



ELSEVIER

Contents lists available at [SciVerse ScienceDirect](http://www.sciencedirect.com)

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajemThe
American Journal of
Emergency Medicine

Correspondence

Technique of axillary use of a Combat Ready Clamp to stop junctional bleeding ☆☆☆

Junctional body regions are too proximal for a regular limb tourniquet to fit and include the groin and axillary areas [1,2]. Recently, we described a technique of the use of the Combat Ready Clamp (Combat Medical Systems, Fayetteville, NC) in prehospital hemorrhage control and a cadaver model used in its regulatory approval, but such uses were only in the groin [3–5]. Uncontrolled upper extremity hemorrhage in war is common, disabling, and lethal; recently, we counted 833 US military casualties hospitalized with a junctional wound coded during the current wars. Of the 151 casualties with an upper extremity injury amenable to a Combat Ready Clamp in axillary use, 16.6% died of wounds (25/151; Kragh et al, unpublished data). To show users how to apply a Combat Ready Clamp to stop axillary bleeding, we illustrate its technique of use. To help users understand the device's efficacy, we report data used in its regulatory application.

To test efficacy, we used Wake Forest University Medical Center's cadaver hemorrhage control model; but instead of groin bleeding, we modeled axillary bleeding in a protocol approved by the Wake Forest institutional review board [4]. After the donor bequeathed the body under ethical oversight of the School of Medicine, a male cadaver was used (age, 75 years; weight, 150 lb). The body was refrigerated until

☆ Sources of support: This project was funded with internal US Army Institute of Surgical Research funds and the Defense Health Program (Proposal 201105: Operational system management and postmarket surveillance of hemorrhage control devices used in medical care of US servicepersons in the current war) and not from any of the following organizations: National Institutes of Health, Wellcome Trust, Howard Hughes Medical Institute, or other. The work has not been presented yet, except locally in part. Financial disclosures that might relate to this work are as follows: Dr Kragh is an employee of the US government and receives institutional support where he works, the US Army Institute of Surgical Research. Noninstitutional support occasionally comes from other governmental agencies such as the Defense Health Program and the US Army Medical Research and Materiel Command for specific projects or related work. He has offered free advice on scientific matters at no cost to Operative Experience, M2 Inc, Tiger Surgical LLC, Tactical Medical Solutions LLC, Combat Medical Systems Inc, Composite Resources Inc, Delfi Medical Innovations Inc, North American Rescue Products LLC, H & H Associates Inc, Creative & Effective Technologies Inc, TEMS Solutions LLC, Blackhawk Products Group, Hemaclear, Tactical Development Group, Compression Works LLC, Tier-One Quality Solutions, Kforce Government Solutions, CHI Systems, Tactical Emergency and Medical Simulations Training (TeamsT), Athena GTX, Pélagique LLC, Hawaii Product Development Inc, RevMedx Inc, SAM Medical Products, Speer Operational Technologies, and Entrotech Inc. He has received payment (special government employee) for occasional work for the Food and Drug Administration for device consultation (510(k) panelist). In 2007, he received some funds for work for the National Institutes of Health. He has received honoraria for trustee work for the nonprofit Musculoskeletal Transplant Foundation. He has worked as a technical representative to the US government's contracting officer in agreements with Physical Optics Corporation; Resodyn Corporation; International Heart Institute of Montana Foundation; Daemen College; Noble Biomaterials, Inc; Wake Forest Institute of Regenerative Medicine; National Tissue Engineering Center; Pittsburgh Tissue Engineering Initiative; University of Texas Southwestern Medical Center; Arterioocyte, Inc; and Kelly Space and Technology, Inc.

☆☆ Disclaimer: The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the Department of Defense or US government. The authors are employees of the US government. This work was prepared as part of their official duties, and as such, there is no copyright to be transferred.

used on May 18, 2012. The right subclavian artery was cannulated with pump tubing. Water simulated blood flow at 500 mL/min at 56 beats/min (Watson-Marlow pump model 603S issue 1; Bacon Technical Industries, Inc, Concord, MA). The axillary artery was isolated in the axilla, transected, and clamped with a hemostat in between iterations of Clamp use. The artery lumen bleeding was seen before, during, and after device use.

Users target the underlying axillary artery in the deltopectoral groove (where soldiers nestle rifle butts when shooting) of the abducted arm (Fig. 1). The target point is 1 cm distal (caudal) to the palpable tip of the coracoid; this soft, low point is where the Combat Ready Clamp's disk head is centered.

