Does a Controlled Fluid Resuscitation Strategy Decrease Mortality in Trauma Patients?

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Gaziantep University/TURKE
Haemorrhage remains the biggest killer of major trauma patients

- Expected deaths will increase to 8 million/year by 2020

- 1/3 of pts are coagulopathic on admission

- Up to 20% of pts might be preventable

- The most important treatment is to stop haemorrhage

Wang et al, Critical Care Medicine. 2014
Hemorrhagic shock is responsible for 30–40% of deaths from trauma, and it is believed to be the most common cause of potentially preventable deaths. The cause of death of approximately 50% of patients, who die within the first 24 h after trauma, is bleeding.
The mortality of coagulopathic pts is 3–4 times higher than pts without coagulopathy

Causes reduced platelet activation, aggregation and adhesion to von Willebrand factor on endothelial surfaces

Caused by tissue injury, hypoxia, hypoperfusion, platelet and coagulation protease dysfunction.

Fluid administered both in vitro and in vivo is an iatrogenic cause of traumatic coagulopathy

Aya HD, Br J Anaesth 2013

Bolliger D, Brit J Anaesth 2009;
Pathophysiology of Acute traumatic coagulopathy

Restoration of the physiological balance

DCR is current best practice for bleeding trauma patients

Cohen MJ, J Trauma Acute Care Surg 2013
Haemodilution causes

- Prolongation of PT
- Reduction FVII
- Abnormal fibrin polymerisation
- Fibrinogen dysfunction
- Poor clot stability

Shaz BH, J Trauma 2011.
Fenger-Eriksen C, J Thromb Haem 2009
More than 40% of trauma patients develop a coagulopathy after >2 L of crystalloid, rising to >70% after >4 L.

- The more fluid replacement
- The more coagulopathy

Maegele M. Injury 2007;
Up to 2003

- Traditional concepts of polytrauma resuscitation

Advocated by ATLS long time

- Promote aggressive fluid administration aimed at restoring lost intravascular blood volume

Poor outcomes

- Approachment may contribute to continued bleeding by increasing the hydrostatic pressure on blood clots
- A dilution of coagulation factors, and an aggravation of hypothermia
### Historical trends in resuscitation strategies

<table>
<thead>
<tr>
<th>Era</th>
<th>Resuscitation approaches and other related issues</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>WWI</td>
<td>None</td>
<td>Early death</td>
</tr>
<tr>
<td>WWII/Korean War</td>
<td>Albumin, plasma, and blood use</td>
<td>Better early survival but organ failure resulting in late deaths (especially acute renal failure)</td>
</tr>
<tr>
<td>Vietnam War</td>
<td>Crystalloids and banked blood use. Improved rapid evacuation methods</td>
<td>Better early survival. Organ failure resulting in late deaths still a problem, with less acute renal failure and more ARDS</td>
</tr>
<tr>
<td>1970s-early 1980s</td>
<td>Goal-directed aggressive resuscitation, use of pulmonary artery catheters, and oxygen delivery calculations to deliver “supra-normal” resuscitation</td>
<td>Further improvement in early survival, increased MOF, and late deaths</td>
</tr>
<tr>
<td>Mid 1980s-1990s</td>
<td>Rapid field triage, maturation of civilian trauma systems, introduction of “damage control surgery,” improved ICU care</td>
<td>Improved early survival in severely injured. More MOF but better survival in MOF patients due to improved ICU care</td>
</tr>
</tbody>
</table>

ARDS, acute respiratory distress syndrome; MOF, multiple organ failure; ICU, intensive care unit; FFP, fresh frozen plasma; KIA, killed in action.
This strategy reported an 8% reduction in absolute mortality in for patients receiving delayed fluid resuscitation and experiencing a lower SBP preoperatively.
Immediate versus Delayed Fluid Resuscitation for Hypotensive Patients with Penetrating Torso Injuries

