CELOX / OMNI-STAT Chitosan-Based Hemostatic Agents:

The Superior Standard for Bleeding Control

A Review

Executive Summary

KEY FINDINGS

- Rapid, durable hemorrhage control—even in coagulopathy
- Demonstrated survival advantage with reduced blood loss
- Safe, versatile, and effective across the continuum of care
- High clinical value with substantial cost avoidance

Hemorrhage remains the leading cause of death in trauma and bleeding control is paramount to survival. Bleeding only stops with a clot and, according to Virchow, a clot only forms when flow is reduced. The faster bleeding stops, the better one's chances of survival. The first link in the chain of care begins in the field and progresses into the hospital. This is where fast acting Chitosan based hemostatic agents outshine other hemostatics and can impact survival and ultimately save lives.

There are many internal absorbable hemostatic agents available to surgeons for use in the operative field. Although these agents are often efficacious in controlled settings, they are costly, unstudied, and unproven in the presence of coagulopathy and physiological extremis. Unfortunately, due to ease of availability within the hospitals, these agents are frequently misused in emergency departments, trauma bays, intensive care units, and in procedural areas. Emergency use outside their intended purpose and environment is frequently ineffective, falls short of expectations, and adds considerable unnecessary cost to patient care.

Temporary topical hemostatic agents, particularly those based on chitosan technology, fill a critical and underutilized gap in hospital hemorrhage control. Chitosan-based agents act independently of the clotting cascade by directly binding red blood cells, allowing for effective hemorrhage control even in patients receiving anticoagulants or suffering from trauma-induced coagulopathy. Unlike kaolin-based products, chitosan is

an organic polymer with absorbable properties and inherent antibacterial and antifungal activity.

From a clinical perspective, the ability to achieve hemostasis within approximately 60 seconds and maintain clot durability under arterial pressure fundamentally changes how we manage bleeding in trauma bays, emergency departments, ICUs, and procedural suites. Applicator-based delivery systems offer a significant advantage in penetrating injuries such as gunshot wounds, where traditional gauze packing is often challenging and ineffective.

From a value standpoint, the implications are equally compelling. With acquisition costs under $45 per unit, temporary topical hemostatic agents can prevent the inappropriate use of internal absorbable surgical products costing hundreds to thousands of dollars. Faster hemorrhage control reduces blood product utilization, decreases nursing time at the bedside, minimizes dressing changes, and may lower the risk of line-associated infections[1,2].

These agents are not experimental. They are supported by over 20 years of prehospital and military use, recommended by the Committee on Tactical Combat Casualty Care, validated by independent peer-reviewed studies demonstrating improved survival and reduced re-bleeding, and deployed in more than 42 countries worldwide. The lessons learned in combat and pre-hospital environments are directly applicable to modern civilian hospitals, especially given the economic constraints facing healthcare.

For hospital value analysis committees tasked with balancing clinical excellence, operational efficiency, and cost containment, temporary topical chitosan-based hemostatic agents represent a rare convergence of intended purpose and better outcomes at lower cost.

Seeking topical hemorrhage control across trauma care.

From pre-hospital to in-hospital, hemorrhage is responsible for up to 40% of trauma-related deaths and remains the leading cause of preventable mortality following injury[3]. The growing emphasis on pre-hospital hemorrhage control has further reinforced the critical importance of rapid, effective bleeding management at the point of injury. The Stop the Bleed initiative launched by the Department of Defense in partnership with the American College of Surgeons has fundamentally reshaped trauma care by training civilians, first responders, and healthcare personnel to recognize life-threatening hemorrhage and intervene immediately. The focus has been on countermeasures such

