



Mitigating the Lethal Diamond in Rural Medicine

IMPROVING TRAUMA OUTCOMES IN
RESOURCE-LIMITED SETTINGS

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About Me

Learning Objectives

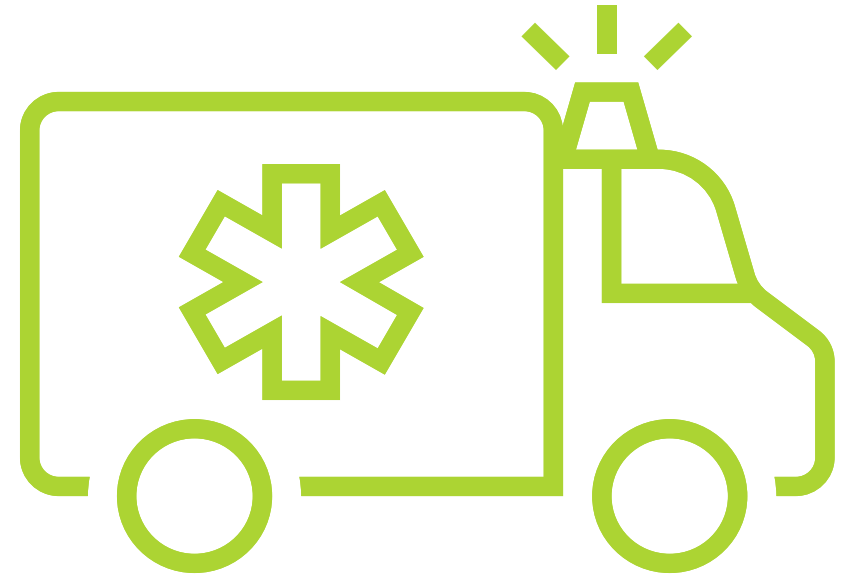
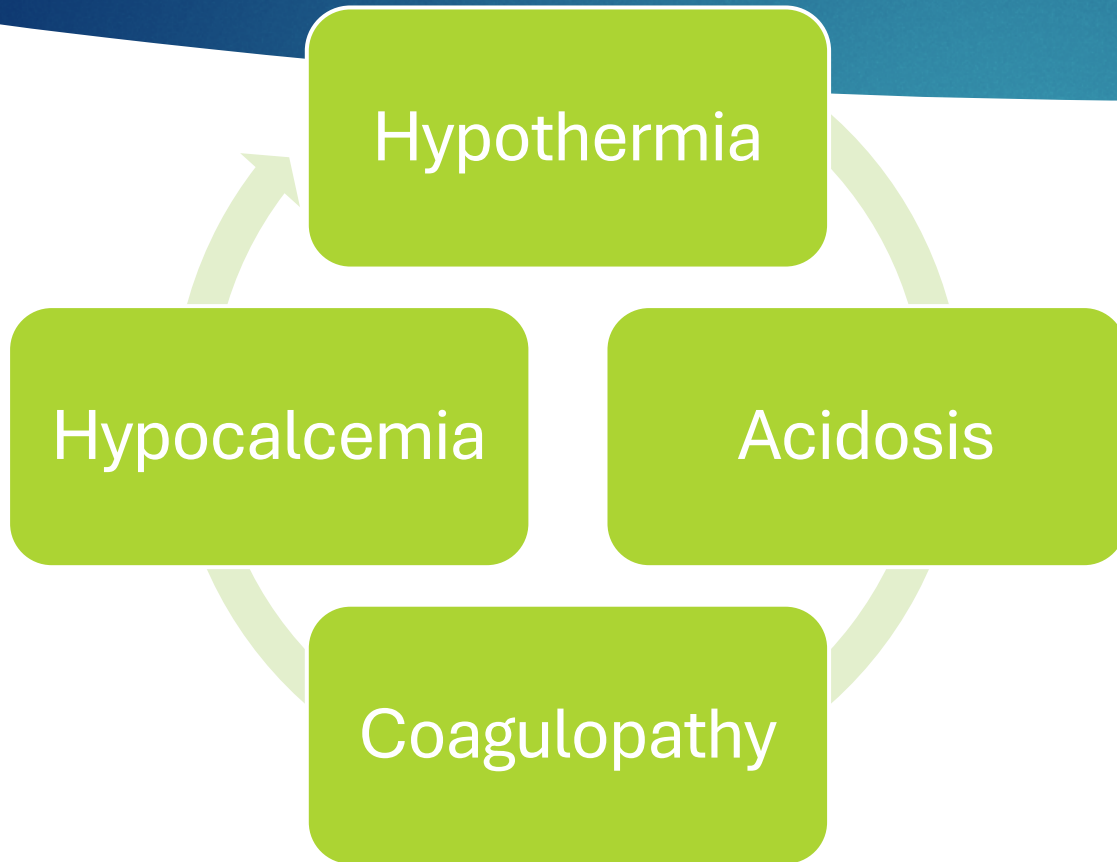
1. Define the components of the lethal diamond and their pathophysiology.

