

**Round 2**

# **Crush Syndrome in Resource-Constrained Environments: Modified Delphi Survey #2**

Here, we present questions that require further voting to generate consensus. Thank you for your participation!

Q1. What is your name? (First name, Last name)

**Summary**

*Summary of Round 1 .*

**Below is a summary of the key findings from the round one survey.**

We have summarized the areas that reached consensus (>75% agreement).

**1. Crush injury definition**

There was consensus (87%) for the following definition of crush injury:

"Crush injury is the local manifestation of direct physical trauma, and can present as muscle injury and swelling, along with possible muscle necrosis and neurologic dysfunction in the affected areas. It can be due to the primary direct effect of trauma or ischemia-reperfusion injury related to compression."

**2. Crush syndrome as a spectrum of disease**

- There was consensus (93%) that crush syndrome is a spectrum of disease.
- There were several models presented for this spectrum, with mild forms involving subclinical to mild self-limited clinical findings such as CK elevation, and severe forms requiring urgent interventions such as dialysis, surgery, or mechanical ventilation.

**3. Resource availability**

- Urine output monitoring and respiratory support were universally available at the participants' locations of work.
- Dialysis was available in 75% of participants' facilities.
- We note that the participants of this Delphi process slightly over-reflect well-resourced facilities

#### 4. Laboratory availability

- >75% of respondents reported the following laboratory tests were available most or all of the time:
  - Urine dipstick, serum bicarbonate, lactate, pH, CK/CPK, calcium, potassium, creatinine, and urea.
- 50% of respondents reported serum and urine myoglobin were never available.

#### 5. Laboratory evaluation

For diagnosis -

- Creatinine and CK/CPK were rated very to extremely useful for the diagnosis of crush syndrome (75% respondents)
- Serum bicarbonate, potassium, urea, pH, lactate, and urine dipstick, were found to be next most helpful (>50% respondents)

For prognostication -

- Urine output, serum CK, serum creatinine and serum pH were extremely useful tests for prognostication of crush syndrome (>75% respondents)
- Serum lactate, bicarbonate, potassium, urea and EKGs were found to be the next most helpful tools (>50% of respondents)

#### 6. Adjunct tools

Use of total body surface area and use of point-of-care ultrasound was not supported by participants.

#### 7. Time point for clinical decision tool

Participants favored using data gathered within 4-6 hours of crush injury (>80% of respondents).

#### 8. Endpoints

The top 3 clinical outcomes selected for the predictive model were AKI (80%), need for dialysis (85%), and need for respiratory support (80%).

#### 9. Composite outcome

Participants felt the predictive model should use a composite outcome (80%). Suggested outcomes included RRT/dialysis, hemodynamic instability, electrolyte derangements, mechanical ventilation, surgical interventions, ICU admission, organ failure, or death.

#### Controversial Issues

*Section 1 . In this section, we request your feedback on some areas of controversy from Round One.*

## Q2. Crush Syndrome Definition

In Round One, 33% of participants entered free text responses with a new definition (this has been compiled and summarized as Definition 1 presented here). In Round One, 47% of participants selected Definition 2, which was derived from the literature.

The following are updated definitions for **crush syndrome**:

### Definition 1:

Crush syndrome is the systemic manifestation of extensive skeletal muscle damage, due to the disruption of cellular integrity and release of its contents into circulation. It manifests as haemodynamic and metabolic disturbances, and can result in acute kidney injury, multisystem organ dysfunction or death.

### Definition 2:

Crush syndrome is the systemic manifestation of crush injury, which can result in acute kidney injury, multisystem organ dysfunction or death.

### What is your preferred definition for crush syndrome?

- ☐ Definition 1
- ☐ Definition 2

## Q3. Prehospital Crush

Participants discussed the challenge of detecting crush syndrome in the prehospital or austere setting.

### Should we build a separate predictive model for crush syndrome specific to the prehospital setting?

(i.e. using prehospital data such as injury mechanism, vitals and GCS, to see if we can predict clinically relevant endpoints for crush syndrome)

- ☐ Yes, fully supported
- ☐ Yes, supported with some reservations
- ☐ No, not supported

Q3.1. Please provide your rationale for your above response regarding prehospital crush syndrome prediction.

#### Q4. Anaerobic vs. Aerobic Mechanisms of Crush

One of the participants provided the following comments:

"Myorenal syndrome or myonephropathic syndrome can be classified as aerobic and anaerobic.

[The aerobic type] occurs after whipping, or when patients sustain multiple crush injuries to muscles and soft tissues; no ischaemic component is present.

