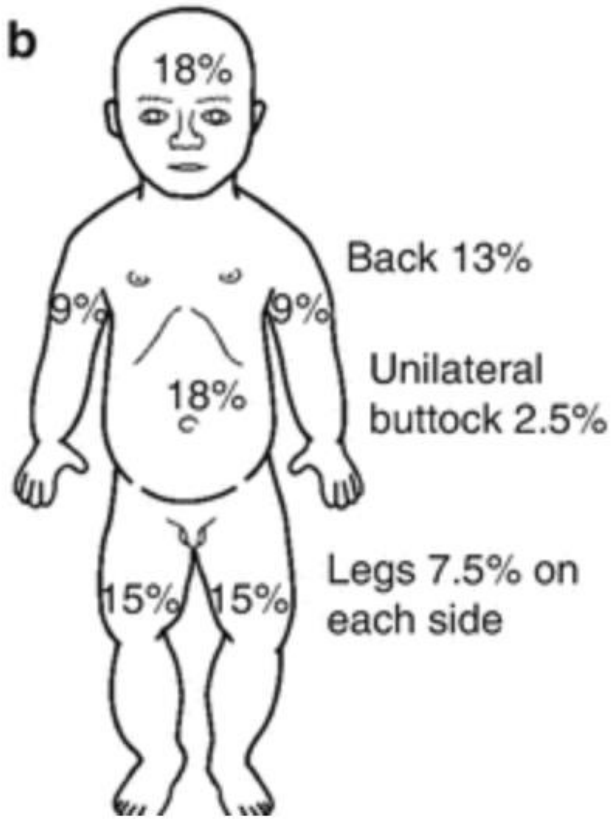
41 year old man presenting after being found down outside of a burning building. He was intubated on scene.


Superficial thickness (first degree)
Partial or intermediate thickness (second degree)
Full thickness (third degree)
Fourth degree
Epidermis
Dermis
Adipose tissue
Muscle
Bone
• Painful
• Does not blister
• Does not scar
Superficial partial thickness burns do not require surgery, but may scar and be more painful
Deep partial thickness burns require surgery and form more scars and are less painful
• Blisters and weeps
• With increasing depth, increased risk of infection
• With increasing depth, increased risk of scarring
• Dry
• Insensate to light touch and pin prick
• Small areas will heal with substantial scar or contracture
• Large areas require skin grafting
• High risk of infection
• Involves muscle or bone
• Leads to loss of the burned part



Palm and fingers of the patient = 1% TBSA





2 mL x kg x BSA = fluids over 24 hours (first half within the first 8 hours)

Initial Fluid Resuscitation Formulas for Larger Burns

Modified Brooke Formula**

% TBSA burned
X **2** cc/hr **Lactated Ringer's (LR)** ***LR preferred d/t LESS ACIDIC*
X body weight in kg

Give **½ in 1st 8 hrs**, the **rest in next 16 hours**, using urine output as a guide.
- Pediatrics – to this volume, add maintenance fluids (which contain dextrose).

1. **Calculate the 24 hour volume needed for a 50 kg man with 90% TBSA burn wounds.**
2. **How does your volume needed change if EMS has bolused the patient with 2L of IVF prior to arrival?**
3. **When is time 0 for resuscitation?**

Calculate the 24 hour volume needed for a 50 kg man with 90% TBSA burn wounds.