2. Identify why rural environments heighten its risk and impact.

3. Apply evidence-based strategies to mitigate each component.

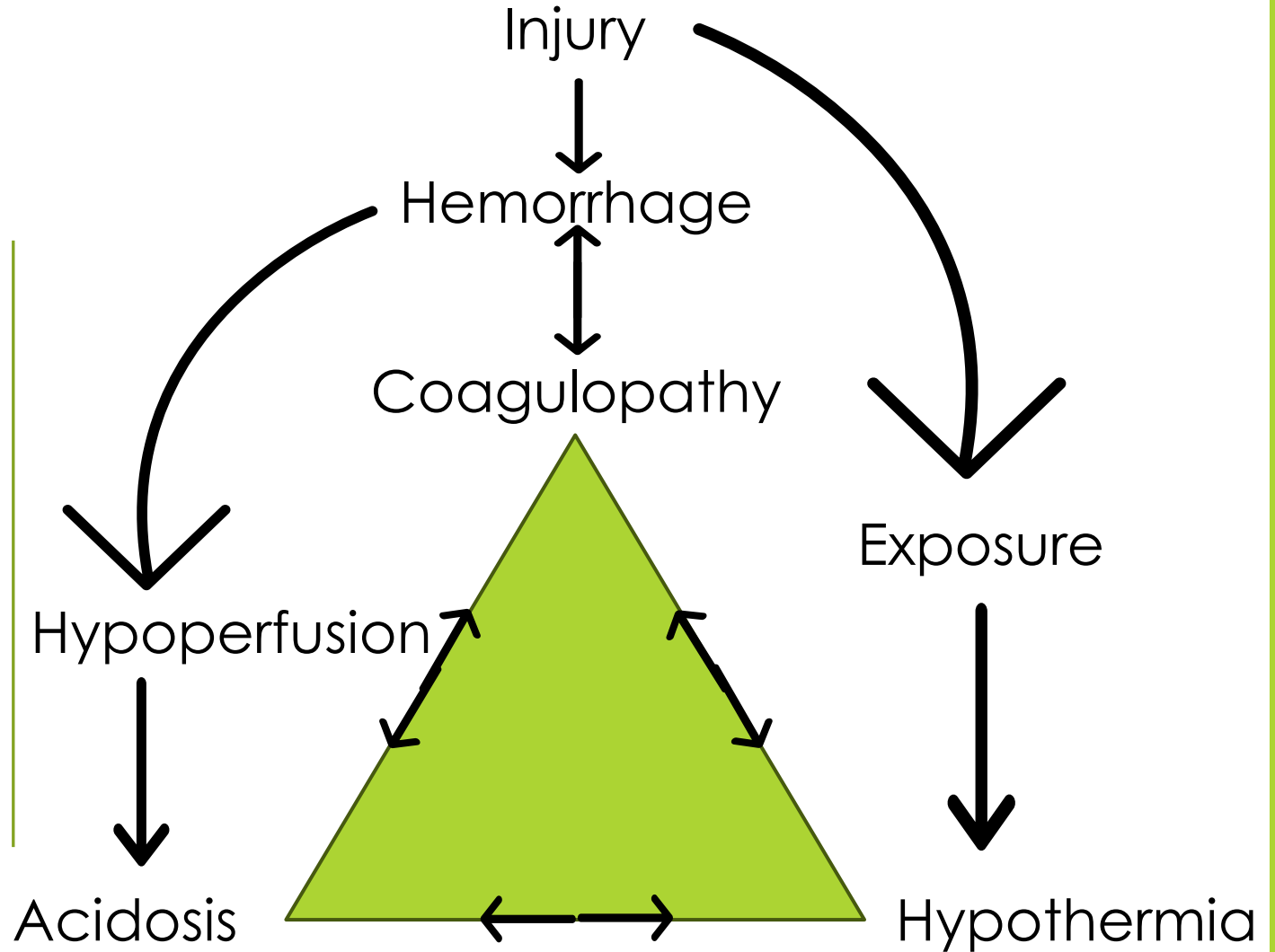
4. Integrate early interventions within limited-resource settings to improve outcomes.

