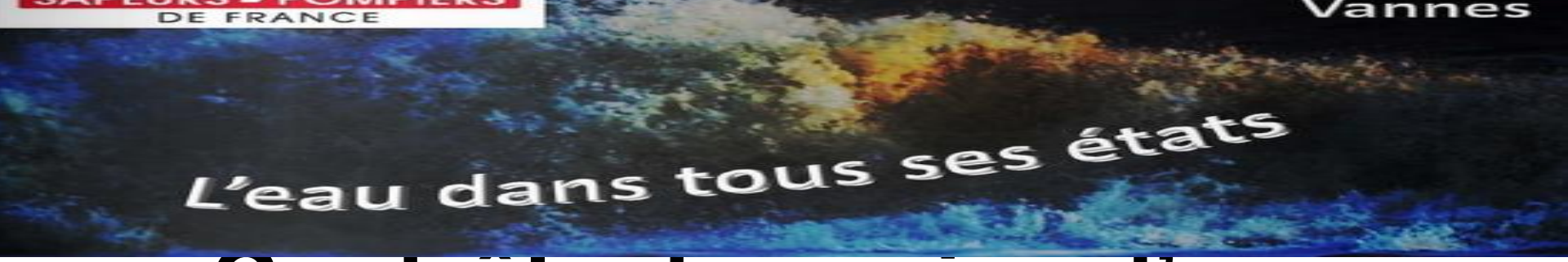


« Contrôle des voies d'eau »
Damage control vasculaire :
modalités en fonction de l'intervenant, retour d'expérience

Dr Lemaire
Pr Jean-Pierre Tourtier
Ecole du Val-de-Grâce
Brigade de Sapeurs-Pompiers de Paris