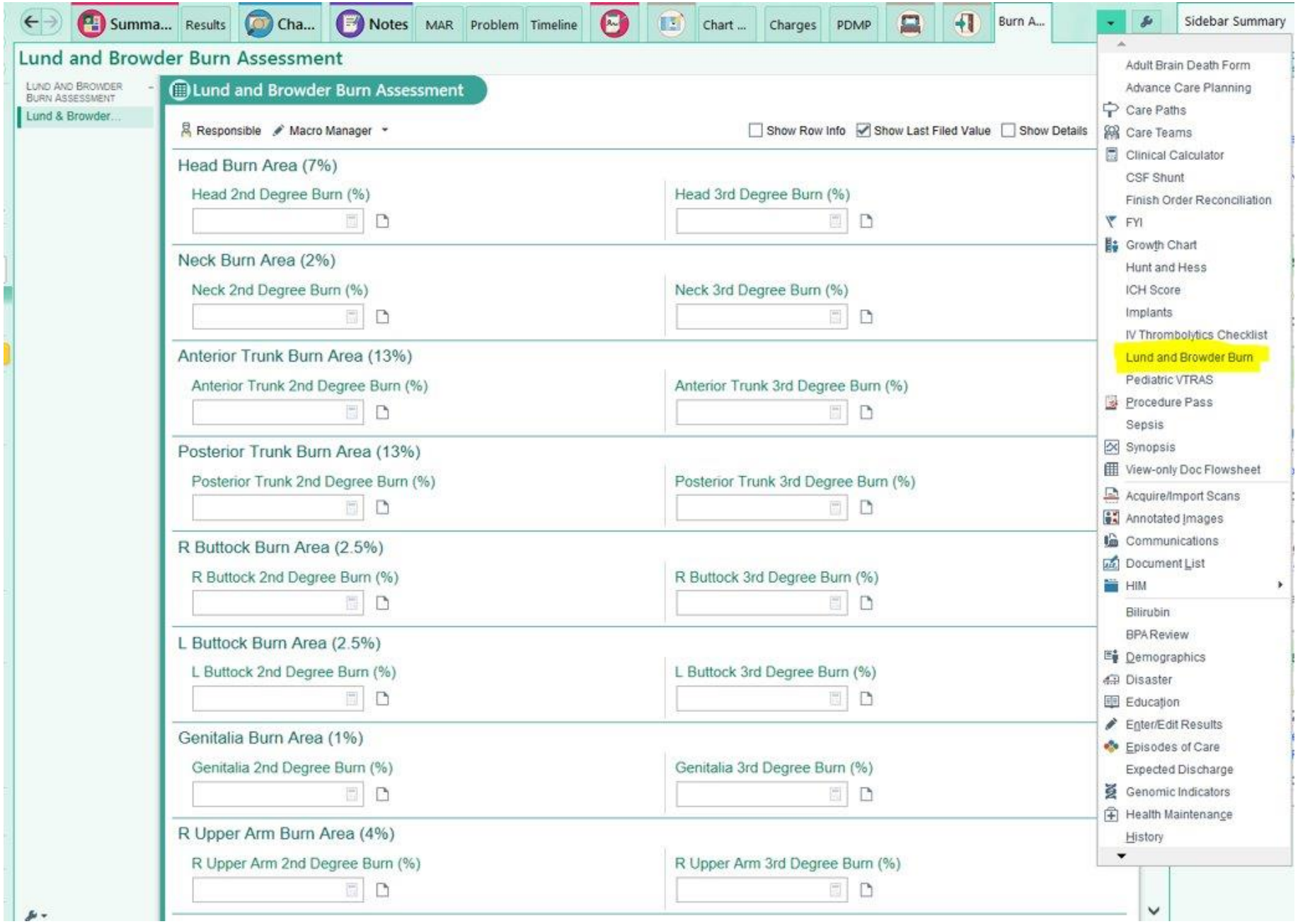
a) 2 x 50 kg x 90% = 9000 mL

How does your volume needed change if EMS has bolused the patient with 2L of IVF prior to arrival?

a) 3,500 mL in the first 8 hours

When is time 0 for resuscitation?

a) When the injury occurs, not when EMS started treatment or when patient arrives to trauma bay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Results
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Timeline
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Burn A...
Sidebar Summary
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LUND AND BROWDER BURN ASSESSMENT
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Lund and Browder Burn Assessment
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Macro Manager
Show Row Info
Show Last Filed Value
Show Details
Head Burn Area (7%)
Head 2nd Degree Burn (%)
Head 3rd Degree Burn (%)
Neck Burn Area (2%)
Neck 2nd Degree Burn (%)
Neck 3rd Degree Burn (%)
Anterior Trunk Burn Area (13%)
Anterior Trunk 2nd Degree Burn (%)
Anterior Trunk 3rd Degree Burn (%)
Posterior Trunk Burn Area (13%)
Posterior Trunk 2nd Degree Burn (%)
Posterior Trunk 3rd Degree Burn (%)
R Buttock Burn Area (2.5%)
R Buttock 2nd Degree Burn (%)
R Buttock 3rd Degree Burn (%)
L Buttock Burn Area (2.5%)
L Buttock 2nd Degree Burn (%)
L Buttock 3rd Degree Burn (%)
Genitalia Burn Area (1%)
Genitalia 2nd Degree Burn (%)
Genitalia 3rd Degree Burn (%)
R Upper Arm Burn Area (4%)
R Upper Arm 2nd Degree Burn (%)
R Upper Arm 3rd Degree Burn (%)
Adult Brain Death Form
Advance Care Planning
Care Paths
Care Teams
Clinical Calculator
CSF Shunt
Finish Order Reconciliation
FYI
Growth Chart
Hunt and Hess
ICH Score
Implants
IV Thrombolytics Checklist
Lund and Browder Burn
Pediatric VTRAS
Procedure Pass
Sepsis
Synopsis
View-only Doc Flowsheet
Acquire/Import Scans
Annotated Images
Communications
Document List
HIM
Bilirubin
BPA Review
Demographics
Disaster
Education
Enter/Edit Results
Episodes of Care
Expected Discharge
Genomic Indicators
Health Maintenance
History

Burn Pathophysiology

- Massive inflammation from depth and extent of burn injury and evaporative loss from the destruction of the cutaneous barrier
- Leading to progressive volume depletion and organ perfusion leading to failure
- If unabated this will most certainly lead to death

History of Burn Resuscitation


Fit to Print.

VOL. LXXI....No. 23,319.

NEW HAVEN THEATRE BURNS; FIND 4 DEAD; MAY BE 30 VICTIMS

Blaze Starts on Stage and Sweeps Through Old Structure With Great Rapidity.

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Rialto Theatre Fire 1921

Cocoanut Grove Nightclub 1942

History of Burn Resuscitation

Investigator (Formula)	Year of publication	1st 24 hour period	2nd 24 hour period
Harkins	1942	Plasma @ 1000cc x TBSA + Saline @ ≤ plasma volume administered	
Cope & Moore (Surface Area Formula)	1947	Plasma 75cc x TBSA (IV) + Electrolyte sol. 75cc x TBSA (po) + 2000cc fruit juice (po) or 2000cc glucose in water (IV) Electrolyte sol. = 1/3 $NaHCO_3$ + 2/3 NaCl. Half of the total to be given in first 8 hrs, second half given in subsequent 16 hrs.	One half the total volume given in the first 24 hrs.
Evans (Surface Area-Weight Formula)	1952	Colloid @ 1cc x kg x TBSA + Saline @ 1cc x kg x TBSA + 2000cc glucose in water	Colloid @ (1cc/kg x TBSA)/2 + Saline @ (1cc/kg xTBSA)/2 + 2000cc glucose in water
Brooke Army Hospital	1953	Colloid 0.5cc x kg x TBSA + Electrolyte sol. 1.5cc x kg x TBSA + 2000cc glucose in water	50% to 75% of previous colloid and electrolyte vol. + 2000cc glucose in water
Muir & Barclay	1962	Plasma @ (kg x TBSA)/2 given over 4 hrs x 3, 6 hrs x 2 and 12 hrs x 1 + 60cc to 100cc water po	
Baxter & Shires (Parkland)	1968	RL @ 4cc x kg x TBSA. Half of the total to be given over first 8 hrs, second half given in subsequent 16 hrs	Plasma @ 0.3 to 0.5 cc x kg x TBSA to be given over 8 hrs. + RL and glucose in water titrated to urine output of 50cc/hr
Griffiths & Laing	1981	Plasma @ kg x 7.5%, 1/3 to be given over first 8hrs, 1/3 over next 12 hrs, final 1/3 over the next 20-36 hrs.	
Slater & Goldfarb (West Penn)	1991, 2005	FFP @ 75cc x kg over 36 hrs + RL @ 83cc/hr. FFP titrated to urine output of 0.5 to 1.0 cc/kg.	FFP and RL continued x 48hrs.
Matsuda & Tanaka (Vitamin C)	1992, 1995, 1997	Ascorbic acid @ 66mg x kg in RL titrated to urine output of 0.5 to 1.0 cc/kg for a minimum of 8 hrs	