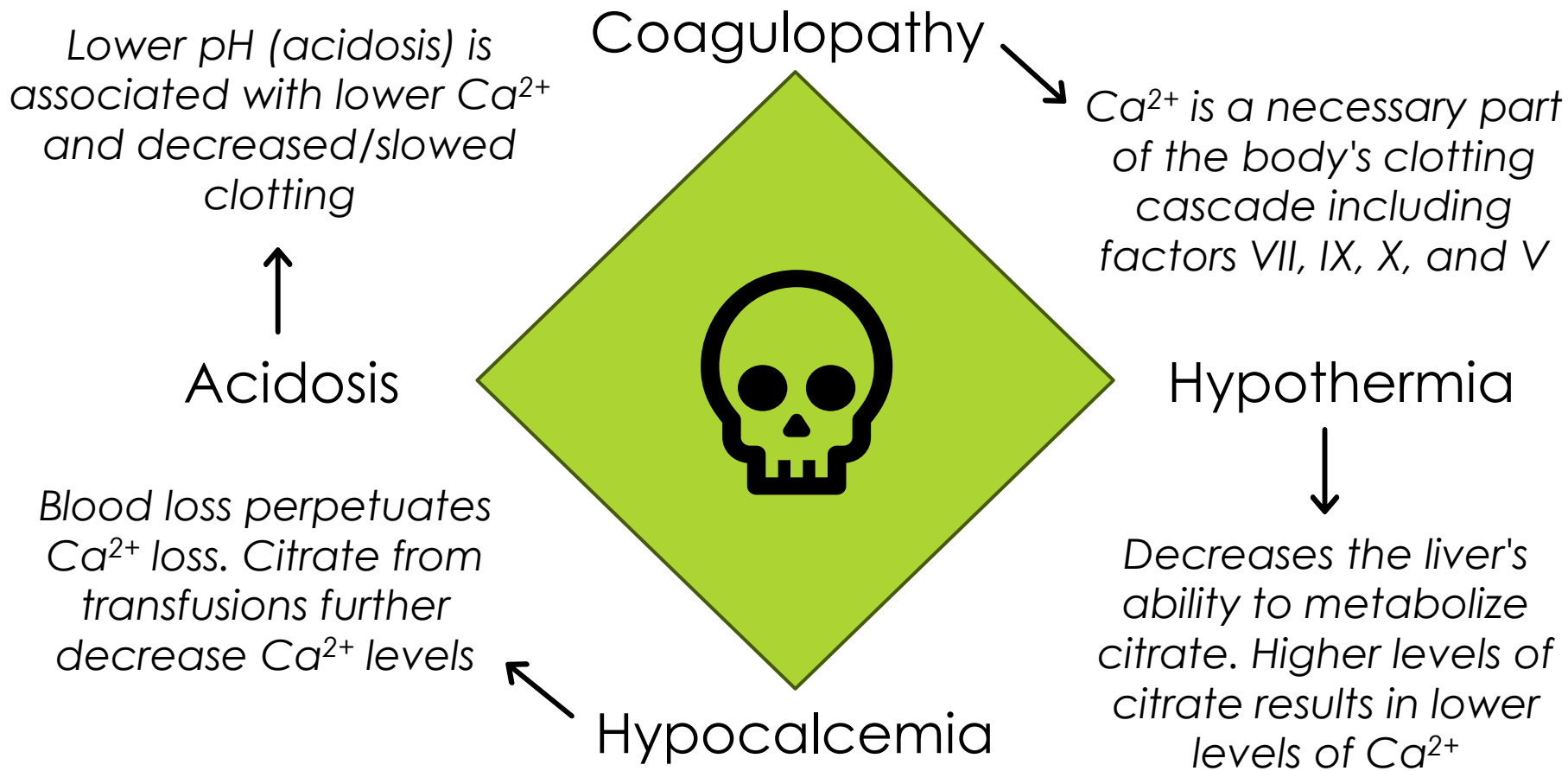
The Lethal Diamond Concept



Each factor worsens the others, leading to rapid decompensation.

