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## 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an upper extremity injury amenable to a Combat Ready Clamp in axillary use, 16.6% died of wounds (25/151; Kragh et al, unpublished data).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

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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.

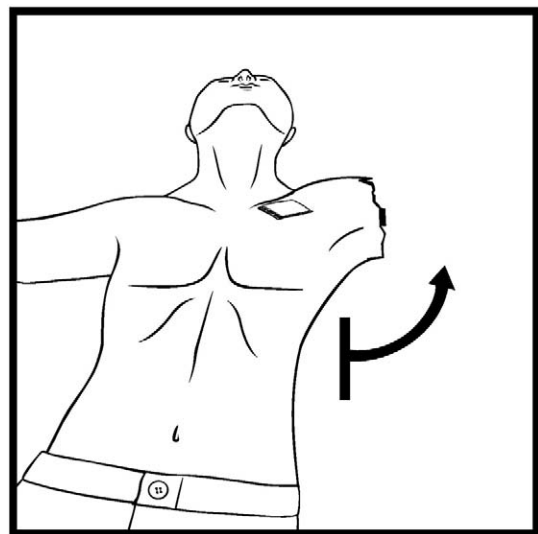


Fig. 1. Positioned casualty for hemorrhage control at the axilla.

# Report Documentation Page

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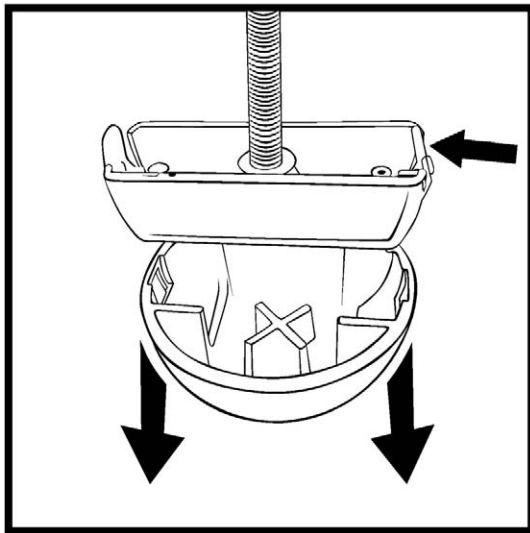


Fig. 2. Circular disk head snapped off its inner square disk head before use.

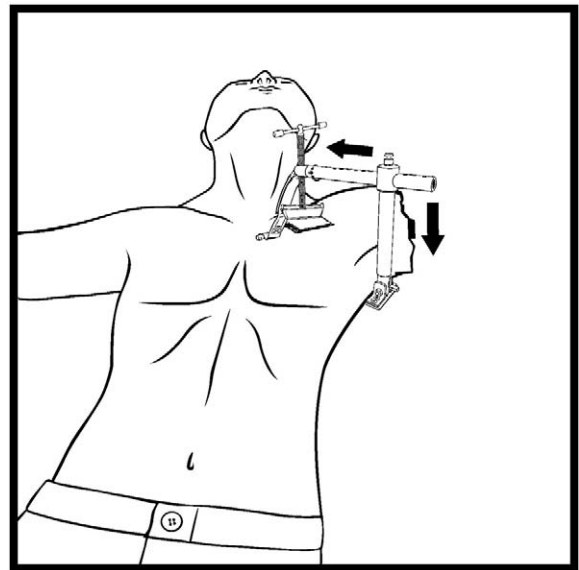


Fig. 4. Placing the square disk head atop the target, parallel to—but not on—the clavicle.

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.

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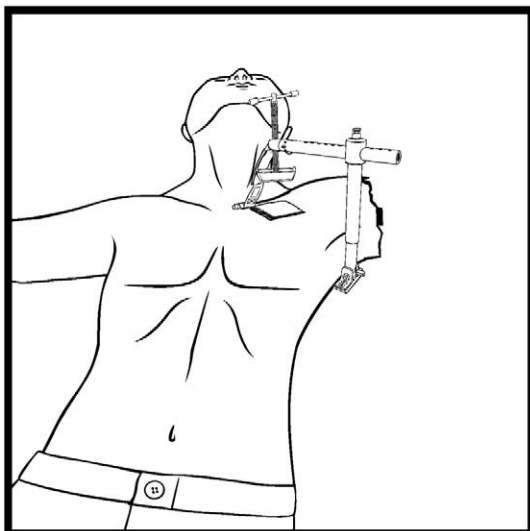


Fig. 3. Vertical arm adjustment for square disk head contact atop the target.

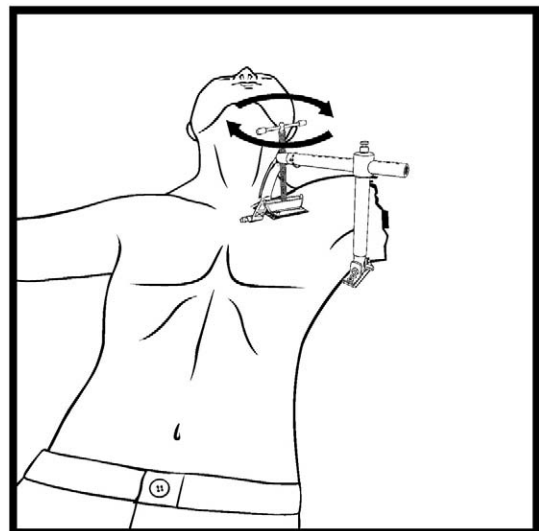


Fig. 5. Turning the T-handle clockwise to compress the target to stop bleeding.

**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

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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](mailto: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](mailto: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](mailto: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](mailto:Michael.dubick@us.army.mil)

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## Laboratory assessment of out-of-hospital interventions to control junctional bleeding from the groin in a manikin model<sup>☆</sup>

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

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