

Pain Generation by Tourniquet Application: A Comparative Study of Two Hemorrhage Control Devices

A Novel Approach to Combat Hemorrhage Control and Extended Evacuation
Management

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Disclosures

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Data and protocols presented are based upon observational field experience

Hemorrhage remains the leading cause of preventable death in combat

Standard Compression Bandage	Tourniquet (CAT)	Hemostatic Gauze
Opaque — no wound visibility	Total cessation of arterial flow	Limited wound types
Absorbent pad interferes with confirmation of hemorrhage control	Limb ischemia/injury — amputation risk	Requires appropriate technique and sustained manual pressure
Ineffective for arterial wounds	Extremities only	High cost (~\$40/unit)
Blind adjustment = rebleed risk	Significant patient pain	Limited effectiveness alone

No single device adequately controls hemorrhage, permits simultaneous wound observation and treatment, and allows for preservation of distal perfusion

The ELAD Bandage (Elastic Adhesive Dressing)

Six integrated engineering features

1

Clear sterile elastic wrap

Fully transparent — continuous hemorrhage visualization at any stage. Adhesive around the indicator pad allows for one-handed application.

2

Sterile minimally absorbent indicator pad

Reflects real-time hemorrhage status. Stable stain = controlled.

3

Calibrated grid pattern

Quantifies stain area serially — objective, measurable record.

Features 1–3 create a window effect: simultaneous quantifiable observation and treatment without removing the dressing.



The ELAD Bandage (Elastic Adhesive Dressing)

Six integrated engineering features

4

Self-adherent material

Sequential wrapping increases compression, effective even for arterial wounds. Controlled unwrapping titrates to minimum necessary effective pressure. The self-adherent wrap creates a sealed wound compartment — hemostasis may be achieved even for arterial wounds at compression below systolic blood pressure. Material can be easily hand-torn; excess material adheres to prior layers for rapid re-tightening.

5

Effective for junctional hemorrhage, neck wounds

The wrapping system conforms to any body contour — effective for groin, axilla, neck, and other junctional wounds where a standard tourniquet cannot be applied.

6

Sole modality or transitional step-down from tourniquet

Placed directly over the wound, the ELAD can be used as a sole modality without a tourniquet, or as a controlled transitional step-down — allowing progressive tourniquet release while continuously monitoring hemostasis through the clear wrap/indicator pad window.

Addressing Limitations of All Existing Approaches in a Single Device

Feature	Standard Bandage	Tourniquet (CAT)	Hemostatic Gauze	Elastic Adhesive Dressing (ELAD)
Arterial hemorrhage control	X	✓	✓	✓
Wound visibility	X	✓	X	✓
Quantifiable bleeding indicator	X	X	X	✓
Preserves distal perfusion	✓	X	✓	✓
Other anatomical zones	✓	X	✓	✓
One-handed application	X	✓	X	✓
Approx. unit cost	~\$10	~\$30	~\$40	~\$18

Approximate costs from publicly available sources. Data from Retiya Medical Solutions market analysis, 2024.

ELAD Cited to Formulate AHA Guidelines

Circulation

2024 American Heart Association and American Red Cross Guidelines for First Aid

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ABSTRACT: Codveloped by the American Heart Association and the American Red Cross, these guidelines represent the first comprehensive update of first aid treatment recommendations since 2010. Incorporating the results of structured evidence reviews from the International Liaison Committee on Resuscitation, these guidelines cover first aid treatment for critical and common medical, traumatic, environmental, and toxicological conditions. This update emphasizes the continuous evolution of evidence evaluation and the necessity of adapting educational strategies to local needs and diverse community demographics. Existing guidelines remain relevant unless specifically updated in this publication. Key topics that are new, are substantially revised, or have significant new literature include opioid overdose, bleeding control, open chest wounds, spinal motion restriction, hypothermia, frostbite, pregnancy, anaphylaxis, snakebites, oxygen administration, and the use of pulse oximetry in first aid, with the inclusion of pediatric-specific guidance as warranted.

Key Words: AHA Scientific Statements • American Heart Association • emergencies • first aid • Red Cross • wounds and injuries

- with participants who received direct pressure alone (32.5%).⁸ There are currently no data addressing which type of dressing may be more effective in the first aid setting, but 3 in-hospital RCTs suggest no difference between dressing types in time to cessation of bleeding or complications.^{9–11}
- 3. Commercial pressure dressings and elastic adhesive dressings may be effective in maintaining hemorrhage control or even as the primary means of hemorrhage control when applied by people who have received bleeding control training, including by non-health care personnel.^{12–14}
 - 4. No studies were identified evaluating the effectiveness of manual compression of the femoral or brachial artery (also known as pressure points) to control distal hemorrhage. Data on the use of pressure points for life-threatening

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The ELAD Bandage has been co-developed by the presenter together with Major Sody Naimer, IDF Medical Corps — first author of references 12 and 13 — using the same manufacturer and material as the original published studies.