2000 Pruitt coined term “fluid creep” to describe increasing resuscitation volumes and lead to problems such as abdominal and extremity compartment syndromes, pulmonary and cerebral edema, ARDS, and MODS

2007 Saffle performed a comprehensive review of fluid creep and inciting factors

- restricting early fluid resuscitation
- consider use of routine colloid
- use resuscitation protocols
- avoidance of continuous opioid use during first 24 hours

2008 ABA Practice Guidelines for Burn Shock Resuscitation

- Fluid resuscitation regardless of solution type titrated to maintain UOP of 0.5-1 ml/kg/hr in adults and 1-1.5 ml/kg/hr in children

- The addition of colloid containing fluid following burn injury especially 12-24h post burn may decrease overall fluid requirements

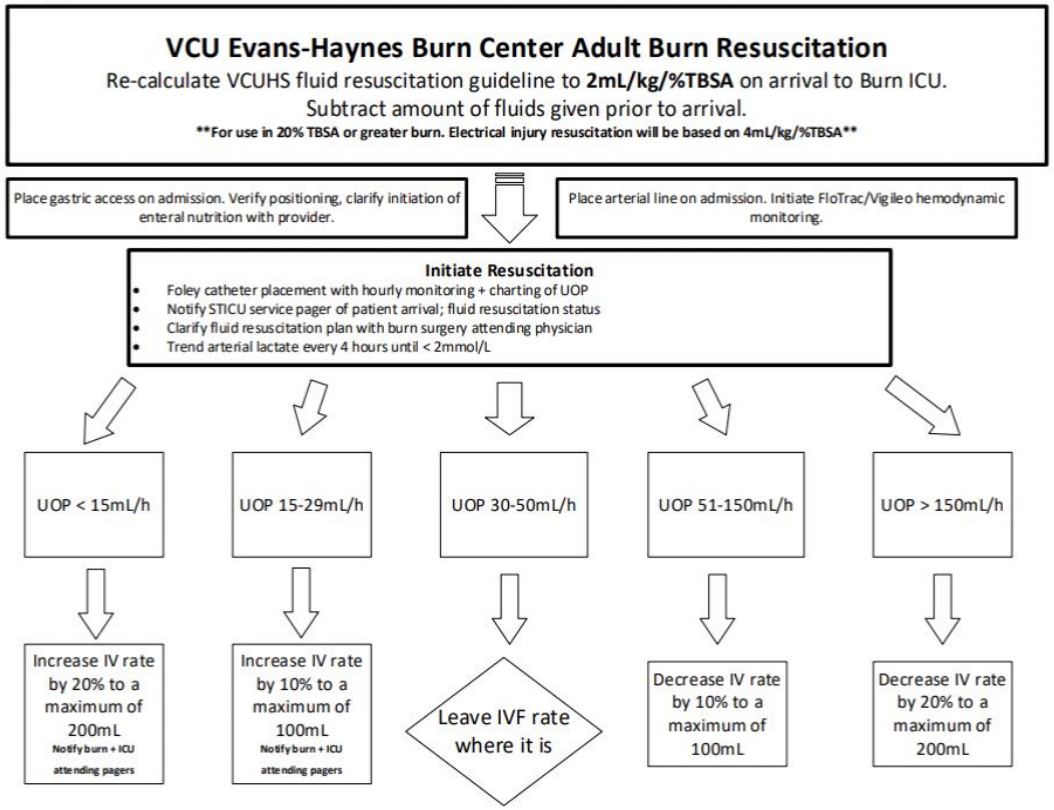
- Maintenance fluids should be administered to children in addition to their calculated fluid requirements caused by injury.

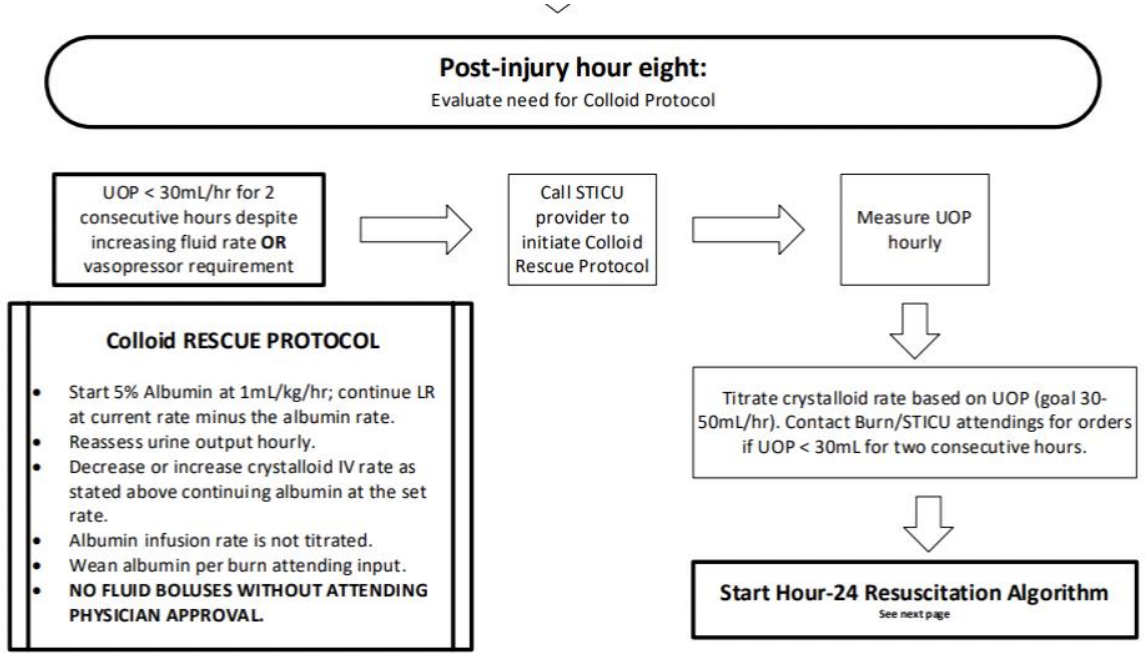
- Increased volume requirements can be anticipated in patients with full-thickness injuries, inhalation injury, and a delay in resuscitation.