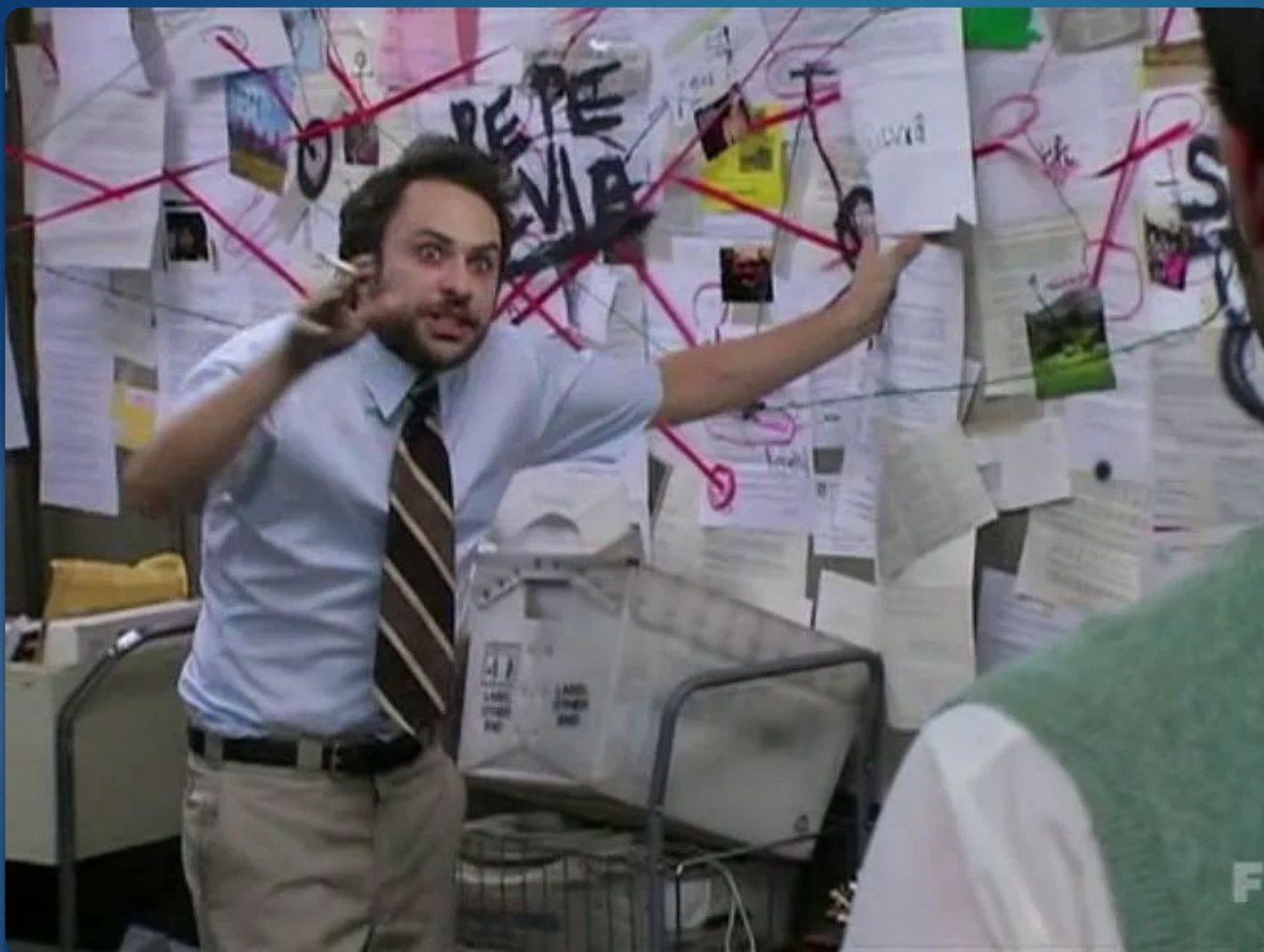
The Evolution from the Lethal Triad to the Lethal Diamond