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>IMMEDIATE RESUSCITATION (N = 309)</th>
<th>DELAYED RESUSCITATION (N = 289)</th>
<th>P VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic blood pressure (mm Hg)</td>
<td>79±46</td>
<td>72±43</td>
<td>0.02</td>
</tr>
<tr>
<td>Hemoglobin (g/dl)</td>
<td>11.2±2.6</td>
<td>12.9±2.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Platelet count ($\times 10^{-3}$/mm$^3$)</td>
<td>274±84</td>
<td>297±88</td>
<td>0.004</td>
</tr>
<tr>
<td>Prothrombin time (sec)</td>
<td>14.1±16</td>
<td>11.4±1.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Partial-thromboplastin time (sec)</td>
<td>31.8±19.3</td>
<td>27.5±12</td>
<td>0.007</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
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<th>DELAYED RESUSCITATION</th>
<th>P VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival to discharge — no. of patients/total patients (%)</td>
<td>193/309 (62)*</td>
<td>203/289 (70)†</td>
<td>0.04</td>
</tr>
<tr>
<td>Estimated intraoperative blood loss — ml‡</td>
<td>3127±4937</td>
<td>2555±3546</td>
<td>0.11</td>
</tr>
<tr>
<td>Length of hospital stay — days§</td>
<td>14±24</td>
<td>11±19</td>
<td>0.006</td>
</tr>
</tbody>
</table>
The concept of permissive hypotension represents a double-edged sword.

Prolonged duration of shock may further aggravate the extent of postinjury coagulopathy.

Hypotensive resuscitation may aggravate the incidence of secondary insults in patients with severe head injuries.

- Other RCTs, however, have not reported significant mortality benefits either from delaying fluid therapy or from targeting a lower SBP.

Dutton RP, J Trauma 2002;
Prolonged Permissive Hypotensive Resuscitation Is Associated With Poor Outcome in Primary Blast Injury With Controlled Hemorrhage


- But other models provide conflicting results; a study in pigs with blast injuries reported a poorer outcome (survival time) with permissive hypotension compared to normotensive resuscitation.

Garner J, Ann Surg 2010
Used different levels of MAP to achieve volemic resuscitation (40, 50, 60, 70, 80, and 100 mmHg).

Approximately 80–100 mmHg exhibited more bleeding, mortality, and organ dysfunction than those subjected to permissive hypotension (50 and 60 mmHg). 40 mmHg showed less bleeding but increased organ dysfunction and mortality.

Caution for patients have head trauma:
Lower pressure levels can cause a reduction in cerebral perfusion pressure, and hence, contribute to the introduction or deterioration of secondary brain injury.

• **A target MAP of 50–60 mmHg** conferred most survival benefit.
• Ninety minutes of permissive hypotension was the tolerance limit.
Hypotensive Resuscitation Strategy Reduces Transfusion Requirements and Severe Postoperative Coagulopathy in Trauma Patients With Hemorrhagic Shock: Preliminary Results of a Randomized Controlled Trial

C. Anne Morrison, MD, MPH, Matthew M. Carrick, MD, Michael A. Norman, MD, Bradford G. Scott, MD, Francis J. Welsh, MD, Peter Tsai, MD, Kathleen R. Liscum, MD, Matthew J. Wall, Jr., MD,

Data from an RCT (man), with 90 pts, in which target MAP of 50 mmHg (LMAP) and 65 mmHg (HMAP) were compared.

The LMAP group
- Received significantly fewer blood products,
- Need smaller volumes of fluids intra-operatively,
- Were less likely to develop post-operative coagulopathy and
Had a significantly lower all cause early mortality rate (p = 0.03).

Morrison CA, J Trauma 2011;
Animal models of uncontrolled haemorrhagic shock with trauma have demonstrated benefit using targeted lower mean arterial pressures (MAP) of 60-70 mmHg whilst bleeding is ongoing.

Human data have added further weight to this approach and suggested both shorter bleeding times and improved mortality.
The comparison of MAP of 40 mm Hg, as opposed to 80 mm Hg

Results: LMAP

**Increased/better**
- Splanchnic perfusion and
- Tissue oxygenation

**Decreased/less**
- Blood loss,
- Apoptotic cell death and
- Tissue injury,
- Acidemia,
- Hemodilution
- Thrombocytopenia,
- Coagulopathy,

Lu YQ, J Trauma 2007;
<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geeraedts LM Jr, <em>Injury</em> 2009</td>
<td>Furthermore, aggressive resuscitation might also result in dilutional coagulopathy, which may worsen bleeding.</td>
</tr>
<tr>
<td>Ley EJ, Clond MA, Srour MK, et al. <em>J Trauma</em> 2011</td>
<td>Crystalloid infusion of 1.5 litres or more in trauma patients was an independent risk factor for mortality.</td>
</tr>
</tbody>
</table>

Many studies between 190-2011 show the benefit of hypotensive resuscitation.
Who uses what?