Service de Santé des Armées

Conflit d’interet avec le sujet

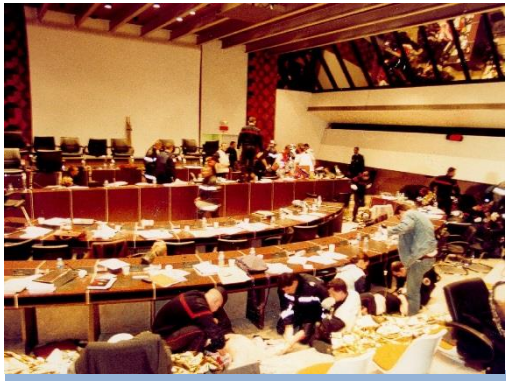
- Aucun

Une évolution des modes d'action terroristes

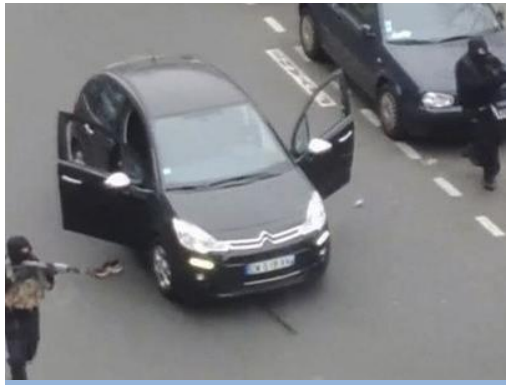
Bombay – 2008
173 décès, 312 blessés

Oslo – 2011
69 décès, 33 blessés

Liège – 2011
5 décès, 125 blessés



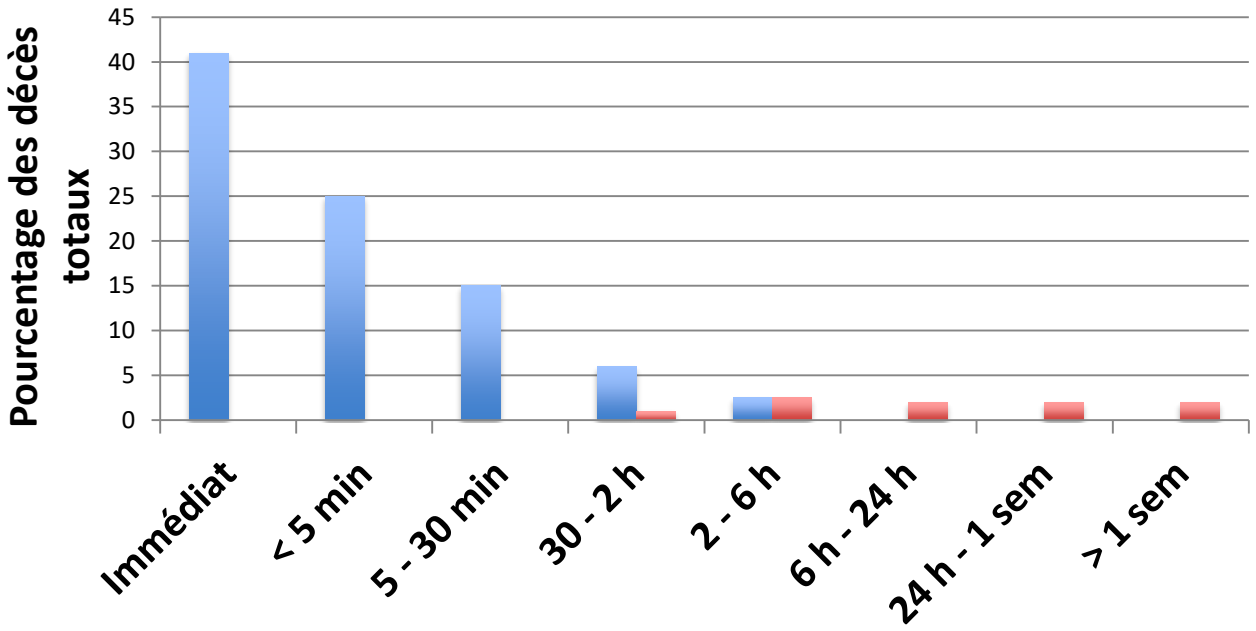