as tourniquets and direct pressure via pressure dressings and wound packing with the inclusion of hemostatic agents. Evidence from military and civilian settings demonstrates that early hemorrhage control prior to hospital arrival significantly reduces mortality and transfusion requirements, underscoring that definitive bleeding control must begin in the pre-hospital environment and continue seamlessly into in-hospital care. Time to hemostasis is a critical determinant of survival and delays in bleeding control directly translate into increased transfusion requirements, physiologic derangement, and mortality. Advancements in trauma care frequently align with innovation and solutions associated with military conflict[4]. Although frequently delayed by bureaucracy, the civilian sector eventually benefits from such leaps in technology, care and management. Advancements in hemostatic agents continues to be one such area where creativity and innovation cross paths with physiology and anatomy. Col Nicholas Senn once said, “The fate of the wounded lies in the hands of the one who applies the first dressing” It is when that dressing has the ability to rapidly stop bleeding regardless of the physiologic constraints can be accomplished then Dr. Senn’s theory will be brought to fruition. Chitosan based hemostatics are that dressing and CELOX is that solution. Although considerable advances have been made with the addition of several operative internal use hemostatic agents, all remain expensive, and unstudied relative to use in physiologic extremis patients. Additionally, such agents are frequently reached for outside of the OR despite their shortcomings due to availability and lack of an alternative. Hospitals currently lack a standardized, scalable product-based approach to rapid hemorrhage control outside the surgical suite. Temporary topical Chitosan hemostatic agents such as CELOX and OMNI-STAT address this gap by providing rapid, externally applied cost-effective hemorrhage control.

“Hemorrhage control begins at the point of injury: Stop the Bleed principles bridge pre-hospital and in-hospital survival.”

Definitions and Pathophysiology

- **The Lethal Triad of Trauma**: Hypothermia, acidosis, and coagulopathy accelerate bleeding and shock and ultimately death if not addressed early.
- **Virchow’s Triad**: Defined by stasis, endothelial disruption, and hypercoagulable states establishes the cornerstones for clot formation and thus identifies areas to best intervene.

- **Vulnerable Anatomy:**
    - Junctional areas
        - Areas with limited compressibility where pressure alone may fail
- **Physiologic Extremis**:
    - Coagulopathy as a result of metabolic instability or anticoagulants.

Table 1: CELOX / OMNI-STAT Market Preparations

Product Name	Product Description	Product Size	Clinical Setting	Practical Applications
CELOX Rapid 5 ft Z-Fold Gauze	Hemostatic gauze (Z-fold)	3″ × 5 ft	Trauma / Emergency Dept / Pre-hospital	Fastest-acting CELOX gauze; designed to stop moderate-to-severe bleeding with ~60 s compression; chitosan-based hemostat on gauze substrate.
CELOX 6 g Applicator (CELOX-A)	Granules with applicator	6 g applicator	Trauma / Emergency Dept / Pre-hospital	CELOX granules preloaded into applicator for gunshot, blast or stab wounds. The high-speed applicator delivers granules directly to the source of bleeding.
CELOX Vascular 2×2	Hemostatic pad	2″ × 2″ pad	IR / Cath Lab / ICUs / Vascular Access	Local management of surface bleeding from vascular access sites (e.g., post-catheter); flexible backing for placement and better feel of the access site.
OMNI-STAT 4×4 Gauze	Hemostatic gauze pads	4″ × 4″ pads	Trauma / ED / OR / Wound Care	Temporary topical dressing to help control bleeding where standard gauze is insufficient.
OMNI-STAT 3g Granules	Hemostatic granules (loose)	3 g pouches	Trauma / ED / OR / Wound Care	Granules for irregular wounds or areas difficult to pack with gauze.

Temporary Topical Hemostatic Agents: Role and Rationale

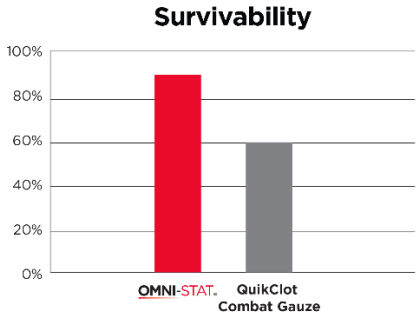
CELOX / OMNI-STAT are externally applied products designed to rapidly control active bleeding and can be removed following stabilization. Unlike internal absorbable agents, they require no surgical field, mixing, reconstitution, or specialized storage and can be applied by physicians, nurses, and pre-hospital providers.