The Lethal Diamond

The Role of Calcium



Me trying
to explain
the Lethal
Diamond

(everything is connected)

Why It Matters in Rural Settings

- ▶ Long transport and response times
- ▶ Limited resources and personnel
- ▶ Environmental exposure
- ▶ Higher incidence of accidental trauma compared to urban settings



Component 1: Hypothermia

Causes: Blood loss, exposure

Effects: Impaired clotting, cardiac depression

Mitigation: Active and passive warming, insulation, minimize exposure



Why It Matters

- ▶ Hypothermia perpetuates the Lethal Diamond by means of acidosis, coagulopathy, and hypocalcemia.
- ▶ Hypothermic trauma patients are more likely to need blood transfusions, ICU admission, and overall mortality.
- ▶ For every 1 degree Celsius dropped, the patient's cerebral metabolism also drops by 6-7%.
- ▶ **Hypothermia is the considered the most preventable corner of the lethal diamond.**

Warming Measures

Passive

- Removing wet clothing
- Warm blankets
- Minimize exposure
- Warm environment

Active External

- Heating Pads/Blankets
- Head Coverings
- Heat Packs
- Bair Hugger

Active Internal

- Warmed IV fluids
- Warmed, humidified O₂
- Endovascular or ECMO rewarming

Component 2: Coagulopathy



Causes: Dilution, consumption, hypothermia



Effects: Poor clot formation

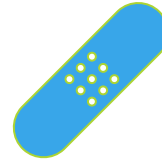


Mitigation: TXA early, bleeding control, limit crystalloids

Why It Matters

- ▶ Coagulopathy in trauma is complex and difficult to treat once it presents.
- ▶ Unlike localized traumatic injuries, bleeding from coagulopathy is not acutely resolved with surgical repair or pressure.
- ▶ Coagulopathy may result in bleeding from uninjured areas such as intracranial hemorrhage.
- ▶ Hemorrhage control becomes increasingly difficult due to a lack of platelets, clotting factors, and fibrinogen.

How To Prevent/Treat Coagulopathies



- ▶ **Early intervention:** Recognizing and treating coagulopathy as early as possible is crucial and can improve outcomes.



- ▶ **Damage control resuscitation:** The focus is on controlling bleeding with a strategy that uses less crystalloid and more blood products.



- ▶ **Tranexamic acid:** This drug is used to counteract the enhanced breakdown of clots that occurs in trauma.



- ▶ **Physical and environmental management:** Keeping the patient warm and minimizing hypoperfusion are key steps in preventing coagulopathy from worsening.

Component 3: Acidosis

Cause: Hypoperfusion → lactic acid

Effects: Worsened coagulopathy, cardiac depression

Mitigation: Rapid hemorrhage control, avoid over-resuscitation

Why It Matters

- ▶ **Worsened coagulopathy:** Acidosis impairs the production of thrombin and other clotting factors, and it can accelerate fibrinolysis, which increases bleeding.
- ▶ **Reduced organ function:** The acidic environment can disrupt cellular and organ function throughout the body.
- ▶ **Increased mortality:** Severe acidosis ($\text{pH} < 7.0$) is strongly linked to higher mortality rates in trauma patients.
- ▶ **Amplifying effect:** This acidosis further exacerbates the other parts of the lethal diamond: it impairs the function of clotting factors and enzymes, worsening coagulopathy, and it can worsen hypothermia and hypocalcemia.