Nanterre 2002
5 décès, 125 blessés



Paris – 2015
20 décès, 18 blessés

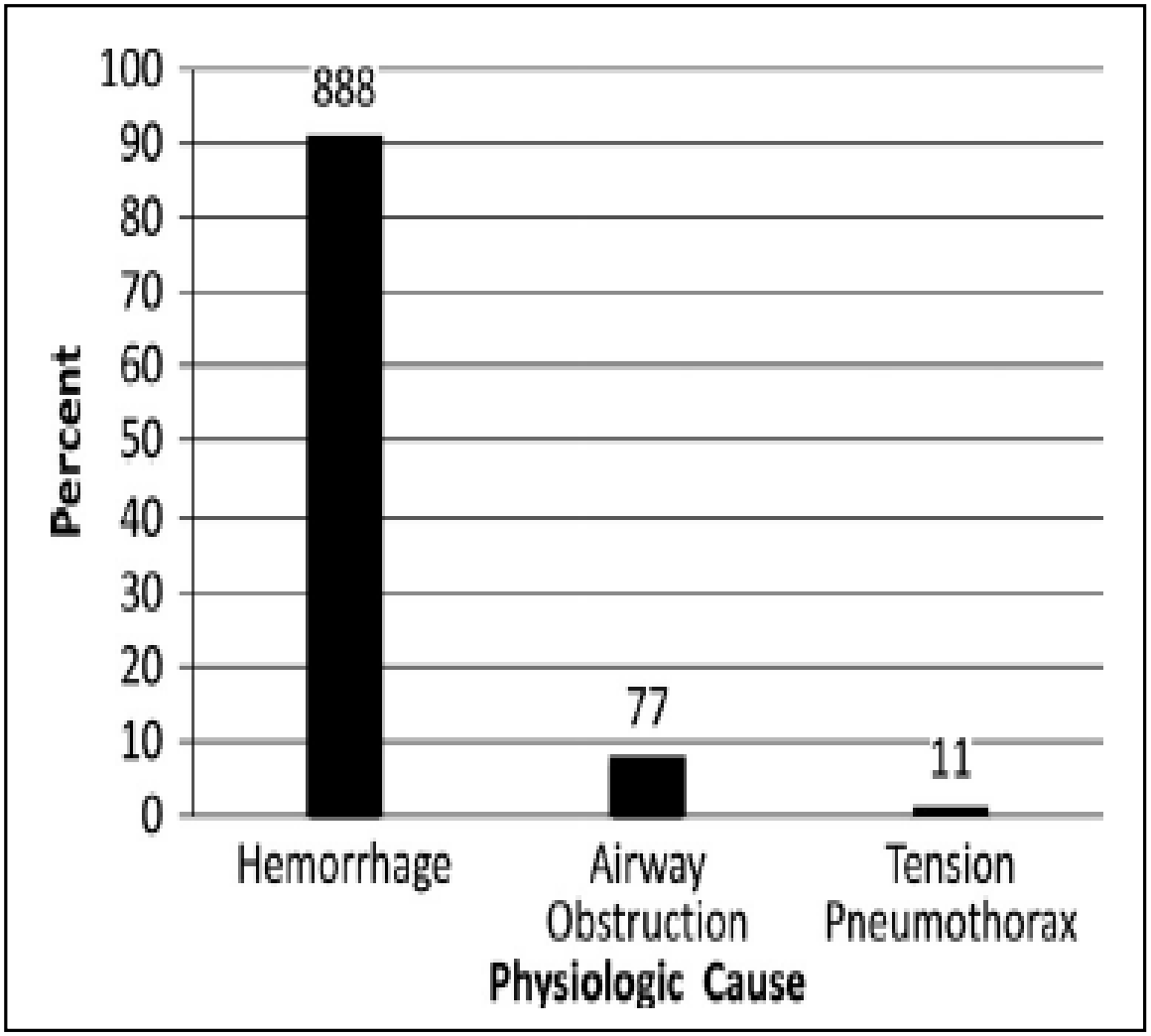
Paris – 2015
129 décès, 352 blessés

Expérience militaire : médecine préhospitalière



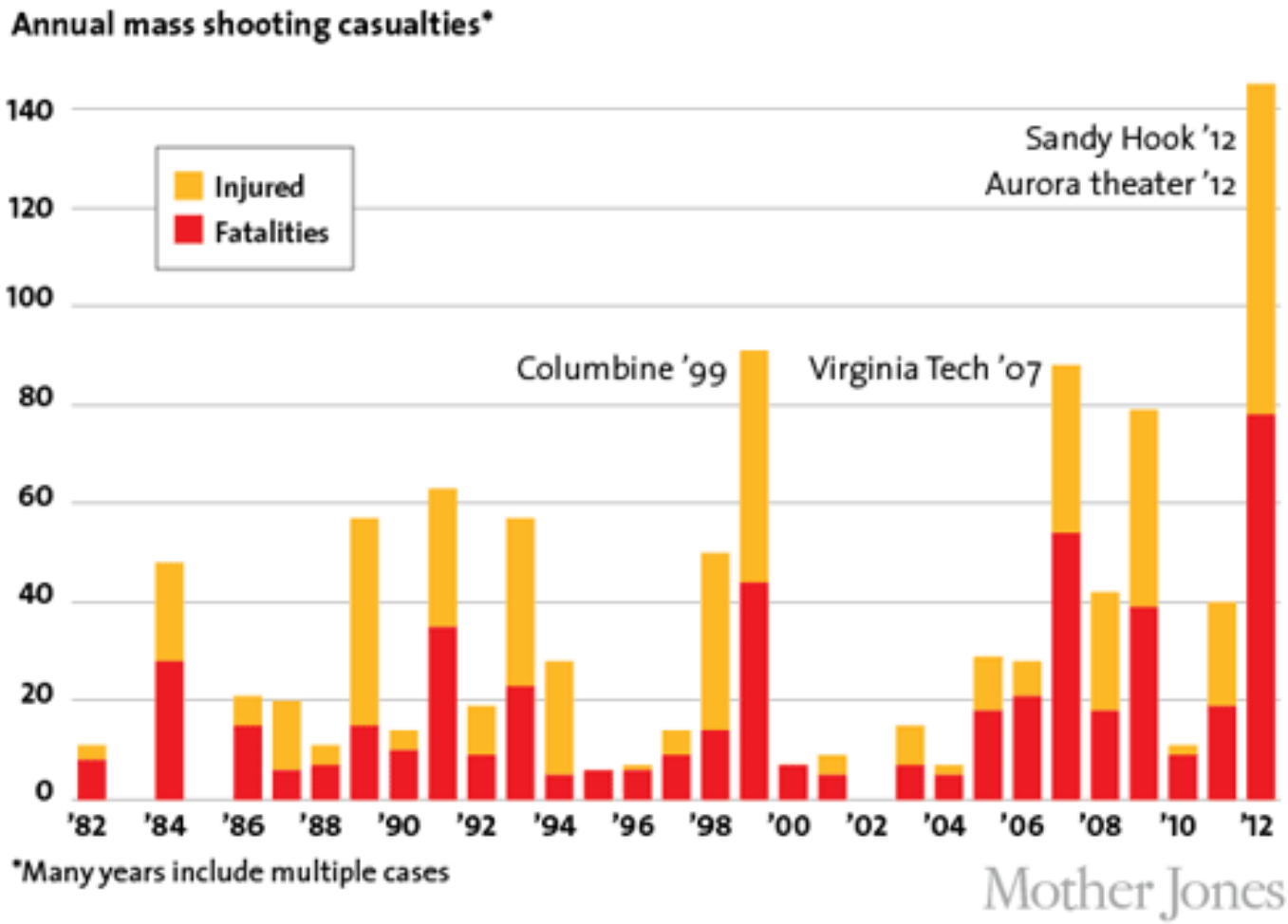
Bellamy RF. Combat Trauma Overview. Textbook of Military Medicine.