Case 1.5

You start your resuscitation and the patient has 30 mL/hr of urine output. However, after 8 hours, you are notified that the patient's urine output has been 0 mL/hr for the past two hours.

Appendix:





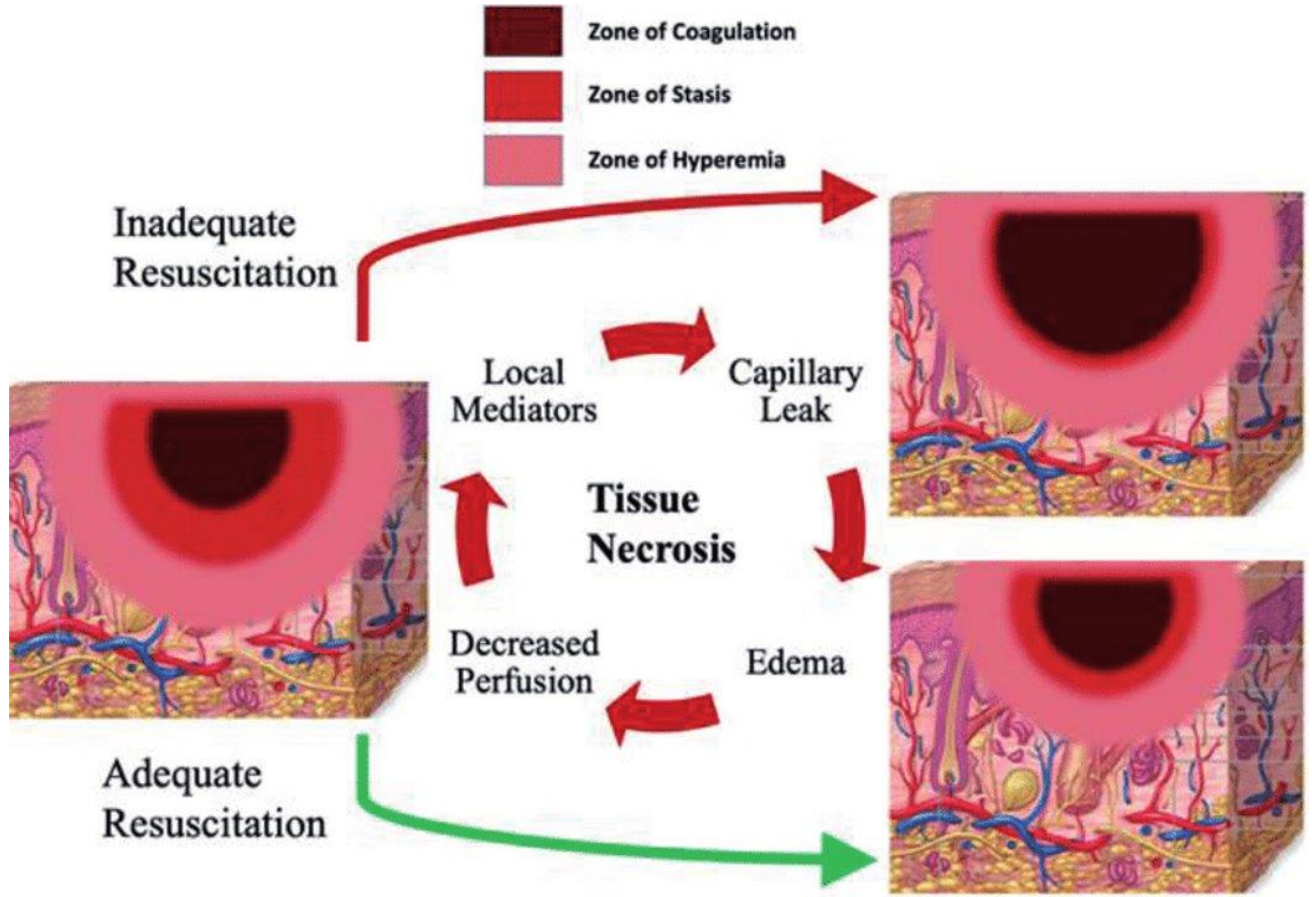
Fluid Resuscitation for Adult Patient (Aged ≥ 15 years)

What about the bolus?