Prehospital mainly Crystalloid infusion

Mainly military trauma Systems use WBT

Most advanced civilian trauma systems are still reliant on PRBC, FFP, Plt and Cryo

Mature trauma systems now replace blood with blood products from the outset

Haemorrhage resuscitation

These are typically given in an empirical manner initially, according to local policy.
Other considerations

Hypertonic saline

• Clinical studies however do not provide compelling evidence to support the use of HTS either for TBI or for haemorrhagic shock.
• Many RCTs have not demonstrated mortality benefit
Liberal Versus Restricted Fluid Resuscitation Strategies in Trauma Patients: A Systematic Review and Meta-Analysis of Randomized Controlled Trials and Observational Studies*

Chih-Hung Wang, MD1; Wen-Han Hsieh, MS2; Hao-Chang Chou, MD1; Yu-Sheng Huang, MD1; Jen-Hsiang Shen, MS3; Yee Hui Yeo, MS4; Huai-En Chang, MS5; Shyr-Chyr Chen, MD, MBA1; Chien-Chang Lee, MD, MSc6,7

Meta-Analyses guidelines of RCT and the Meta-analysis Of Observational Studies in Epidemiology guidelines were used for this study.

The terms for hypotensive resuscitation, small/limited/restricted volume resuscitation, and delayed resuscitation; trauma, hemorrhagic shock, hypovolemic shock, and shock were searched.
RESULTS

- 11 studies, including four RCTs, and seven observational studies were identified.
- Available studies from 1990 to 2012 were selected.

- Duke MD, *J Trauma Acute Care Surg* 2012
• **RCTs. For the four RCTs, there was no significant difference in** overall mortality between liberal and restricted fluid resuscitation strategies (RR, 1.18; 95% CI, 0.98–1.41; I², 0%).

Forest plot for randomized controlled trials. Comparison of the effects of liberal versus restricted fluid resuscitation on overall mortality, expressed as risk ratio (RR) and 95% CI.
Comparison of the effects of liberal versus restricted fluid resuscitation on overall mortality, expressed as RR and 95% CI.

**B**

<table>
<thead>
<tr>
<th>Study</th>
<th>RR (95% CI)</th>
<th>Weight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bickell, et al. 1994</td>
<td>1.26 (1.00, 1.58)</td>
<td>96.21</td>
</tr>
<tr>
<td>Duton, et al. 2002</td>
<td>1.00 (0.26, 3.80)</td>
<td>3.88</td>
</tr>
<tr>
<td>Morrison, et al. 2011</td>
<td>1.24 (1.01, 2.54)</td>
<td>9.92</td>
</tr>
<tr>
<td>Overall (I-squared = 0.0%)</td>
<td>1.25 (1.01, 1.55)</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Comparison of the effects of liberal versus restricted fluid resuscitation on overall mortality, expressed as RR and 95% CI.

- Twenty-four-hour mortality was not significantly different between two strategies (RR, 1.29; 95% CI, 0.58–2.88; I², 0%; two studies).
3. A. Forest plot for observational studies. Comparison of liberal versus restricted fluid resuscitation on overall mortality, expressed as odds ratio (OR) and 95% CI

**Observational Studies**

The summary estimate showed that **liberal fluid resuscitation was associated with significantly higher mortality** in patients with trauma-related hemorrhage conditions (OR, 1.14; 95% CI, 1.01–1.28; $I^2$, 21.4%)
## DISCUSSION

<table>
<thead>
<tr>
<th>The liberal fluid resuscitation strategy</th>
<th>Restricted fluid resuscitation strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RCTs</strong></td>
<td>lower mortality (RR, 1.25; 95% CI, 1.01–1.55; I², 0%)</td>
</tr>
<tr>
<td><strong>Obsv studies</strong></td>
<td>lower mortality (OR, 1.14; 95% CI, 1.01–1.28; I², 21.4%)</td>
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- RCTs suggest that a restricted fluid strategy might be useful in trauma patients with penetrating injury but without TBI.
- The observational studies, the use of restricted fluid resuscitation strategies could be expanded to include those with blunt injury or TBI.
- Further confirmation in prospective RCTs is needed.
There has been limited, but evolving evidence for the role of permissive hypotension in trauma resuscitation
Reduced crystalloid volumes are less likely to dislodge formed clots. Less likely to create dilutional coagulopathy. Reduced pressures are less likely to dislodge formed clots.