These agents are particularly valuable in:

- Trauma bays and EDs
- ICUs managing line-related bleeding
- Interventional radiology (IR) and cardiac catheterization laboratories
- Pre-hospital and tactical environments
- Palliative and end of life care

In standardised swine models with active extremity arterial hemorrhage, CELOX Gauze achieved hemostasis in up to 90% of cases vs. ~30–60% for QuikClot Combat Gauze; shed blood volume reduced four fold[5].

Figure 1. Statistically significant improvement in survival vs QuikClot



Mechanism of Action and Product Differentiation

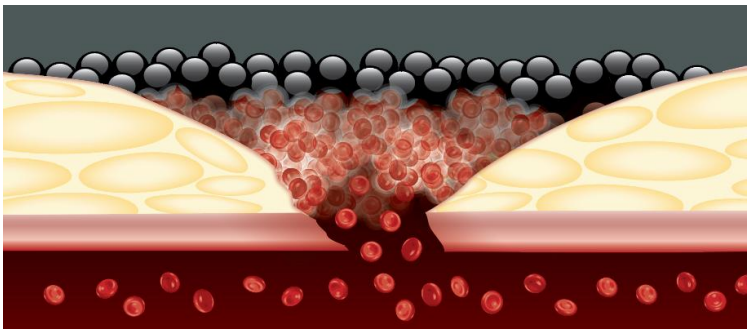
CELOX /OMNI-STAT Hemostatic Agents

Chitosan is a positively charged organic polymer derived from chitin. Its mechanism of action relies on physical formation of a robust gel plug that seals the wound. By creating a physical barrier, and through the activation of platelets via platelet concentration, it stops bleeding and reduces re-bleed independent of the intrinsic or extrinsic coagulation pathways. This allows effective hemorrhage control in patients with:

- Therapeutic anticoagulation
- Trauma-induced coagulopathy
- Hypothermia

When applied in granular form, CELOX/OMNI-STAT gels upon exposure to blood thus forming a “robust” plug that is coagulogenic. This plug can serve to initiate tamponade at the site of bleeding, thus furthering its efficacy in stopping bleeding at its source.

Figure 2. Mechanism of action of chitosan-based hemostatic agents (plug formation via mucoadhesion and platelet concentration independent of clotting cascade).



Inert and Safe

- **Low embolization risk**: forms a surface clot, not intravascular[6,7].
- **Biocompatible**: validated in regenerative tissue engineering models[8].
- **Clinical safety**: 292-case surveillance found **99.3% first-time hemostasis, zero adverse events**, even in anticoagulated patients[9].
- **No allergy concerns**: no cross-reactivity despite shellfish origins[10].

Chitosan is an inert organic compound that reduces to N-Acetyl Glucosamine (GlcNAc). GlcNAc is an amide derivative of the monosaccharide glucose. It is a secondary amide between glucosamine and acetic acid and is significant in several biological systems.

Comparison With Kaolin-Based Products

Kaolin-based products rely on activation of Factor XII to initiate clot formation. While effective in some scenarios, this mechanism is less reliable in anticoagulated or coagulopathic patients. Additionally, kaolin is an inorganic mineral with no known metabolic pathway for absorption and lacks antimicrobial properties.

Clinical Effectiveness: Speed and Durability

Speed to hemostasis is critical in trauma care. CELOX / OMNI-STAT have demonstrated hemostasis within approximately 60 seconds in both experimental and clinical settings[11]. The clot formed is durable and capable of withstanding arterial

pressure, distinguishing these products from powders and cellulose-based agents that liquefy rapidly and are limited to minor oozing.

Extended wear times of up to 72 hours reduce the need for frequent reapplication and dressing changes, decreasing nursing workload, and potential infection risk[1,2].