ELAD Used in over 150 Cases in Multiple Conflict Zones

~100

Ukraine Combat Cases

Dozens in Israel,
Gaza, and
Lebanon

Severe arterial
wound trauma in
South Africa

No Reported
Device-Related
Amputations

Combat Deployment

Ukraine — Nearly 100 cases

Nearly 100 combat trauma cases in the Ukrainian military. Extended evacuation scenarios with prolonged wear times

Israel, Gaza, & Lebanon — dozens of cases

Cases of variable severity — extremity, junctional, and craniofacial wounds, including the severe facial GSW case shown opposite. ELAD wrapped over entire head/face, created a single controlled compartment.

Civilian Trauma

Severe femoral artery laceration

Device applied as sole modality for arterial hemorrhage control. Hemostasis achieved without tourniquet.

Illustrative Case: Severe Facial GSW — Gaza



3D CT reconstruction of craniofacial injury. Device intact until OR removal. Full recovery.

ELAD Bandage Use in Ukraine



Extended Evacuation Creates a Life-Threatening Secondary Issue

Venous Stasis Cascade During Prolonged Compression

0–2 hrs	Acceptable compression — hemostasis maintained
2–4 hrs	Venous congestion begins; capillary back-pressure rises
4–8 hrs	Progressive edema; DVT risk increases
6–12 hrs	Compartment pressure critical — ischemia risk
12+ hrs	Myonecrosis / rhabdomyolysis possible

The Conventional Dressing Dilemma

Leave it TIGHT

- Venous stasis progresses
- DVT, compartment syndrome, amputation

LOOSEN to check the wound

- Opaque dressing: cannot see wound status
- Catastrophic rebleed risk
- Operating blind — no way to monitor

Three ELAD Design Features Address Extended Wear

Observation and Pressure Titration

1

Simultaneous Observation and Treatment

Clear elastic wrap + minimally absorbent pad with overlying grid permit continuous wound status visualization during any wrap or unwrap motion. Observation of hemorrhage status in real time. Grid stain measurement provides objective, quantifiable hemorrhage tracking at every monitoring interval.

► Eliminates the blind-adjustment risk of conventional dressings

2

Sequential Wrap / Unwrap Pressure Titration

Each wrap adds a discrete compression increment; each unwrap reduces it. The minimum effective pressure — sufficient for hemostasis, minimal enough to reduce venous stasis — can be found and maintained. Two consecutive stable grid readings required before further decompression.

► Titrates to minimum effective pressure with continuous visual feedback

Three Design Features Enable Extended Wear

3

Excess Material Reserve for Rapid Re-tightening

Device applied with 2–3 extra wraps beyond initial requirement and torn, reserve material stored and ready. If grid shows stain expansion at any interval, excess material is applied as an additional outer layer — instant re-tightening without removal or re-dressing.

► Rapid hemostatic rescue without disturbing the wound dressing

Expanded field studies addressing venous stasis in extended evacuation are currently in planning with the Ukrainian Armed Forces.

Monitoring Interval Schedule		
T = 0–60 min	Every 15 min	Baseline only — no decompression
T = 1–3 hrs	Every 30 min	Attempt decompression if check clear
T = 3–6 hrs	Every 20 min	Decompression at each interval if at all possible
T = 6–12 hrs	Every 15 min	Active cycling — adjunct measures
T = 12+ hrs	Every 10–15 min	Maximum vigilance — physician required

Seven-Point Clinical Check	
1	Grid stain measurement
2	Skin color distal to dressing
3	Capillary refill
4	Swelling / tissue turgor
5	Temperature symmetry
6	Sensation and pain response
7	Distal pulse (Doppler if available)

Controlled Crossover Trial: Pain Mitigation During Complete Limb Arterial Occlusion

Study Design

Prospective
controlled
crossover trial

Population

Healthy IDF soldiers
Age 18–40

Exclusions

Vascular disease
Pain amplification syndrome
Pregnancy

Primary Endpoint

Visual Analogue Scale (VAS)
pain score at T=1 and T=5
min

Crossover Protocol

Path A

ELAD applied to one thigh
→ *Washout 5 minutes*
→ CAT applied to
contralateral thigh

Efficacy Metric

Complete arterial occlusion confirmed
by absence of popliteal flow
Doppler ultrasonography