Tissue oxygen delivery and clearance of metabolic waste must, however, be maintained at a level compatible with life.
Haemostatic resuscitation and transfusion strategies

• One of the central tenets of haemostatic resuscitation is the early use of ‘balanced transfusion’; aiming to deliver red blood cells (RBC) and fresh frozen plasma (FFP) in a ratio approaching 1 unit of RBC to 1 unit of FFP with the aim of attenuating coagulopathy.

<table>
<thead>
<tr>
<th>RBC</th>
<th>PRBC alone provides little haemostatic capability</th>
</tr>
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<tbody>
<tr>
<td>FFP</td>
<td>High volumes of FFP are independently associated with serious complications including MOF, ARDS</td>
</tr>
<tr>
<td>FFP</td>
<td>FFP takes time to thaw</td>
</tr>
<tr>
<td></td>
<td>PRBC and FFP without platelets and cryoprecipitate give no clear benefit</td>
</tr>
</tbody>
</table>

So incorporating equivalent ratios at an early stage appears vital.
<table>
<thead>
<tr>
<th>Study</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borgman MA. J Trauma 2007</td>
<td>High ratios of FFP:RBC reduce death rate by 46%</td>
</tr>
<tr>
<td>Zehtabchi S, Acad Emerg Med 2009</td>
<td>No absolute agreement as to which specific FFP:RBC ratio (i.e. 1:1, 2:3, etc.) improves mortality</td>
</tr>
<tr>
<td>Duchesne JC, J Trauma 2008</td>
<td>Advocated the aggressive transfusion strategy of preemptive plasma substitution at a 1:1 ratio</td>
</tr>
<tr>
<td>Kashuk JL, Trauma 2008</td>
<td>Advocating the 1:1 concept have significant shortcomings (retrospective)</td>
</tr>
<tr>
<td>Scalea TM, Ann Surg 2008</td>
<td>Prospective but not controlled showed no benefit of a standardized 1:1 transfusion protocol</td>
</tr>
<tr>
<td>N. Curry, / Injury, Int. J. Care Injured 2012</td>
<td>The survival threshold appeared to be in the range of 1:2 to 1:3 FFP:RBC, and data did not support the use of a routine 1:1 transfusion</td>
</tr>
<tr>
<td>Gunter OL J Trauma 2008</td>
<td>Demonstrated that a 1:5 (plt:RBC) transfusion strategy for coagulopathic pts with massive transfusions was associated with increased survival.</td>
</tr>
<tr>
<td>Holcomb JB, J Am Med Assoc 2015; 313: 471e82</td>
<td>High Plt:FFP:PRBC ratios confer a survival advantage, But whether that is at 1:1:1 or 1:1:2 is not clear despite recent investigation.</td>
</tr>
<tr>
<td>Author</td>
<td>Year</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Inaba K, J Am Coll Surg 2010</td>
<td>FFP has been reported of little benefit in patients receiving fewer than 10 units of RBC, with higher incidence of ARDS and no improvement to survival</td>
</tr>
<tr>
<td>Inaba KJ. Am Coll Surg 2010;</td>
<td>Supported the idea of higher than standard doses of platelets and fibrinogen in massively transfused trauma patients</td>
</tr>
<tr>
<td>Phan HH, Vox Sang 2010;</td>
<td>No high quality evidence to confirm that platelets:RBC should be given at a 1:1 ratio</td>
</tr>
<tr>
<td>Magnotti LJ, J Trauma 2011</td>
<td>Increased of FFP has no benefit on mortality</td>
</tr>
<tr>
<td>de Biasi AR, Transfusion 2011</td>
<td>High number of RBC administration (instead of FFP:RBC ratio=1:1) was significantly associated with worse mortality in the first 2 h of resuscitation, and was a more sensitive marker of mortality</td>
</tr>
<tr>
<td>Spinella PC, J Trauma 2009;</td>
<td>Fresh whole blood (FWB) is argued by many to be the optimum transfusion product for patients in need of MT</td>
</tr>
<tr>
<td>West MA, J Trauma 2006</td>
<td>A target Hb level of 7–10 g/dl may be recommended as a safe transfusion strategy in polytrauma</td>
</tr>
</tbody>
</table>
Hemostatic Effects of Fresh Frozen Plasma May be Maximal at Red Cell Ratios of 1:2

Background: Damage control resuscitation targets coagulopathy with the early administration of high-dose FFP. FFP is administered empirically and as a ratio to packed red blood cells (PRBC). There is controversy over whether the FFP:PRBC ratio with respect to outcomes, and their ratio has not been studied. We report preliminary findings as FFP:PRBC ratios on coagulation.