Expérience militaire importante : Un décès sur cinq évitable

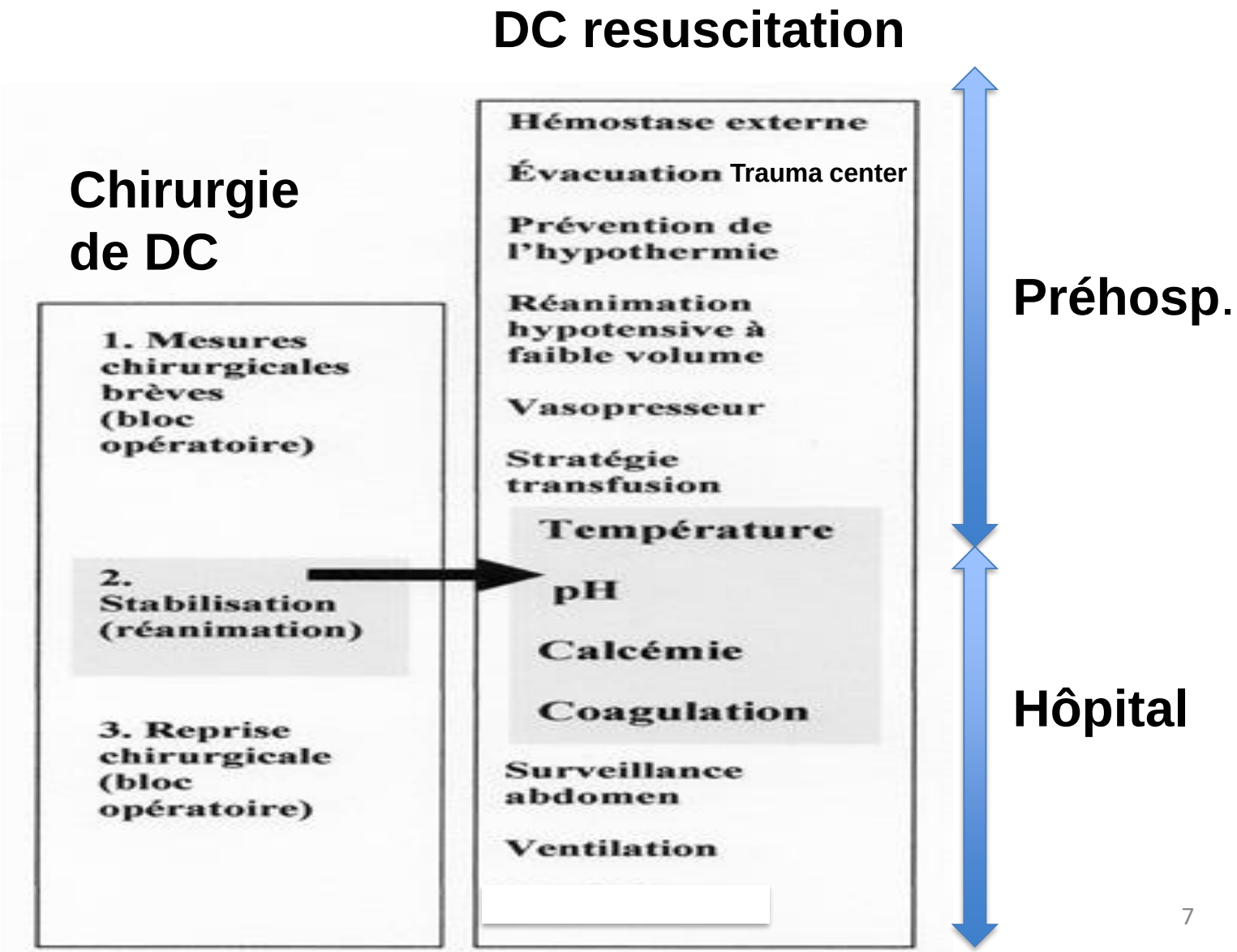


Eastridge et al. Death on the battlefield (2001-2011): Implications for the future of combat, J Trauma 2012

Spécificité des fusillades en milieu civil : une létalité importante



Principes de damage control



Contexte

- Sécurisation précaire initialement
- Nombreux morts
- UA : hémorragique
  - hémorragie tronc :

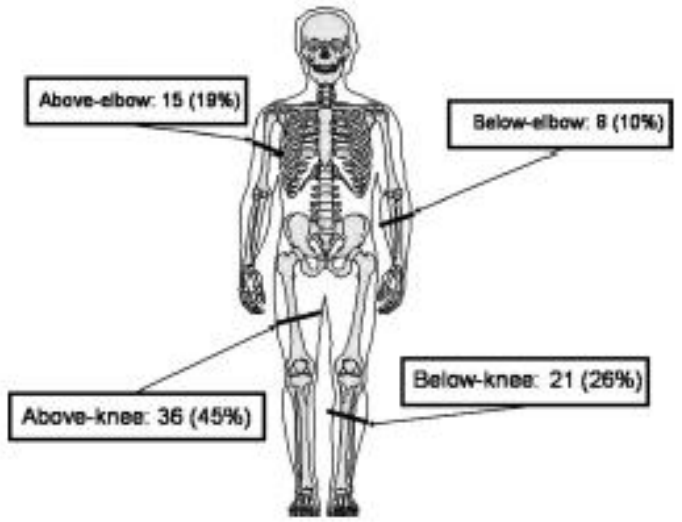
    Thorax : ½ assis, O2; exsufflation; hémostase
  - Membres : hémostase externe

- Nombreux impliqués
- Saturation des moyens de communication
- Organisation

1. (Re)découverte du garrot

Irak, 2004. 31st Combat support hospital

Rétrospectif : 80 garrots sur 67 patients



57% des décès par hémorragie des membres auraient pu être évitées par un garrot + précoce

	Tourniquet (%)	No Tourniquet (%)	p^*
No bleeding on arrival	83.3	60.7	0.033
No bleeding on arrival (injuries requiring primary or debridement amputations)	92	50	0.058 (NS)
No bleeding on arrival (reconstructable vascular injuries)	69	60	0.456 (NS)
No bleeding on arrival (upper extremity injuries)	85	40	0.037
No bleeding on arrival (lower extremity injuries)	83	72	0.308 (NS)
No bleeding on arrival (ISS >15)	85	17	<0.0001

Beekley AC et all. J Trauma 2008

Efficacité du garrot

Irak, 2006

Prospectif: 232 patients, 309 plaies de membres, 428 garrots

Table 6 Effectiveness of Tourniquets by Limb Region

Body Region	Patients; N	Limb Regions; N	Tourniquets; N	Effective; N (%)	Ineffective; N (%)
Forearm	9	9	13	12 (92)	1 (8)
Arm	62	71	97	79 (81)	18 (19)
Leg	22	27	32	32 (100)	0 (0)
Thigh cuisse	162	205	285	209 (73)	76 (27)

* Patients had 1–4 limbs injured with 1–4 tourniquets used per limb; 3 patients had tourniquets on their ipsilateral thigh and leg. There were 8 limbs with unknown tourniquet effectiveness.