Overall Superiority of CELOX Rapid®

Several reviews in the published literature support the superiority of Chitosan based hemostatics, specifically CELOX Rapid when compared to all others. Sánchez-Roldán et al, in their comprehensive review titled *Effectiveness of topical hemostatic agents for management of external bleeding: a systematic review, concluded that both* CELOX Rapid® *and* Combat Gauze® XL were the most effective in controlling hemorrhage with CELOX Rapid distinguishing itself over Combat Gauze® XL. They specifically cited its speed, its reliability in coagulopathy, and its overall operational simplicity making it the optimal hemostatic agent for *external hemorrhage control in the pre-hospital and tactical settings*[12].

- **Superior hemostatic efficacy**: Across comparative animal models and observational human data, CELOX Rapid achieved faster and more reliable hemorrhage control than alternatives such as QuikClot®, HemCon®, and standard CELOX®, and performed at least as well as Combat Gauze® XL.
- **Speed of action and ease of use**: CELOX Rapid requires **significantly less wound-packing time** (often ~1 minute), which is critical in care-under-fire or austere environments.
- **Effectiveness independent of the coagulation cascade**: As a chitosan-based mucoadhesive agent, it remains effective in **coagulopathy**, a common condition in severe trauma and massive hemorrhage where kaolin- or factor-dependent agents may lose efficacy.
- **Clinical and operational benefit**: The review identifies CELOX Rapid as particularly attractive due to its combination of rapid application, low blood loss, high survival signals in experimental models, and suitability for both military and civilian prehospital use, especially when combined with a tourniquet.

Applications Across Hospital Sites of Care

Trauma Bay and Emergency Department

CELOX is highly effective at overcoming anatomic vulnerabilities in penetrating trauma, such as gunshot and stab wounds in junctional areas or where a deep tract exists. The granule applicator delivery systems provide a significant advantage in deep or narrow wound tracts where traditional gauze packing is difficult or ineffective.

CELOX/ OMNI-STAT have proven efficacy in large surface bleeding, lacerations, avulsions. Regardless of whether the source is arterial or venous, these Chitosan based dressings provide rapid hemorrhage control that is cost effective.

Rural and critical access hospitals frequently represent the first point of care for patients with life-threatening hemorrhage. In these settings, definitive surgical or endovascular intervention may be unavailable, thus requiring upgrade to a higher level of trauma care. This often results in prolonged transport times which place patients at significant risk for continued blood loss, physiologic deterioration, and death if the hemorrhage is not adequately controlled.

Temporary topical chitosan-based hemostatic agents such as CELOX and OMNI-STAT provide an effective means of achieving rapid hemorrhage control thus allowing for safer transport by reducing ongoing bleeding. Their ability to form a durable clot, independent of the coagulation cascade, makes them particularly valuable in austere environments where patients may be hypothermic, anticoagulated, or coagulopathic. In rural trauma systems, these agents serve as a critical bridge to definitive care [2].

Intensive Care Unit

Line-related bleeding from arterial lines, PICCs, central venous catheters, ECMO cannulas, and Impella sheaths presents a frequent challenge in ICUs. Rapid hemostasis reduces dressing changes, nursing time, and may decrease the risk of catheter-related bloodstream infections[1,2].

Interventional Radiology and Cardiac Catheterization

These agents serve as adjuncts to mechanical closure devices, particularly in anticoagulated patients or those with persistent access-site bleeding.

*Access-site bleeding: CELOX controlled hemorrhage in **100% of heparinized swine femoral injuries**; controls failed[7].*

Military and Pre-Hospital

CELOX has over 20 years of military use and is recommended by the Committee on Tactical Combat Casualty Care (CoTCCC). Multiple peer-reviewed studies demonstrate improved survival and reduced re-bleeding rates in battlefield and pre-hospital environments[7,13]. These findings translate directly to civilian trauma systems and align with Stop the Bleed initiatives[12].