Methods: This is a prospective study of trauma patients requiring >4 U PRBC at admission or before and after each 4 U PRBC interval. For each interval analyzed by rotational thromboelastometry, FFP:PRBC ratios were compared with the FFP:PRBC ratio of each interval.

Results: Intervals from 50 patients were analyzed. Coagulopathy deteriorated with lower FFP:PRBC ratio (p = 0.006). 56% deterioration was observed in the prothrombin time (p = 0.047), and 38% increase in maximum clot firmness. A ratio with ≥1:1 ratio did not confer any additional advantage. There was marked variability in response to FFP, and hemorrhage deteriorated in some patients exposed to 1:1 ratios. The benefit of FFP plasma were confined to patients with coagulopathy.

Conclusions: Interim results from this prospective study suggest that FFP:PRBC ratios of ≥1:1 do not confer any additional advantage over ratios of 1:2 to 3:4. Hemostatic benefits of plasma therapy are limited to patients with coagulopathy.
• Mortality, ICU admission, length of stay, need for emergent surgery were outcomes.

Acute transfusion practice during trauma resuscitation: Who, when, where and why?

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\textsuperscript{a}Department of Traumatology, Division of Surgery, John Hunter Hospital and University of Newcastle, Newcastle, NSW, Australia
\textsuperscript{b}Hunter Area Pathology Service, John Hunter Hospital, Newcastle, NSW, Australia

Aim: to describe the patterns, indications and timing of ET at level 1 trauma centre.

Methods: A 12-month prospective study was performed on all trauma admissions requiring ET. Demographics, mechanism, injury severity (ISS) were collected. Timing, location, volume, the clinician initiating first unit of transfusion, reason for transfusion was recorded, with corresponding blood gas results and physiological parameters. Mortality, ICU admission, length of stay, need for emergent surgery were outcomes.

Results: From 965 trauma admissions 91 (9\%) required ET (76\% male, median age: 38 (10–88, IQR: 22–59), blunt mechanism: 87\%, ISS: 25 (4–66, IQR: 16–34), 43\% (39/91) had massive transfusion protocol (MTP) activation. ET was initiated in ED (52\%), OR (38\%) or ICU (10\%). MTP transfusions were started at a median of 0.5 h (0.5–4, IQR: 0.5–1.5), whilst non-MTP transfusions were initiated at a median 3 h (0.5–23, IQR: 2–9). The first unit of ET was initiated by trauma surgeon (35\%), anaesthetist (30\%), ED (19\%), ICU (13\%) and general surgeon (3\%). Transfusions triggers at the first unit of transfusion were 'expected or ongoing bleeding' 29\%, dropping haemoglobin 26\%, haemorrhagic shock 24\%, hypotension 10\%, tachycardia 8\%. Median systolic blood pressure was 90 (45–125, IQR: 80–100), heart rate was 100 (53–163, IQR: 80–128), haemoglobin was 9\% (50–160, IQR: 55–144) g/l and base excess was −4.2 (−22.1 to −2.7, IQR: −7.2 to 2.4) mmol/l at the time of transfusion. Emergency surgery was required in 86\% (78/91). ICU admission rate was 69\% (63/91). Mortality was 14\%. Low volume transfusion (1–2 units) was more likely to lead to overtransfusion (Hb > 110 g/l).
The risks of blood and blood products transfusion

- MOF
- Infection
- ARDS
- Single organ failure
- Increased length of stay

Lelubre C, Transfusion 2009;
Zehtabchi S, Acad Emerg Med 2009;
Damage control resuscitation

• Fluid administration
• Operative exposure

Hemorrhage

Coagulopathy

DEATH TRIAD

Acidosis

Hypothermia

TRAUMA

Control bleeding

Haemostatic resuscitation

Hypotensive or Novel hybrid resuscitation

Massive transfusion

2011, Ann Surg
The basic tenets of DCR

- Avoid crystalloid resuscitation
- Aim for permissive hypotension whenever possible
- Prevent coagulopathy through early use of blood products
- Aggressively break the vicious cycle of acidosis, coagulopathy, and hypothermia
RESULTS—390 patients underwent DCL. Of these, 282 were pre-DCR and 108 were DCR. Groups were similar in demographics, injury severity, admission vitals and laboratory values. DCR patients received less crystalloids (median 14 L vs. 5 L), RBC (13 U vs. 7 U), plasma (11 U vs. 8 U) and platelets (6 U vs. 0 U) in 24-hr; all p<0.05. DCR patients had less evidence of the lethal triad upon ICU arrival (80% vs. 46%, p<0.001). 24-hour and 30-day survival were higher with DCR (88% vs. 97%, p=0.006 and 76% vs. 86%, p=0.03). Multivariate analysis controlling
Definition of haemorrhagic shock