Kragh JF et al, J Trauma 2008

Choix du type de Garrot

Table 5 Tourniquet Device Counts, Effectiveness, and Morbidity

Tourniquet Name	Patients; N*	Devices; N*	Limbs; N*	Effective; N (%)	Ineffective (%)	Morbidity; N*(%)	Back-Up (%)
CAT	156	210	202	166 (79)	44 (21)	43 (21)	5
EMT	91	115	115	106 (92)	9 (8)	9 (8)	0
SOFT	50	62	61	41 (66)	21(34)	20 (33)	2
SATS	2	2	2	0 (0)	2 (100)	2 (100)	0
RMT	2	2	2	0 (0)	2 (100)	2 (100)	0
London bridge	1	1	1	1 (100)	0 (0)	1 (100)	0
Improvised	15	16	15	4 (25)	12 (75)	12 (80)	17
Unknown	14	19	17	14 (74)	5 (26)	3 (18)	0

Kragh JF et al, J Trauma 2008

Quand poser le garrot ?

Irak 2006-2007

499 patients et 862 garrots posés sur le terrain ou en structure chirurgicale

13 nationalités

Survie 90% si pose du garrot avant le choc et 18% si posé après le choc

Table 6. Shock, Survival, and Setting Results from 2-by-2 Contingency Testing

Given shock presence, prehospital vs. ED use was not associated with survival	$p = 1.0$
Given shock absence, prehospital vs. ED use was not associated with survival	$p = 0.5$
Given survivors, prehospital vs. ED use was associated with shock (absent vs. present)	$p < 0.001$
Given non-survivors, prehospital vs. ED use was associated with shock (absent vs. present)	$p < 0.001$
Given prehospital use, shock (absent vs. present) was associated with survival	$p < 0.001$
Given ED use, shock (absent vs. present) was associated with survival	$p < 0.001$
Prehospital vs. ED use was associated with survival without considering shock	$p = 0.015$
Shock (absent vs. present) was associated with prehospital vs. ED use without considering survival	$p < 0.001$
Shock (absent vs. present) was associated with survival without considering prehospital vs. ED use	$p < 0.001$

ED = emergency department.

Kragh JF et al. J Emerg Med 2011

Garrot : enseignements

ELSEVIER SAUNDERS
SURGICAL CLINICS OF NORTH AMERICA
Surg Clin N Am 87 (2007) 157–184

Lessons Learned from Modern Military Surgery

Alec C. Beekley, MD*, Benjamin W. Starnes, MD, James A. Sebesta, MD
US Army Medical Corps, Madigan Army Medical Center, 9040 Fitzsimmons Avenue, Fort Lewis, WA 98431, USA

- Objectif = arrêt du saignement et disparition du pouls
- Mise en place AVANT état de choc
- Sous le feu = à la racine du membre
- Sinon : 1 main au dessus de ce qui saigne
- Si possible apparent
- Efficace y compris jambe et avant bras …
- Réévaluation médicale systèmatique
- Possibilité de cumuler les garrots
- Attention à la récidive de saignement
    - lors du remplissage …
    - sous les couvertures ou les pansements …

Pansements hémostatiques : utilisation clinique

- **Expérience militaire**

  Irak, Afghanistan, Gazah

The Journal of TRAUMA® *Injury, Infection, and Critical Care*

QuikClot Use in Trauma for Hemorrhage Control: Case Series of 103 Documented Uses

Peter Rhee, MD, MPH, Carlos Brown, MD, Matthew Martin, MD, Ali Salim, MD, Dave Plurad, MD, Donald Green, MD, Lowell Chambers, MD, Demetrios Demetriades, MD, PhD, George Velmahos, MD, and Hassan Alam, MD

Table 3 Effectiveness by Mechanism

Mechanism	Reported Efficacy for Hemorrhage Control
Blunt trauma	6/8
Blast (artillery, rockets, improvised explosive devices)	21/22
Penetrating	
Stab wound	3/5
Gunshot wounds	65/68

BSPP : 30 utilisations 2011-2014 :

Hemostatic dressings in civil prehospital practice: 30 uses of QuikClot Combat Gauze.

Travers S, Lefort H, Ramdani E, Lemoine S, Jost D, Bignand M, Tourtier JP.

Eur J Emerg Med. 2015 Sep 8. [Epub ahead of print]