The guidelines for using the Combat Ready Clamp are as follows: [6]

1. Snap off the large, circular disk head to use the inner square pressure disk (Fig. 2).
2. Slide the baseplate under casualty to target the pressure point.
3. Slide the baseplate in until the vertical arm touches casualty's side near the target (Fig. 3).
4. Put disk head over the target to be compressed parallel to—but not on—the clavicle (Fig. 4).
5. Adjust the horizontal arm length by using its locking pin.
6. Adjust the vertical arm by using the locking pin to press the disk head onto the target to slow bleeding.
7. Turn the T-handle clockwise to compress the target until bleeding stops (Fig. 5).
8. Snap the buckle and remove the slack from the strap.
9. Write the application time on the strap label.
10. When moving the casualty during Combat Ready Clamp use, be careful not to displace it.

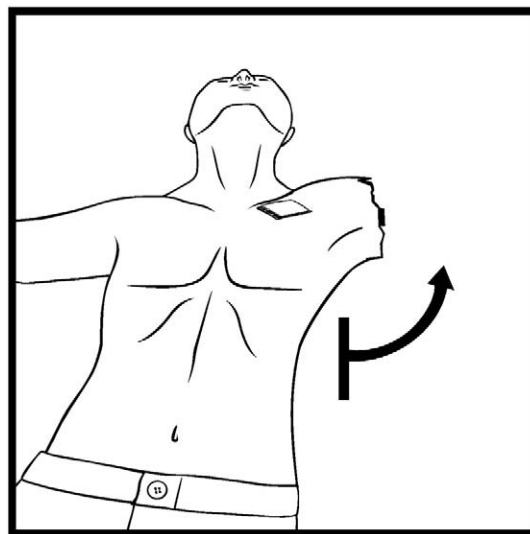


Fig. 1. Positioned casualty for hemorrhage control at the axilla.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 31 AUG 2013		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Technique of axillary use of a Combat Ready Clamp to stop junctional bleeding.				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Kragh Jr. J. F., Johnson J. E., Henkel C. K., Dubick M. A.,				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) United States Army Institute of Surgical Research, JBSA Fort Sam Houston, TX				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 3	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

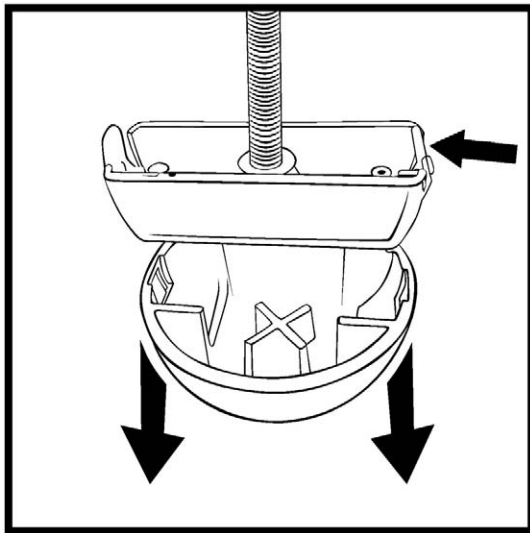


Fig. 2. Circular disk head snapped off its inner square disk head before use.

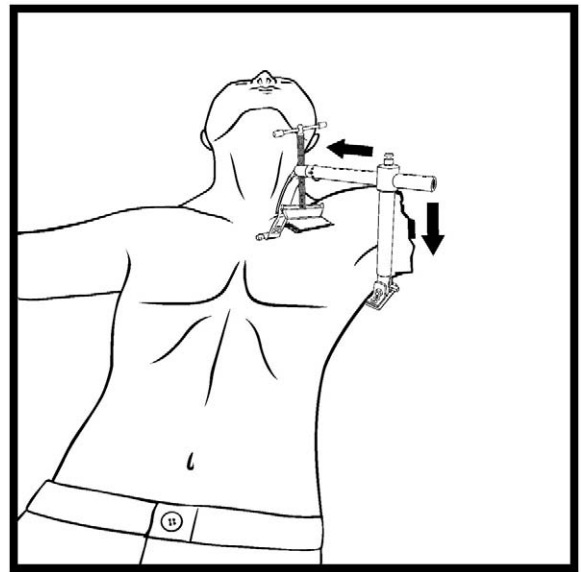


Fig. 4. Placing the square disk head atop the target, parallel to—but not on—the clavicle.