- CELOX Rapid® is especially advantageous in care-under-fire and austere environments.
- The reduced application time associated with CELOX Rapid® may provide a meaningful survival advantage[2].

Infection Control

- Multiple in-vitro and clinical studies support the antimicrobial properties of Chitosan derivatives[14,15].
    - Chitosan's antibacterial and antifungal properties
    - Potential relevance to line-site management and CLABSI reduction[15].

Palliative and End-of-Life Care

Beyond trauma and acute resuscitative settings, CELOX has an established role in the management of catastrophic external bleeding in palliative and end-of-life care. In patients with advanced malignancy or terminal illness, the goals of care prioritize comfort, dignity, and reduction of distress for both patients and caregivers rather than definitive hemorrhage control or resuscitation.

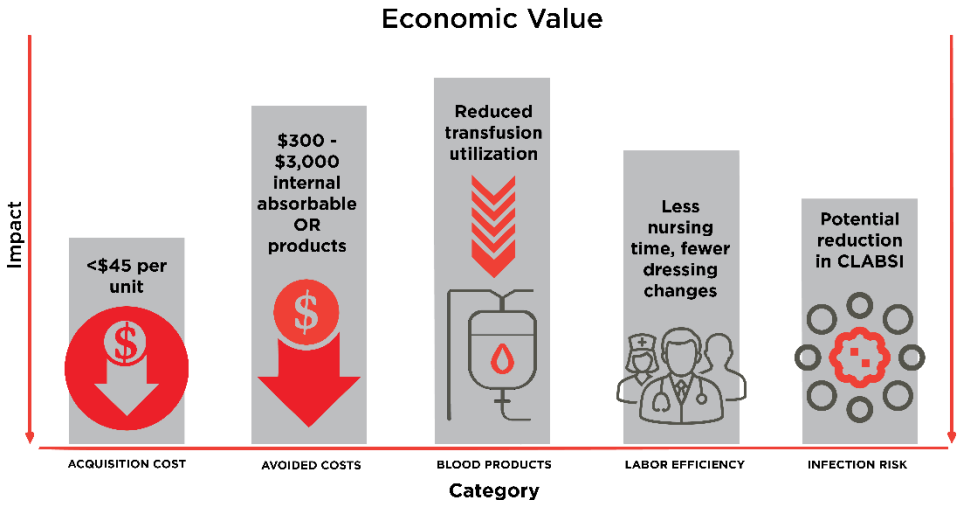
In Europe, CELOX is explicitly referenced within the Specialist Palliative Care Audit and Guidelines Group (SPAGG) Catastrophic Bleeding Guidelines as a recommended hemostatic option during advance care planning and in the management of terminal

hemorrhage. These guidelines identify hemostatic gauze and granules, including CELOX™, as appropriate interventions to stem visible bleeding, reduce panic, and support calm, dignified end-of-life care in both inpatient and community settings.

Cost Effective

CELOX / OMNI-STAT cost less than $45 per unit, compared with internal absorbable surgical products costing hundreds to thousands of dollars. Faster hemorrhage control reduces blood product utilization, avoids escalation to operative intervention, and improves workforce efficiency. All are key considerations for hospital value analysis committees[1].

Table 2 – Direct and Indirect Cost



The Necessary and Clear Advantage:

The Recommended Universal Hospital and Pre-Hospital Standard

CELOX and OMNI-STAT, both temporary topical chitosan-based hemostatic agents, provide rapid, durable hemorrhage control across the continuum of trauma care. Their clinical effectiveness, ease of use, and favorable cost profile support broader adoption as a standard component of both pre-hospital and in-hospital hemorrhage control strategies.

Both CELOX and OMNI-STAT should be considered the minimum universal standard for hospital wide hemorrhage control.