N°	age	sex	cause	cause/ weapon	wound localization	anticoagulant	shock	bleeding	action before QG	Is there an QG accumulation at the level of the prehospital team?	complete stop of the bleeding after introduction of QG	difficulties at using QG	perfusion (ml)	vasopressor drugs	Hospital department	Transfusion	surgery	Duration of hospitalisation	future
1	26	M	suicide attempt	razor	upper limb	no	no	arterial	bandage	avoid tourniquet or pressure point	complete stop	no	<500	No	ICU	no	yes	1	return at home
2	30	M	suicide attempt	subway	lower limb	no	no	venous	none	avoid tourniquet or pressure point	complete stop	no	700	No	ICU	no	yes	78	return at home
3	49	F	suicide attempt	fall	head	no	yes	arterial	bandage	spare time (scalp)	complete stop	yes	1500	Yes	ICU	yes	yes	7	dead
4	74	M	accident	car	neck	no	no	arterial	bandage	other actions ineffectives	complete stop	no	1900	Yes	ICU	yes	yes	1	dead
5	22	M	aggression	knife	upper limb	no	yes	arterial	pressure point	other actions ineffectives	incomplete stop	no	2500	Yes	ICU	yes	yes	7	return at home
6	36	M	aggression	glass	neck	no	yes	arterial	bandage	other actions ineffectives	complete stop	no	1500	No	ICU	no	yes	3	return at home
7	21	M	aggression	knife	neck	no	no	venous	bandage	other actions ineffectives	complete stop	no	0	No	surgery	no	yes	4	return at home
8	45	M	aggression	knife	head	no	no	NE	bandage	other actions ineffectives	incomplete stop	no	<500	No	ED	no	yes	2	return at home
9	35	M	accident	knife	perineum	no	no	NE	bandage	other actions ineffectives	incomplete stop	yes	<500	No	ED	no	yes	2	return at home
10	27	M	aggression	fire arm	lower limb	no	no	arterial	pressure point	avoid tourniquet	complete stop	no	<500	No	ICU	no	yes	12	return at home
11	34	M	aggression	knife	neck	no	no	arterial	bandage	other actions ineffectives	complete stop	no	650	No	surgery	no	yes	1	return at home
12	50	M	accident	car	perineum	no	yes	arterial	bandage	other actions ineffectives	incomplete stop	no	2000	Yes	ICU	yes	yes	14	dead
13	72	M	accident	saw	lower limb	VKA	no	venous	bandage	avoid tourniquet or pressure point	complete stop	no	<500	No	ICU	no	yes	2	return at home
14	34	M	aggression	knife	lower limb	no	no	arterial	tourniquet	tourniquet removed after QG	complete stop	no	1000	No	ICU	no	yes	3	return at home
15	46	M	accident	car	head	no	no	arterial	none	spare time (scalp)	complete stop	no	<500	No	ICU	no	yes	1	return at home
16	76	F	accident	fall	head	ASA	no	arterial	bandage	spare time (scalp)	complete stop	no	<500	No	ED	no	yes	12	return at home
17	24	M	aggression	knife	upper limb	no	no	arterial	bandage	other actions ineffectives	complete stop	no	<500	No	ICU	no	yes	2	return at home
18	36	M	aggression	knife	neck	no	no	arterial	bandage	other actions ineffectives	incomplete stop	no	750	No	ICU	no	yes	3	return at home
19	32	F	accident	glass	upper limb	no	no	arterial	bandage	avoid tourniquet or pressure point	complete stop	no	<500	No	ICU	no	yes	2	return at home
20	75	F	accident	knife	neck	no	yes	venous	none	other actions ineffectives	complete stop	no	1000	Yes	ICU	no	no	1	dead
21	27	M	aggression	knife	head	no	yes	arterial	bandage	spare time (scalp)	complete stop	yes	1000	No	ICU	no	yes	3	return at home
22	41	M	accident	fall	head	no	no	arterial	bandage	spare time (scalp)	complete stop	no	<500	No	ED	no	yes	2	return at home
23	50	M	accident	saw	upper limb	no	no	venous	tourniquet	tourniquet removed after QG	complete stop	no	<500	No	surgery	no	yes	3	return at home
24	25	M	accident	knife	upper limb	no	yes	venous	tourniquet	tourniquet removed after QG	complete stop	no	500	No	ED	no	yes	3	return at home
25	37	M	accident	glass	head	no	no	arterial	bandage	spare time (scalp)	complete stop	no	<500	No	ED	no	yes	1	return at home
26	49	M	suicide attempt	knife	abdomen	no	yes	NE	none	other actions ineffectives	no stop	no	4000	Yes	dead	no	no	0	dead
27	50	M	accident	knife	head	no	yes	arterial	bandage	other actions ineffectives	complete stop	no	1500	Yes	ICU	yes	yes	4	return at home
28	82	M	accident	fall	head	VKA	no	arterial	bandage	spare time (scalp)	incomplete stop	no	0	No	ED	no	yes	8	return at home
29	76	M	aggression	knife	neck	no	yes	NE	bandage	other actions ineffectives	no stop	yes	>2500	Yes	ICU	yes	yes	2	dead
30	39	M	accident	glass	lower limb	no	no	NE	bandage	avoid tourniquet or pressure point	complete stop	no	500	No	surgery	no	yes	2	return at home

- Arme à feu 15/30
- Saignement artériel 19/30

- Utilisations après échec autres techniques (26/30) et/ou sur zone inaccessible au garrot (14/30)

Arrêt complet du saignement : 22/30
Diminution du saignement : 6/30
Echec : 2/30

Pansements hémostatiques : en pratique

- **Très faible niveau de preuve**
  (études animales, cas cliniques ou séries non comparatives…)

- **Mais importante expérience militaire et civile depuis plus de 10 ans**

- **Plusieurs modèles disponibles**

- **Importance de la forme / Rôle du packing**

- **Nécessite 5 minutes de compression**

- **Rôle en 2ème intention si échec des autres techniques ou pour convertir un garrot tactique**

Hémorragies jonctionnelles

Combat Ready Clamp (CRoC)

Sam Jonctional Toruniquet

Abdominal Aortic Jonctionnal Tourniquet (AAJT)

Kragh JF et al. J Spec Oper Med 2014
Pierret et al. Médecine et Armées 2014
Mathieu et al. médecine et armées 2014

Hémorragies jonctionnelles

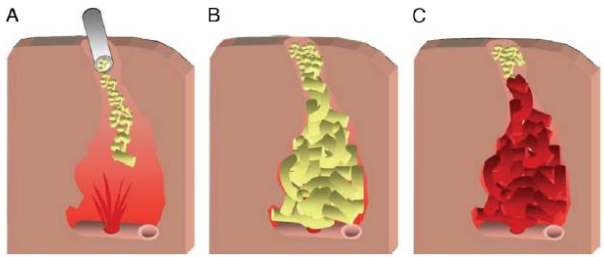
« Cellulose Mini Sponge »