11. In litter loading, roll the casualty onto the uninjured side, place on the litter, and roll the casualty onto the litter.
12. To keep the Combat Ready Clamp in place, transport the casualty on the uninjured side or pad and raise the injured side.
13. Reassess and adjust the casualty and clamp as indicated.
14. The Combat Ready Clamp should be removed *only* at a surgical care facility.

Efficacy was 100 % (15/15) in the cadaver model for controlling axillary hemorrhage (Table). The handle of the Combat Ready Clamp was turned an average of 5.1 turns before hemorrhage was controlled (median 5; mode, 4; range, 3–10). The handle was turned in removal an average of 4.5 turns before hemorrhage returned (median, 4; mode, 4; range, 3–6). Efficacy was 100% whether the shoulder was abducted and externally rotated (10/10) or abducted and internally rotated (5/5).

The main finding of the present study was that the Combat Ready Clamp had 100% efficacy in a laboratory model in controlling axillary hemorrhage. This finding indicated that the Combat Ready Clamp could plausibly control axillary hemorrhage in care.

Limitations of the present report are numerous. The design of the present study was limited in its purpose to provide adequate data for a regulatory application, and cadaver experiments are limited in their ability to mimic trauma care. Cadaver muscle tone is negligible, and if present, such as in casualties who are awake, increased tone may interfere with hemorrhage control measures by disturbing the compressive effect of devices like the Combat Ready Clamp. The nearby brachial plexus to the clamp's compression may risk nerve palsy in casualties, but data are absent.

By describing and illustrating the technique of use, the present study may help increase awareness of hemorrhage control methods for prehospital providers and first responders.

Acknowledgments

The authors acknowledge the Joint Theater Trauma Registry for providing data for this study. Ralph Sweet, RN, aided in protocol management, data acquisition, and analysis. Otilia Sánchez aided in

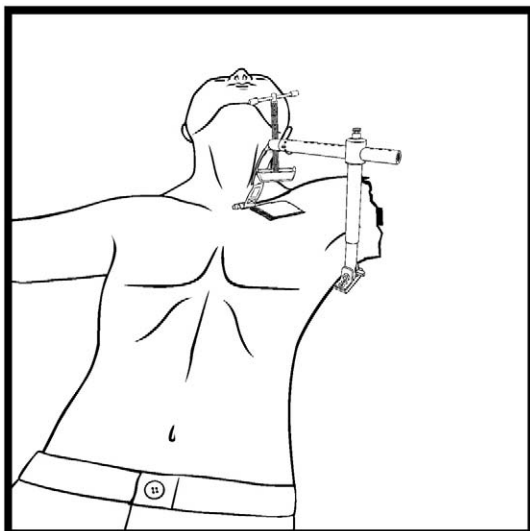


Fig. 3. Vertical arm adjustment for square disk head contact atop the target.



Fig. 5. Turning the T-handle clockwise to compress the target to stop bleeding.

Table
Combat Ready Clamp data in axillary use

Iteration	Efficacy: yes/no	Shoulder position	Handle turn number	
			On	Off
1	Yes	Abduction, external rotation	4	4
2	Yes	Abduction, external rotation	4	4
3	Yes	Abduction, external rotation	4	4
4	Yes	Abduction, external rotation	5	4
5	Yes	Abduction, external rotation	5	6
6	Yes	Abduction, external rotation	6	5
7	Yes	Abduction, external rotation	6	5
8	Yes	Abduction, external rotation	6	6
9	Yes	Abduction, external rotation	6	6
10	Yes	Abduction, external rotation	10	4
11	Yes	Abduction, internal rotation	5	4
12	Yes	Abduction, internal rotation	4	4
13	Yes	Abduction, internal rotation	3	3
14	Yes	Abduction, internal rotation	4	4
15	Yes	Abduction, internal rotation	5	4

manuscript preparation. Chris Murphy, Jason Cauley, and Steve Stutsman of Combat Medical Systems provided the Combat Ready Clamp drawings and instructions.