Figure 3. Competitive Products

AGENT	Mechanism	Limitations	CELOX Advantage
QC (Kaolin)	Activates intrinsic clotting cascade	Ineffective in coagulopathy; sloughing particles; embolic risk	Independent of cascade; effective in coagulopathy
WoundStat (Smectite)	Clay-like plug, factor concentrator	Poor outcomes in penetrating trauma; rebleeding issues	Stable clot; superior outcomes
HemCon/ChitoFlex	Chitosan water/adhesion	Breaks under arterial pressure; higher rebleed rates	CELOX conforms better; lower rebleeding
CELOX	Chitosan cross-links RBCs	None significant; proven safe across settings	Superior survival, cost-effective, multi-setting use

Author Perspective / Summary

Our institution, and several others, have used CELOX A with applicator in both the resuscitation and operative settings for over 15 years. Our operative uses have demonstrated considerable success in the management of both blunt and penetrating injuries and have successfully tamponaded and stopped ongoing hemorrhage in otherwise difficult to manage surgically challenging locations[16]. I have no doubts CELOX A, in this setting, has saved many lives. Clinical experience suggests that off-label application of this device in trauma may address an important unmet need, though formal research is required to support broader adoption and advance the technology.

With over 20 years of clinical use across military, pre-hospital, and hospital environments, CELOX / OMNI-STAT hemostatic agents have repeatedly demonstrated durability, reliability, and life-saving potential. In several studies CELOX has demonstrated a clear survival advantage over other hemostatic agents[5,6,11,12]. Their integration into hospital protocols represents a critical step in closing the gap between pre-hospital and bedside hemorrhage control.

Figure 4. Kozen et al. Statistically significant improvement in survival and reduced re-bleed

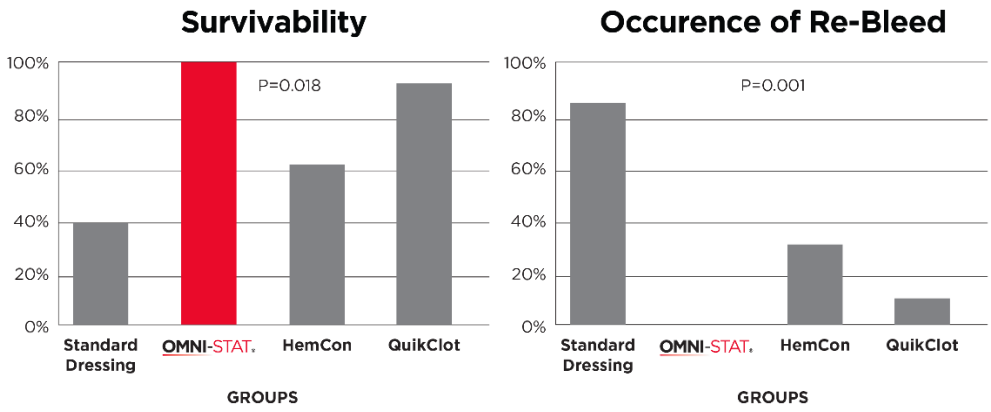


Figure 5. Percentage increase in survival (underlined: p<0.05). NISS, New Injury Severity Score