Modèle porcins avec lésions artère et veine sous clavière

Survie 100% vs 37,5% avec QuiCklot Gauze (p=0,026)

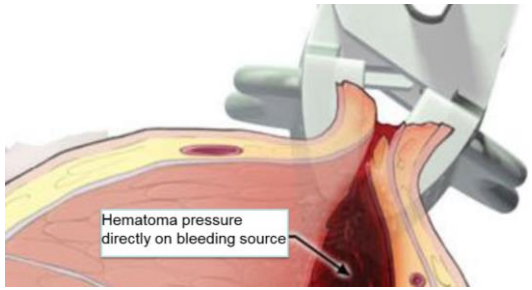
TABLE 2. Secondary End Point Results Demonstrated Statistical Differences Between the Groups for All of the Secondary End Points

Secondary End Point	MSD, mean (SD) (n = 8)	CG, mean (SD) (n = 8)	*p*
Posttreatment blood loss, mL	118.0 (307.9)	1,242.6 (907.1)	0.021
Resuscitation Fluid Volume, mL	400.8 (365.2)	1,708.0 (1,308.5)	0.067
Hemoglobin level at termination, g/dL	6.6 (1.0)	4.3 (3.0)	0.018
MAP at termination, mm Hg	71 (5)	36 (26)	0.002
Treatment application time, s	25 (5)	420 (111)	0.004



Mueller et al. J Trauma Acute Care Surg 2012

Hémorragies :
A la recherche d'autre dispositifs…



iTClamp ™50

- Validé sur cadavre, sur animal
- Plusieurs centaines d'utilisation en traumatologie de guerre
- Intérêt en pratique clinique :
  - Sous le feu ? Plaies multiples ?
  - Hémorragies jonctionnelles ? du tronc ? du scalp ?

Filips et al. Int Rev Armed Med Forces 2013
Motter et al. J trauma Acute Care Surg 2014

1. Hémostase externe en pratique : tout faire pour arrêter immédiatement le saignement

- Garrot
- Compresses, packing, bandes élastiques
  +/- pansements hémostatiques
  +/- hémorragies jonctionnelles

Le piège principal : sous estimer le saignement

- saignement masqué par des pansements inadaptés
- saignement au fond du matelas coquille…
- sous estimation de saignements d'allure modérées (cuir chevelu…)

2. Contrôle précoce de l'hypothermie

Chaque degré perdu ampute de 10% les fonctions d'hémostase

- Impact sur la survie significatif dès T < 35-36° C

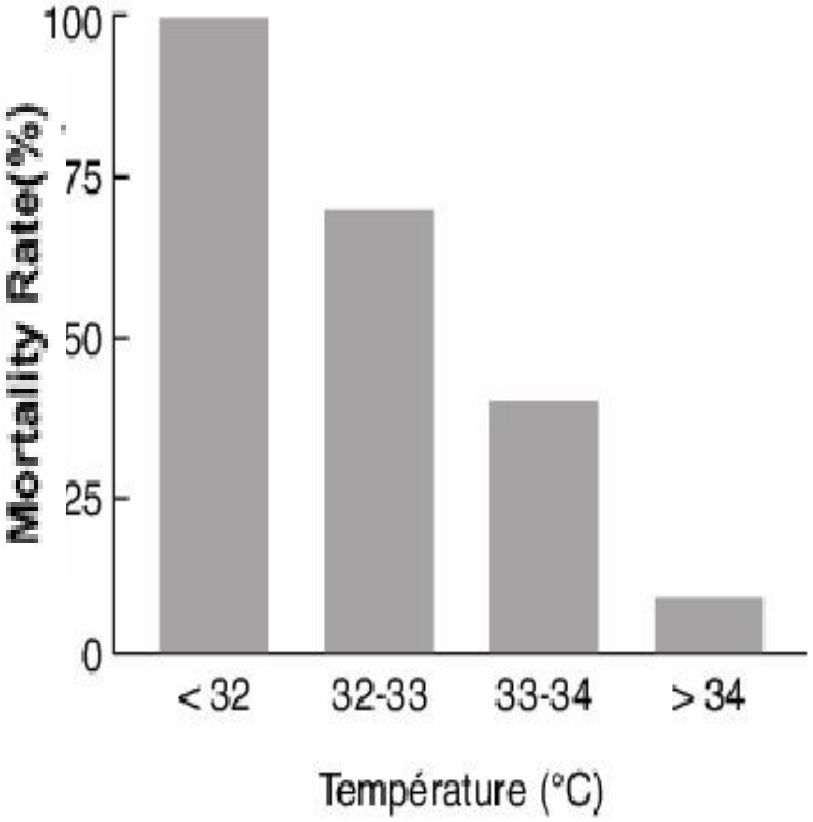
- Pas de survivants si T< 32° C

Rotondo et al. J Trauma 1993
Johnson et al. J Trauma 2001
Sessler. Anesthesiology 2001
Vincent et al. Crit Care 2006
Inaba et al. Wold J Surg 2009
Arthurs et al. Am J Surg 2006