John F. Kragh Jr. COL (Ret), MD
US Army Institute of Surgical Research
Fort Sam Houston, TX
Uniformed Services
F. Edward Hébert School of Medicine
University of the Health Sciences
Bethesda, MD
E-mail address: john.kragh1@us.army.mil

James E. Johnson PhD
Center for Applied Learning
Wake Forest School of Medicine
Wake Forest University
Winston-Salem, NC
E-mail address: jejohn@wfubmc.edu

Craig K. Henkel PhD
Anatomical Resource Clinical Training Center
Center for Applied Learning
Department of Neurobiology and Anatomy
Wake Forest Health Sciences School of Medicine
Winston-Salem, NC
E-mail address: chenkel@wakehealth.edu

Michael A. Dubick PhD
Damage Control Resuscitation
US Army Institute of Surgical Research
Houston, TX
E-mail address: Michael.dubick@us.army.mil

<http://dx.doi.org/10.1016/j.ajem.2013.02.027>

References

- [1] Tai NR, Dickson EJ. Military junctional trauma. *J Roy Army Med Corps* 2009;155(4): 285–92.
- [2] Ficke JR, Obremskey WT, Gaines RJ, et al. Reprioritization of research for combat casualty care. *J Am Acad Orthop Surg* 2012;20:S99–102.
- [3] Tovmassian RV, Kragh Jr JF, Dubick MA, et al. Combat Ready Clamp medic technique. *J Spec Oper Med* 2012;12(4):70–8.
- [4] Kragh JF Jr, Murphy C, Steinbaugh J, et al.: Prehospital emergency inguinal clamp controls hemorrhage in cadaver model. *Mil Med MILMED-S-12.00568*. In press.

- [5] Kragh Jr JF, Murphy C, Dubick MA, et al. New tourniquet device concepts for battlefield hemorrhage control. *US Army Med Dept J* 2011:38–48.
- [6] Instructions for use. Package insert labeling of the Combat Ready Clamp. Fayetteville, NC: Combat Medical Systems; 2010.

Laboratory assessment of out-of-hospital interventions to control junctional bleeding from the groin in a manikin model[☆]

To the Editor,

Junctional body regions between the trunk and its appendages, such as the groin, are too proximal for a regular limb tourniquet to fit [1,2]. Not since 1993's Black Hawk Down has junctional hemorrhage control become such a hot topic in military casualty care [1–7]. In February 2013, the US military's Task Force Medical Afghanistan requested a fill of a gap in junctional hemorrhage control as an urgent operational need, meaning that junctional hemorrhage control devices should be considered urgently to fill a gap in medical care in war. A small but growing body of evidence indicates that hemorrhage control can be attained out-of-hospital with mechanical compression, using such interventions as medical devices, on a pressure point proximal to a bleeding wound [3–9]. To evaluate laboratory use of junctional hemorrhage control interventions, we gathered data on stopping groin bleeding in a manikin model to understand the plausibility of such interventions for future human subject research.

Under an approved protocol, we tested efficacy of interventions in a manikin designed to train medics in out-of-hospital hemorrhage control (Combat Ready Clamp [CRoC] Trainer Manikin, Operative Experience, Inc, North East, MD). We filled the blood reservoir with 4 liters of water; we refilled the reservoir after 5 iterations or 1.5 liters of lost fluid, whichever came first. The manikin had a right-groin gunshot wound through the proximal thigh where the common femoral artery flow was controllable by skin compression over it at the level of the inguinal fold. There was 3 cm between the pressure point where compression was applied and the proximal extent of the wound. Interventions were timed, blood loss was measured, and efficacy was noted. Efficacy was operationally defined as visually stopped flow into the wound from the vessel lumen. Pearls and pitfalls of intervention use were recorded.

Interventions to control hemorrhage included medical device use, manual or digital compression, and improvised use of a rock-like kettlebell (to simulate a rock used in care on the battlefield in a case recorded in the Department of Defense Trauma Registry in 2012). Interventions included digital (finger) compression, manual compression (heel of the hand), knee compression, compression by a 50-lb kettlebell (Hampton Fitness Products, Ventura, CA), and medical device use (Combat Ready Clamp, CRoC, Combat Medical Systems, Fayetteville, NC; SAM Junctional Tourniquet, SAM, SAM Medical Products, Portland, OR; Junctional Emergency Treatment Tool, JETT, North American Rescue Products, Greer, SC; Abdominal Aortic Tourniquet, AAT, Compression Works, Hoover, AL).

The first device assessed was the CRoC which, of the devices studied, was cleared first by the US Food and Drug Administration on August 11, 2010. The first setting of the evaluation (which was for the CRoC) was in a simulation center as previously reported with three to five people, and the other setting of the evaluation was on a table with one to three people [5]. The data from that initial setting is included here for comparison of time to stop bleeding, blood loss volume, and device efficacy [5]. Since the blood loss rate was non-linear (as it is in real situations for casualties because bleeding is brisker initially rather than later), we did not refill the bladder after each iteration. The

[☆] Disclaimer: The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the Department of Defense or US Government. The authors are employees of the US Government. This work was prepared as part of their official duties, and as such, there is no copyright to be transferred.