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Hemostatic Resuscitation in Severe Trauma: Early Administration of Tranexamic Acid Integrated with Massive Transfusion Protocols

Ana Paula de Carvalho Miranda Rosati Rocha [1, 2], Ana Luiza de Carvalho Miranda Rosati Rocha [3], Luís Fernando Rosati Rocha [4, *], Jam Peter Perissé [5]

[1] Department of Radiology, Fluminense Federal University (UFF), Rio de Janeiro, Brazil.
[2] Fleury Group, Rio de Janeiro, Brazil.
[3] Pardini Institute, Rio de Janeiro, Brazil.
[4] Department of General Surgery, Fluminense Federal University (UFF), Rio de Janeiro, Brazil.
[5] Federal Hospital of Bonsucesso, Rio de Janeiro, Brazil.

* Correspondence: lfrosati@yahoo.com.br.

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Trauma is responsible for approximately five million deaths worldwide each year and represents one of the leading causes of preventable mortality [1]. Hemorrhage is the primary determinant of early outcomes and is associated with up to forty percent of preventable deaths following trauma. Modern hemostatic resuscitation integrates damage control resuscitation with balanced massive transfusion, early use of antifibrinolytic agents, and coagulation correction guided by thromboelastography [2, 3]. Tranexamic acid acts by inhibiting plasmin activation, stabilizing fibrin clots, and reducing fibrinolysis. Multicenter studies such as CRASH 2 [1] and CRASH 3 [2] established tranexamic acid as a pharmacological intervention with a significant global impact on survival in patients with hemorrhagic trauma.

Trauma related coagulopathy is multifactorial and involves hypoperfusion, acidosis, hypothermia, and excessive activation of fibrinolysis [1, 3]. When administered within the first three hours after injury, tranexamic acid reduces hemorrhagic mortality by up to twenty seven percent [6]. The CRASH 2 trial demonstrated a one-point five percent absolute reduction in mortality [1], while studies by Lauerman et al. [5] and Yamamoto et al. [6] reported additional reductions in mortality and transfusion requirements. The use of balanced transfusion protocols with a one to one-to-one ratio, as demonstrated in the PROPPR Trial [2], was associated with faster correction of coagulopathy and a lower incidence of organ dysfunction.

Artificial intelligence based predictive tools, such as the Machine Learning Trauma Prediction Model (MITrauma, 2024), have been applied to enable early identification of patients at risk of massive bleeding [1]. These algorithms can optimize the timing of tranexamic acid administration and the activation of massive transfusion protocols, bringing hemostatic resuscitation closer to precision medicine. The incorporation of artificial intelligence into transfusion management represents a promising frontier, allowing data driven decision making and improved efficiency in the use of hospital resources [7]. These tools may play a decisive role in reducing response times and improving survival

rates within regional trauma systems. Early administration of tranexamic acid combined with integrated massive transfusion protocols represents a milestone in the evolution of trauma care. Recent evidence confirms its effectiveness in reducing mortality and optimizing the use of blood products. The adoption of dynamic monitoring technologies and artificial intelligence models is expected to transform hemostatic resuscitation into an increasingly personalized, efficient, and safe process.

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