Over resuscitation leads to poor outcomes

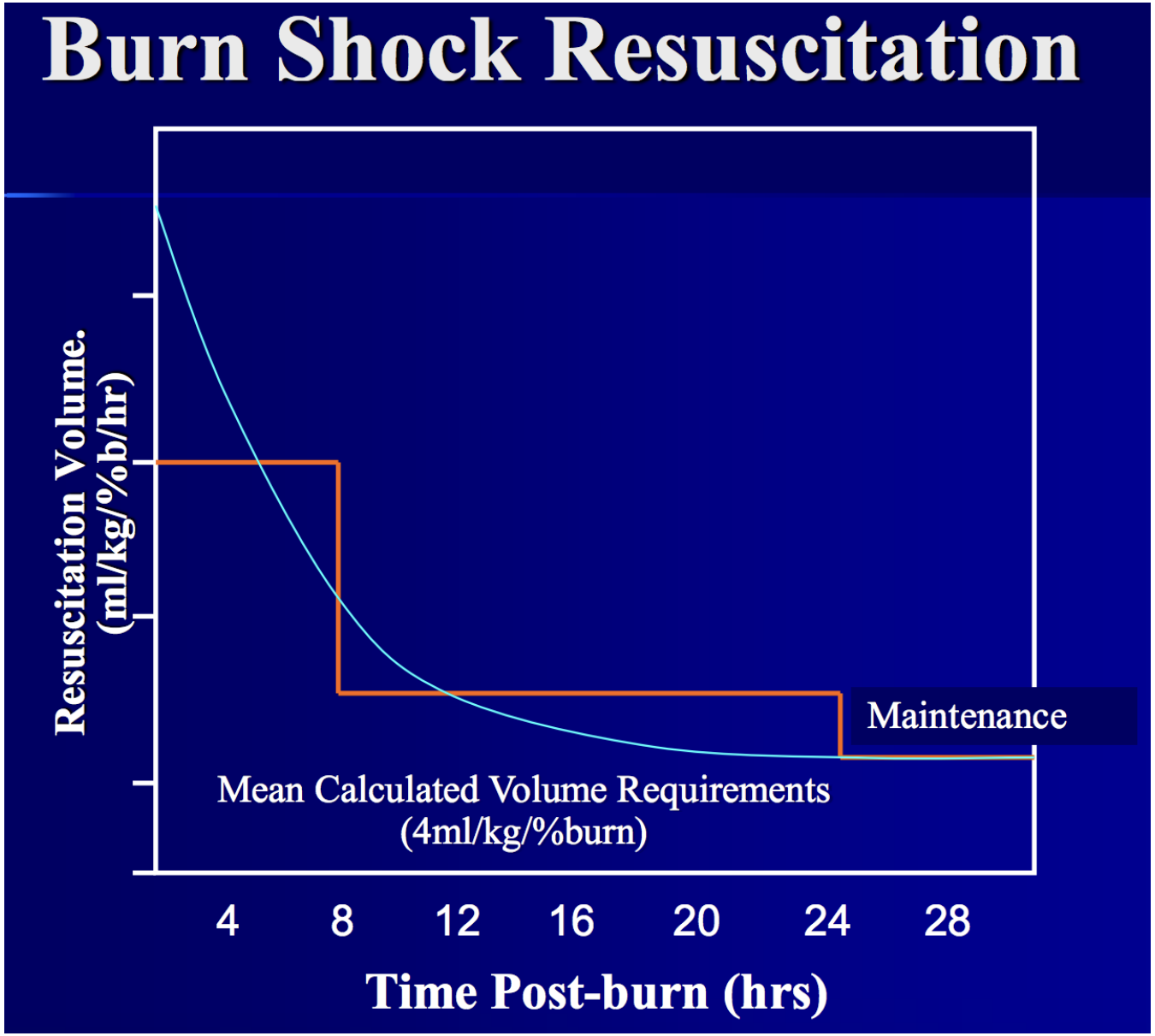
Titration of resuscitation rate to goal urine output of 30 - 50 mL/hr in adults and 0.5 - 1 mL/kg/hr in pediatric patients**

**Pediatric patient: <15 years old



Key tenant is to provide adequate fluid resuscitation

Requires constant monitoring with hourly adjustments



Case 1.9

What are your concerns?

How do you test for it?

You are paged by the RN that, despite increasing the resuscitation fluid rate, the patient's urine output has not improved. The patient has also developed some vent dyssynchrony and elevated peak pressures.

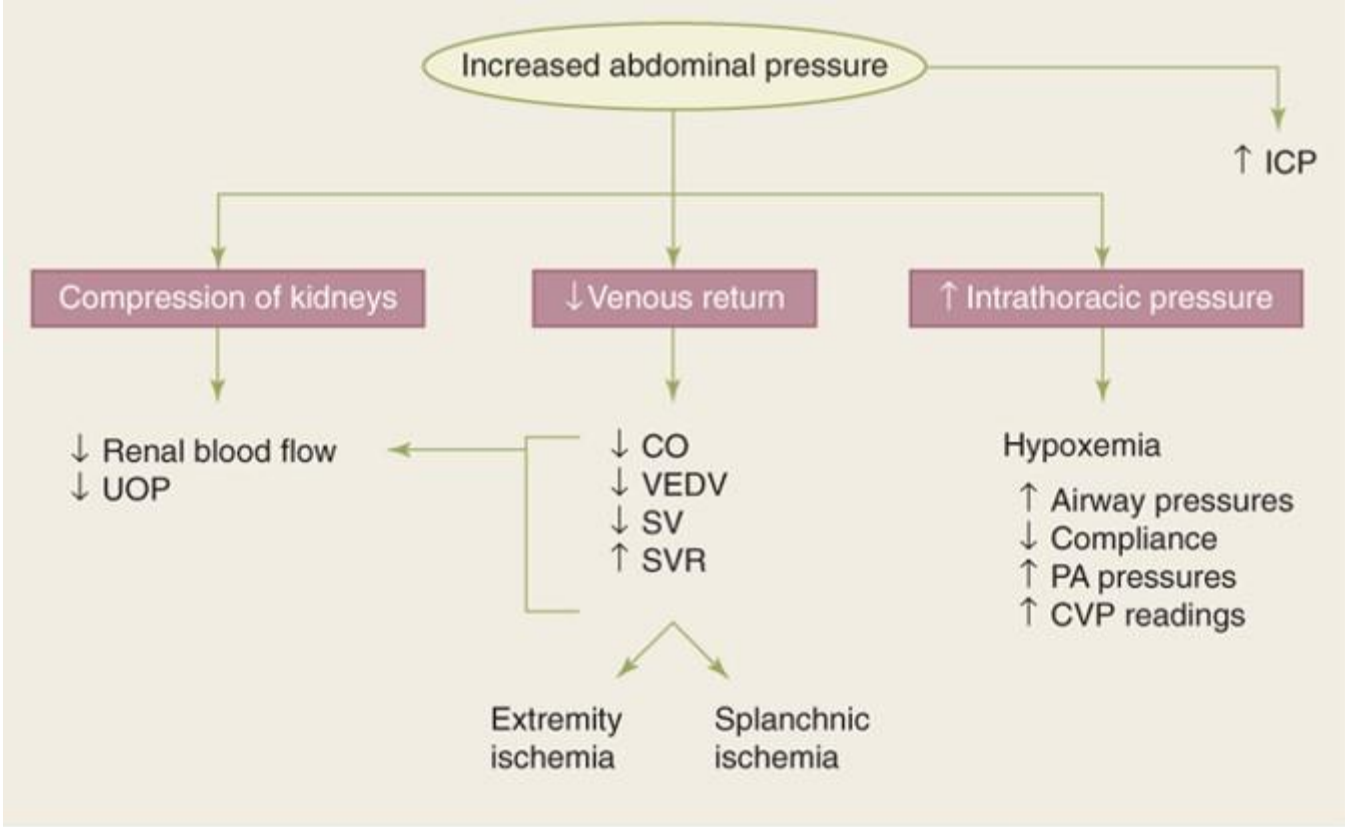
Abdominal Compartment Syndrome

Life threatening complication, sustained IAH (>20 mmHg) leading to multiple organ dysfunctions