Low BE

Expected and ongoing bleeding

Coagulopathy and hypovolaemia

Low Hb with severe traumatic brain injury

Persistent hypotension and tachycardia despite fluid replacement

Dropping Hb (Hb drop to below 80 g/l or below 100 g/l and 30 g/l drop within 2 h)
Use of Hemoglobin-based oxygen carriers (HBOC) for hemorrhagic shock compare with normal saline.

- **Has higher mortality rate** ($P \ 0.015$)
  - Sloan EP, JAMA 1999

- **Similar mortality rates.**
  - Kerner T, Intensive Care, Med 2003

- **Lower need for PRBC transfusion but a significant increase in serious adverse events**
  - Jahr JS, J Trauma 2008

- **Similar mortality and a higher rate of adverse events** ($P \ 0.041$).
  - Moore EE, J Am Coll Surg 2009
Resuscitative strategies in traumatic hemorrhagic shock

**Primary goal: Stop the bleeding**

- **Traumatic haemorrhagic shock**
  - Hemodynamic management
    - Fluid resuscitation
  - Coagulation management
    - Tranexamic acid: 1g IV followed by IV infusion of 1g over 8h
  - Transfusion Coagulation targets
    - Without TBI (GCS ≤8)
      - Hb 7-9 g.dL⁻¹
      - PT/APTT < 1.5 x normal
      - Platelets > 50.10⁹ L⁻¹
      - Fibrinogen ≥ 1.5-2 g.L⁻¹
    - With TBI (GCS ≤8)
      - Hb > 10 g.dL⁻¹
      - PT/APTT < 1.5 x normal
      - Platelets > 100.10⁹ L⁻¹
      - Fibrinogen ≥ 1.5-2 g.L⁻¹
  - Prevention of acidosis
    - Normothermia: Ionised Ca++ = 1.1-1.3 mmol/l
  - Surgical and/or angiographic embolization bleeding control

- Traumatic haemorrhagic shock
  - Inflammation
    - Excessive activation of the coagulation
      - Fibrinolysis
        - Tranexamic acid
          - Beside coagulation monitoring
            - Low volume resuscitation
            - 80 ≤ SAP ≤ 90 mmHg
            - Early administration of vasopressor
          - Normothermia
          - Ionised Ca++ = 1.1-1.3 mmol/l
          - Avoid delays in the delivery
          - Massive transfusion protocol
          - RBCs:FFP ≤ 2:1
          - Early administration of FFP
          - Fibrinogen ≥ 1.5-2 g.L⁻¹
  - Hemodilution
    - Tissue hypoxia
    - Acidosis
    - Anemia
    - Decrease of activity of coagulation factors and platelet function

- Tissue injury
  - Acute Traumatic Coagulopathy
In appropriate patients limiting the rate and volume of fluid resuscitation is becoming the new norm and standard practice.

Drugs are being aggressively investigated.

Permissive hypotension is the new buzz word.
The concept of “damage control resuscitation” with early use of blood components in appropriate pts became cornerstone.

Provide physiological balance, rather than anatomic repair damage.

Patients who are actively bleeding should have their losses initially restored with fluids to replace the extracellular space.

This approach should, however, be conducted according to criteria.
Yes, a Controlled Fluid Resuscitation Strategy can Decrease Mortality in Trauma Patients
<table>
<thead>
<tr>
<th>Indications</th>
<th>Phases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid control of bleeding</td>
<td>Reduced surgical time</td>
</tr>
<tr>
<td>Control and prevention of exsanguination</td>
<td>Reperfusion phase</td>
</tr>
<tr>
<td></td>
<td>Definitive surgical correction</td>
</tr>
</tbody>
</table>

### Damage control surgery
- Prevention and treatment of hypothermia
- Prevention and correction of acidosis
- Prevention and treatment of coagulopathy
- Hemostatic transfusion
- Permissive hypotension

### KEY POINTS
- DCR can be required in severe trauma victims.
- Hypothermia, coagulopathy, and acidosis should be aggressively treated.
- Strategies such as permissive hypotension can be used to decrease the loss of blood.
- Hemostatic therapy may also contribute to a better outcome for these patients.