The anaerobic type occurs when a limb has been ischaemic for several hours and is then reperfused (e.g. when a tourniquet has been on a leg and is then released, or when a leg has been entrapped under collapsed building rubble and is then freed).

In both types, myoglobin is released into the circulation, with nephropathy to follow. However, in the anaerobic type, products of ischemia-reperfusion are also released into the circulation, which can cause multiple organ failure and death (sometimes very rapid death).

It is important to distinguish between these two categories, and a single predictive model should not be used for both."

**Do you agree with this participant's sentiment that patients with ischemia-reperfusion injury are inherently different? Based on your experience, how does ischemia-reperfusion injury influence a given patient's clinical course and outcomes?**

#### Clinical Uncertainty

*Section 2 .* **Given crush injury can present as a spectrum of disease, we imagine that a subset of patients would be fairly easy to triage (i.e. discharge versus hospitalize versus transfer) whereas others would prove more difficult.**

**We would like your input on the patient population that the clinical decision tool should target. To do so, please answer the following questions...**

**Q5.1.** Please describe 1 or more clinical scenarios involving crush injury patients where you feel confident discharging the patient within the first 4 to 6 hours of their emergency department visit.

Q5.2. Please describe clinical scenario(s) involving crush injury patients where you feel confident that a patient will require hospitalization.

Q5.3. Please describe clinical scenario(s) involving crush injury patients where you experience the greatest uncertainty about the triage decision.

Q5.4. In light of the above responses, what patient population should the crush clinical decision tool target?

## History and Exam Findings

**Section 3. Round One of the Delphi focused on laboratory markers for crush. Here, we request your input on pertinent history and exam findings that help you determine the anticipated clinical course.**

*Q6 . Imagine you are working in an environment where you do not have access to any labs (e.g. prehospital environment or austere setting). You encounter a patient who was assaulted about 12 hours ago with blunt objects and sustained soft tissue injuries to the back and thighs alone. There are no fractures, internal organ injuries, or neurologic injuries associated.*

Q6.1. What history and exam findings suggest that the patient is likely to have a full recovery from the crush injury without any specific interventions?

Q6.2. What history and exam findings would suggest that this patient would likely require aggressive resuscitation and hospitalization for the crush injury?

Q6.3. What history and exam findings would suggest that the patient has a high probability of requiring dialysis?

### Acute Kidney Injury in Resource-Limited Setting

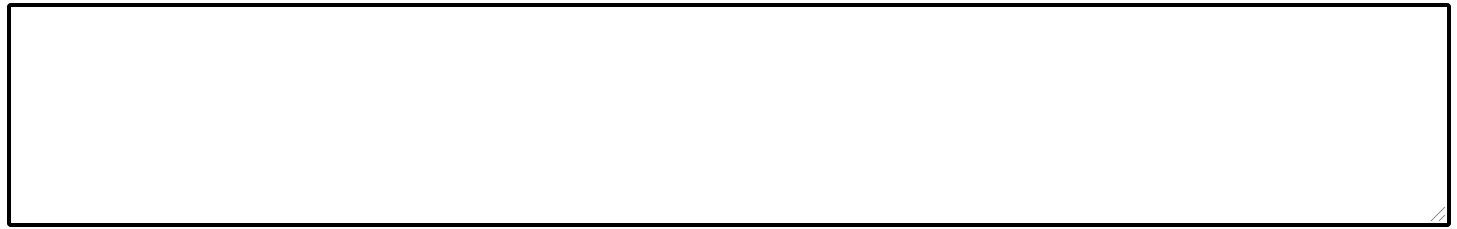
*Section 4 . Q7. Imagine you are working in a rural emergency department. You have access to point-of-care testing such as urine dipstick and venous blood gas, and your lab can run a single serum chemistry and CBC per patient every 12 hours.*

*You encounter a patient who was assaulted about 12 hours ago with blunt objects and sustained soft tissue injuries to the back and thighs alone. There are no fractures, internal organ injuries, or neurologic injuries associated.*

You have no historical labs on the patient. The nurses are too busy to track urine output rigorously.

Q7.1. How would you diagnose clinically important renal injury for the patient with crush injury in this scenario?

Q7.2. Please share your thoughts a practical approach to the diagnosis of clinically important renal injury in resource-limited settings.

**Final thoughts**

*Q8 - optional.* Thank you so much for taking the time to respond to the Round 2 survey for this modified Delphi process. Your expertise is greatly valued.

We will collate your responses and be in touch regarding a brief third and final round to settle any remaining areas of uncertainty. If you have any further thoughts, questions, or comments, please share below.



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