- more at risk if they receive more than 250 cc/kg of fluid during first 24h of resuscitation

Measure by direct and indirect methods

- Direct: intraoperative pressure transducer
- Indirect: intravesicular catheter pressures



Source: F.C. Brunicardi, D.K. Andersen, T.R. Billiar, D.L. Dunn, L.S. Kao, J.G. Hunter, J.B. Matthews, R.E. Pollock: Schwartz's Principles of Surgery, 11e

Renal Replacement Therapy

Fortunately, with major advances in burn resuscitation and the treatment of sepsis, renal failure requiring RRT is unusual in the burn setting.

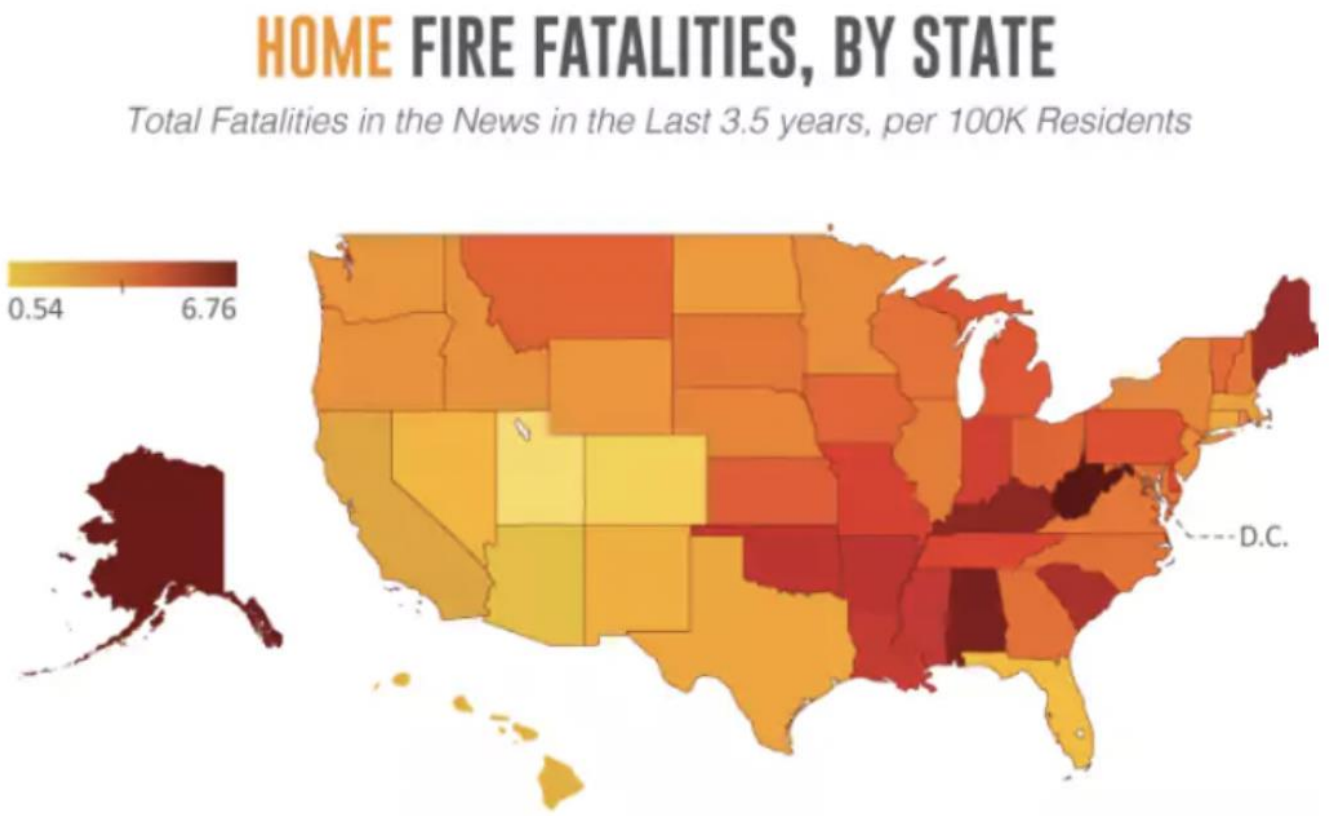
Reported incidence is about 1-3%

However, the need for RRT is associated with an increased mortality risk approaching 80%

Optimal time to initiate RRT has not been determined.

In 2021, **2840 f**atal burn injuries and **11,400** nonfatal injuries out of the 353,500 fires reported

- every 29 seconds!