Correcting and Preventing Acidosis

Control
bleeding

Restore
aerobic
metabolism

Avoid
excessive
fluids

Prevent
hypothermia

Ensure
adequate
perfusion

Balanced
resuscitation

Component 4: Hypocalcemia



Cause: Citrate binds calcium, blood loss



Effects: Impaired clotting, dysrhythmia

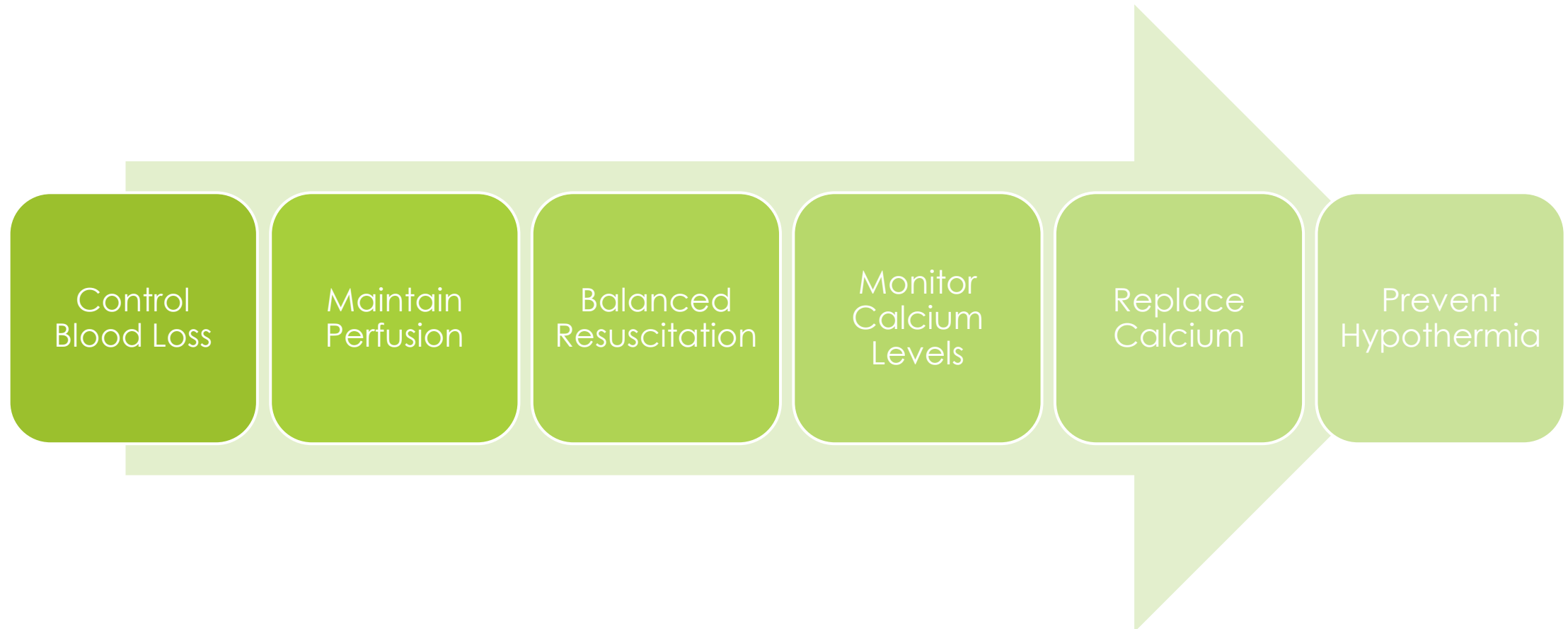


Mitigation: Administer calcium chloride or gluconate

Why It Matters

- ▶ **Impaired Coagulation:** Calcium ions (specifically, ionized calcium) are essential factors for numerous enzymatic reactions in the intrinsic, extrinsic, and common pathways of the clotting cascade (factors V, VII, VIII, IX, X, and XIII). Low calcium levels disrupt these pathways, leading to a derangements in the ability to form stable fibrin clots and control bleeding.
- ▶ **Cardiac Dysfunction:** Calcium is mandatory for normal cardiac muscle contraction and maintaining vascular tone. Hypocalcemia can lead to decreased cardiac output, hypotension, and arrhythmias which exacerbates traumatic shock. Hypotension worsens perfusion resulting in increased acidosis and hypothermia.