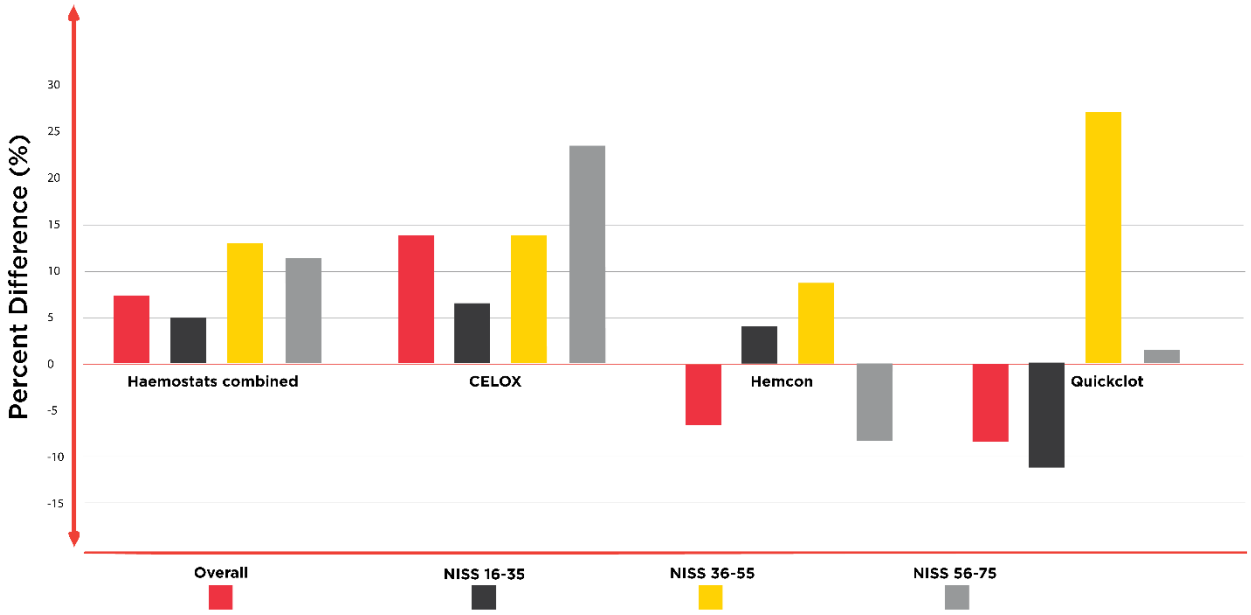


Table 3 – Clinical Problem & Solution

Clinical Problem

Uncontrolled bleeding in trauma bays, emergency departments, ICUs, and procedural areas leads to:

Increased Blood Product Utilization

Escalation to Costly Operative or Procedural Interventions

Increased Nursing workload & Infection Risk

Internal absorbable surgical hemostatic agents are frequently used outside the OR despite high cost and limited effectiveness for active hemorrhage.

Solution

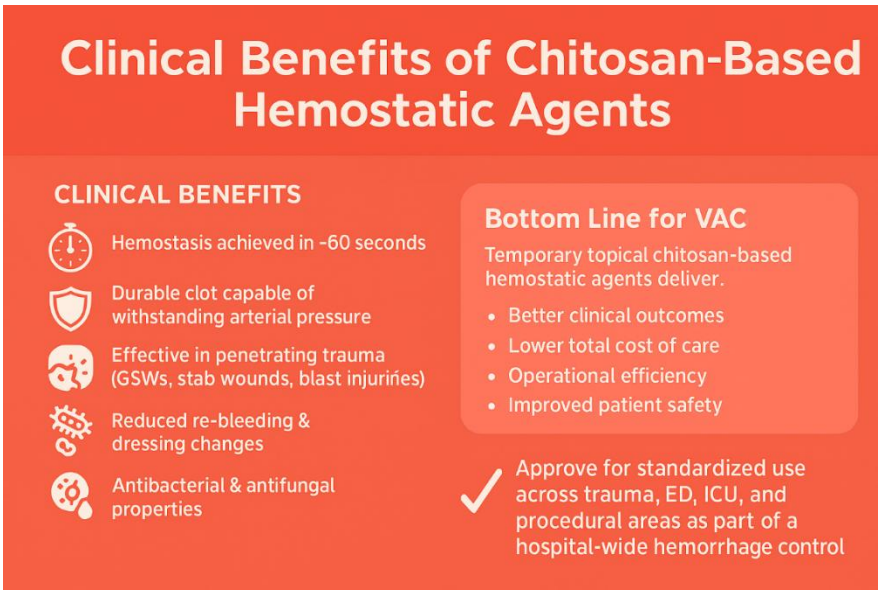
Temporary topical chitosan-based hemostatic agents provide rapid, externally applied hemorrhage control that:

Anticoagulated, coagulopathic & hypothermic patients

No mixing, reconstitution or special storage

Applied by nursing staff & physicians

Table 4 – Summary – Clinical Benefits & Bottom Line



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