STATES WITH THE MOST DEATHS, PER 100K RESIDENTS	
West Virginia	6.76
Alaska	6.11
Alabama	5.44
Kentucky	5.12
Maine	5.11

STATES WITH THE FEWEST DEATHS, PER 100K RESIDENTS	
Utah	0.54
Colorado	0.99
Arizona	1.19
Hawaii	1.20
California	1.21

Predictions of Mortality

Ryan Score

- 1990-1994 three variables for risk factors : burn size > 40%, age >60, and inhalation injury
- heavily weighted on inhalation injury

Baux Scores

- Classic score, developed in 1961, age + % TBSA
- Greater than 140 considered nonsurvivable
- Created Revised Baux Score- adds 17 to number if inhalation injury present

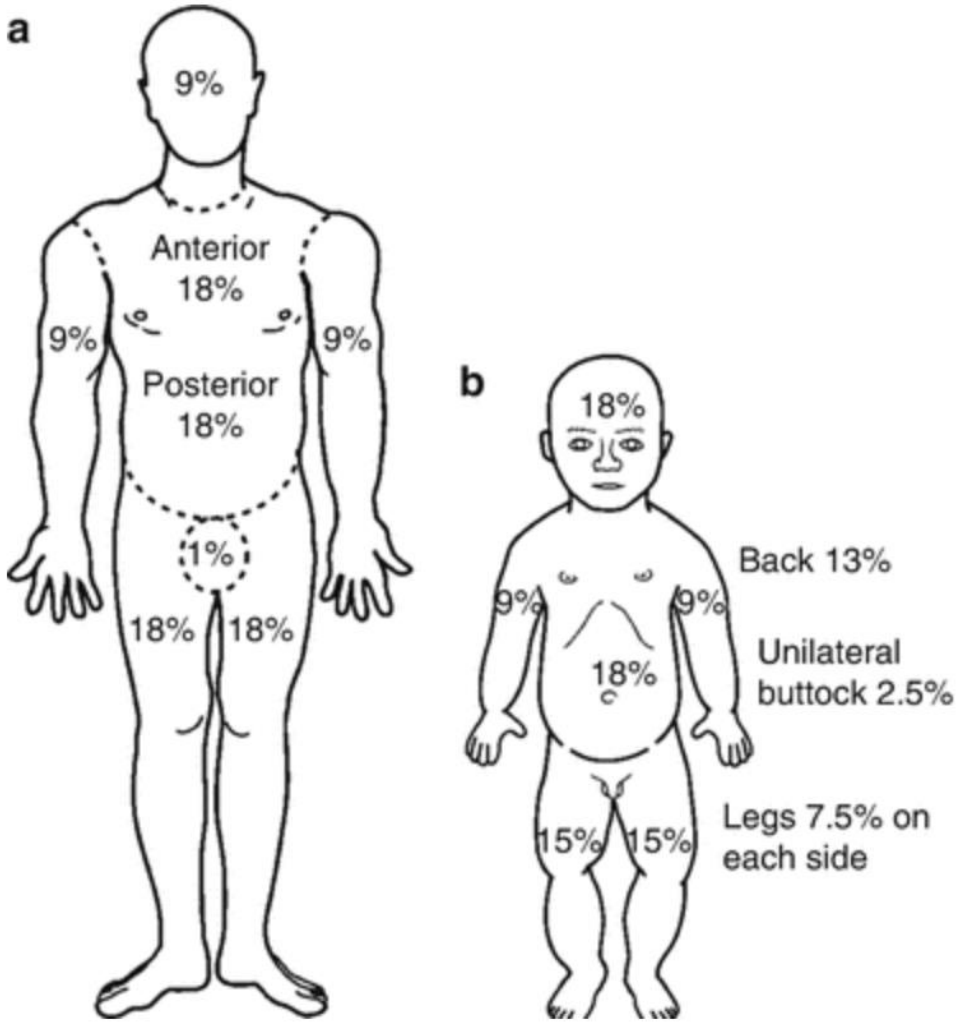
Abbreviated Burn Severity Index

- Developed in 1982, multivariate logistic regression, based on age, sex, TBSA, inhalation injury, and presence of FT burn

Case 2

You are working in the emergency department (ED) of a community hospital when the ambulance arrives with C.R., an 12-year-old girl who was burned after pouring gasoline on in a burn barrel. On arrival to the ED, her vital signs are 100/66, 125, 34, SaO2 93%. A 16-gauge IV is inserted. She appears anxious and in pain.

As you perform your initial assessment, you note superficial partial-thickness burns on C.R.'s right anterior leg, left anterior and posterior leg, and anterior torso. Using the "rule of nines", calculate the extent of A.N.'s burn injury.



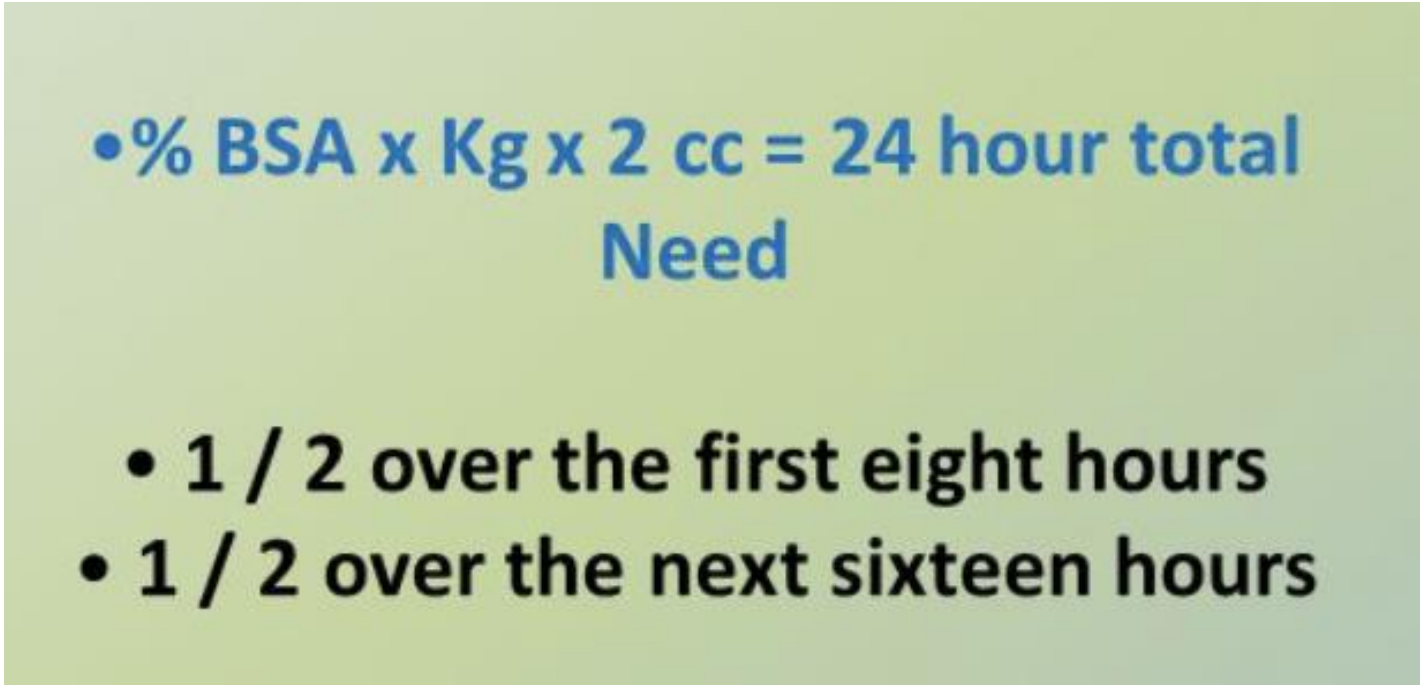
Evan Haynes Burn Center Policy and Procedures