Preventing Hypocalcemia



Rural Trauma Algorithm (M.A.R.C.H. + Diamond Check)

- ▶ **M** - Massive hemorrhage
- ▶ **A** - Airway
- ▶ **R** - Respiration
- ▶ **C** - Circulation
- ▶ **H** - Hypothermia

- ▶ **Diamond Check:** Warm, perfused, clotting, calcium supported

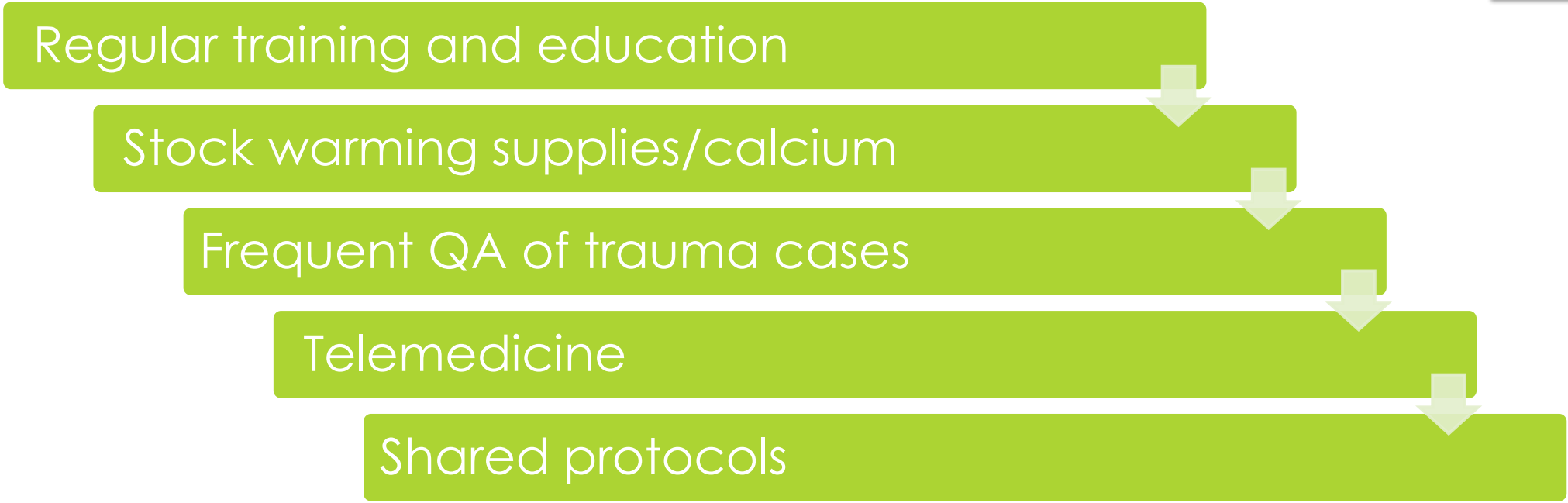
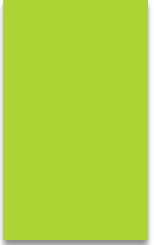
Transport & Evacuation

- Early activation

- Continuous warming

- Communicate physiology

- TXA and warming kits



Regular training and education

Stock warming supplies/calcium

Frequent QA of trauma cases

Telemedicine

Shared protocols

System-Level Interventions

Key Takeaways



- The diamond develops early.



- Early recognition and action save lives.



- Prevent one corner—protect the whole system.

References

- ▶ ATLS, 10th ed.
- ▶ PHTLS, 9th ed.
- ▶ Mutschler M et al., Critical Care (2017)
- ▶ ACS Rural Trauma Course (2022)
- ▶ Azarkane et al. (2024)
- ▶ Casella, J. (2004)
- ▶ McLellan et al. (2023)

Thank You

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