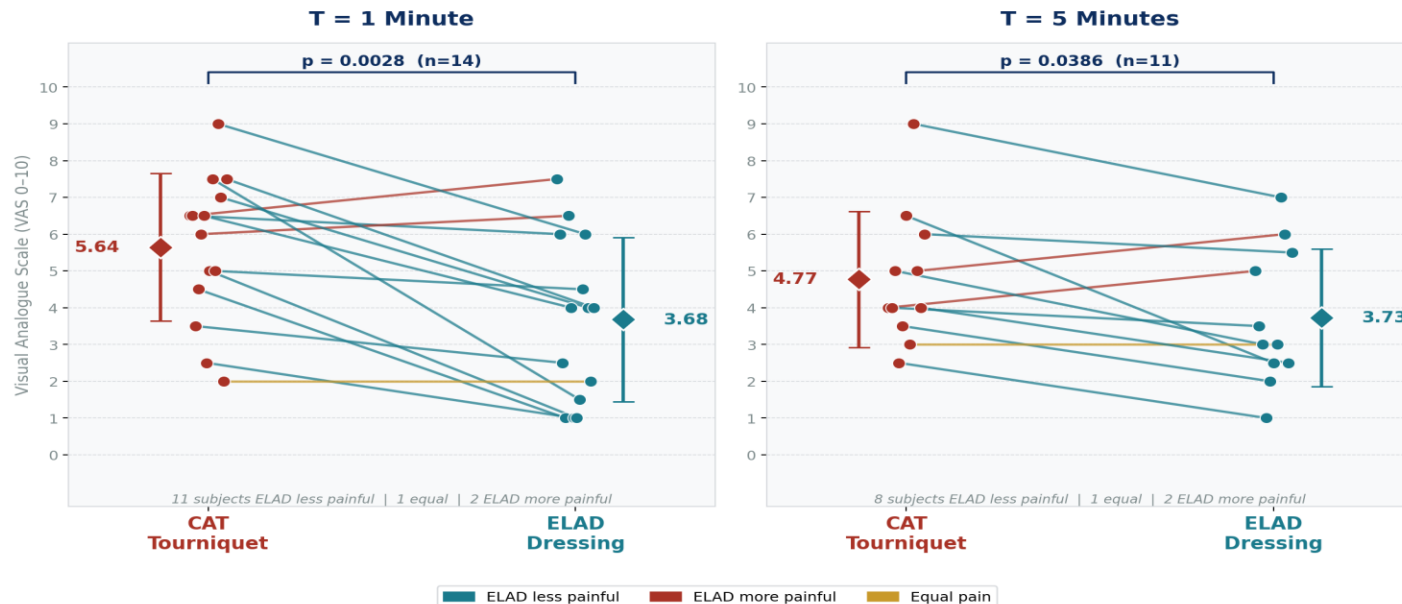
Path B

CAT applied to one thigh
→ *Washout 5 minutes*
→ ELAD applied to
contralateral thigh

Measurement Timeline: T=0 Application (Doppler confirmed occlusion) → T=1 min VAS + Vitals → T=5 min VAS + Vitals
→ T=7 min device removal

Significant Reduction of Pain While Maintaining Hemostatic Efficacy

Pain Induction Comparison: ELAD Bandage vs. CAT Tourniquet
Paired Crossover Trial — Healthy IDF Soldiers (n=14)



Pain Reduction Is Statistically Significant

Key Observations from the Data

11 of 14

Subjects overall experienced less pain with ELAD at 1 min and 5 min

**p =
0.0028**

Paired t-test at 1 min — highly significant

Despite individual variability in pain perception, the group finding is robust. The crossover design controls for between-subject variation, isolating the device effect.

**Reversals
small**

The 2 subjects with more ELAD pain had differences of only 0.5 and 1.0 VAS

2 different subjects at 1 and 5 min. No single individual shows a persistent ELAD disadvantage.

The Compliance Chain

Fear of pain → underuse

Hesitation to apply a device firmly — or at all — is a well-documented response to anticipated patient pain. Undertightening is a common concern with the CAT tourniquet.

Undertightening → failure

Inadequate compression fails to achieve arterial occlusion. The device appears to have been applied but provides inadequate hemostasis.

Less pain → better compliance

Reduced pain induction is expected to increase willingness to apply firm, effective pressure by the casualty, a buddy, or a medic under stress.

Better compliance → lives saved

Hemorrhage is the leading cause of preventable death in combat. A device that achieves equivalent hemostasis with significantly less pain removes a critical barrier to effective use at the point of injury.

Fear of causing pain is directly correlated to inadequate device placement — a well-documented barrier to compliance. Reduced pain is expected to increase compliance and efficacy of application, with direct implications for survival.

Conclusions

1

The ELAD bandage is a viable novel approach for hemorrhage control in combat casualty care for cases of variable nature and severity

2

Integrated engineering features present a unique approach to extended hemorrhage control management

3

Reduction of pain with use of ELAD may help improve compliance and reduce morbidity/mortality from inappropriate use of hemorrhage-control devices

- ▶ Structured extended evacuation protocol in development for Ukrainian Armed Forces
- ▶ Formal prospective trials with standardized outcomes across Ukraine and Israel conflict theaters

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