For patients <15 years old with second or third degree burns totaling greater than or equal to 15% TBSA will receive formal fluid resuscitation.

- 2 mL x % TBSA x weight (Kg)
- If patient is <30 kg, should receive mIVF with D5LR
- ICU level of care
- Must have functioning IV, central access >30% TBSA, enteric access. May consider arterial lines

Goal Urine Outputs

- <30 kg: 1 mL/kg/hr
- >30 kg: 0.5 mL/kg/hr
- Myoglobinuria or rhabdo: 2 mL/kg/hr



C.R. is undergoing burn fluid resuscitation using the modified Brooke formula.

She was admitted at 0400. She weighs 50 kg. Calculate her fluid requirements, specify the fluids used, specify how much will be given, and indicate what time intervals will be used.

C.R. is undergoing burn fluid resuscitation using the modified Brooke formula. She was admitted at 0400. She weighs 50 kg.

1. What is the goal urine output for this patient based on the Evans-Haynes Burn Center protocol?

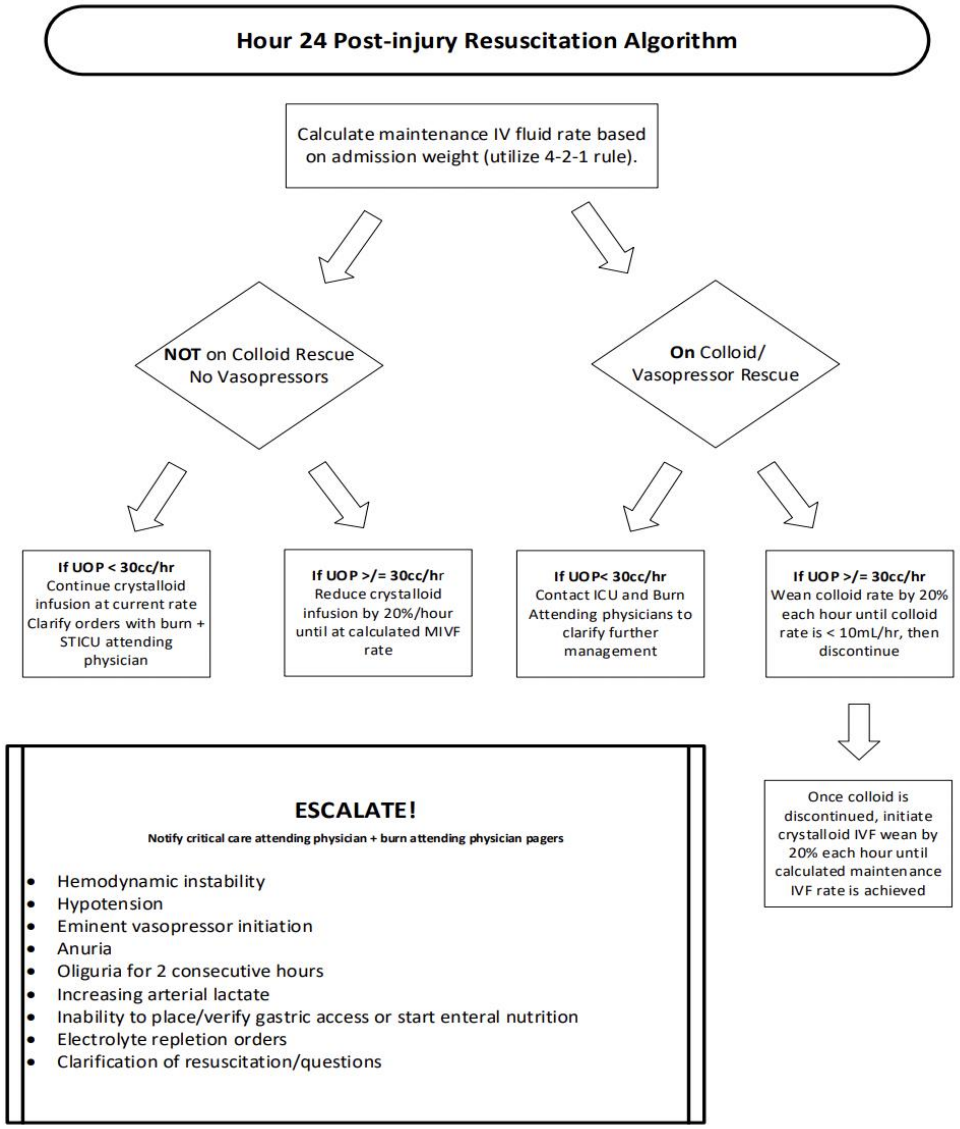
2. What additional orders should you consider for this patient?

C.R. is undergoing burn fluid resuscitation using the modified Brooke formula.
She was admitted at 0400. She weighs 50 kg.

Sixteen hours after the injury, you are notified by the RN that the patient's urine output for the past hour was 15 mL.

1. What do you suspect is occurring and why is it concerning?

2. What adjunct can you consider adding as part of your resuscitation?



Fluid Resuscitation for Adult Patient (Aged ≥ 15 years)

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