2. Contrôle précoce de l'hypothermie

Jurkovich, J Trauma 1987



Karinos, Injury 2010

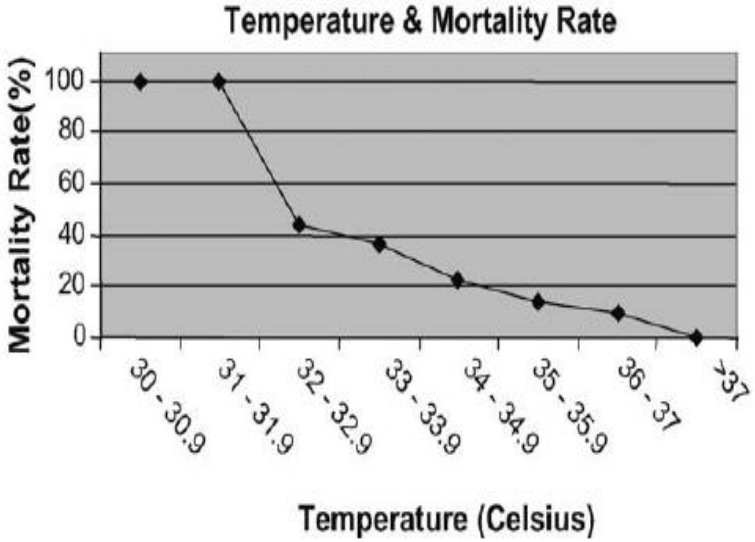
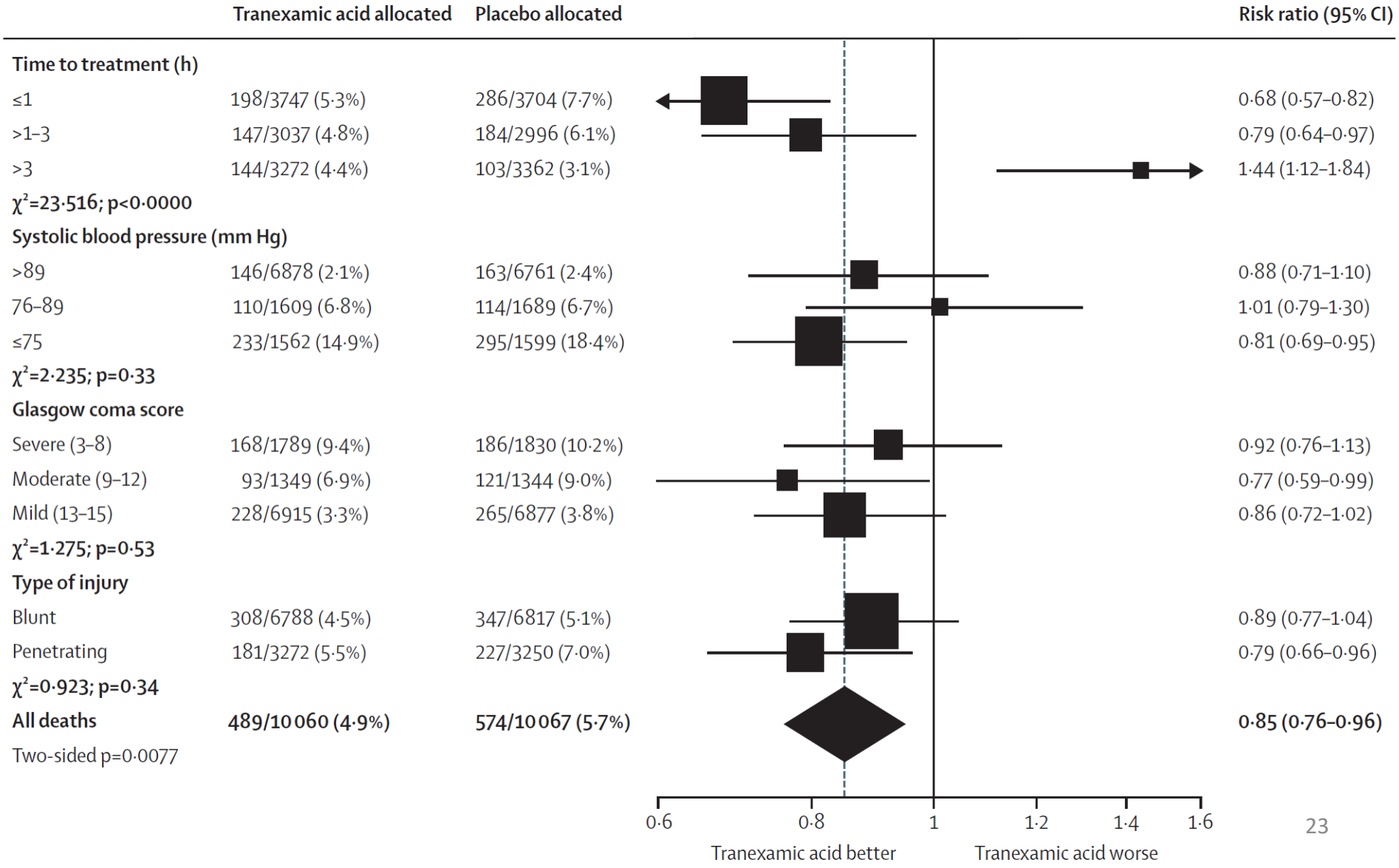


Fig. 5. Relationship of temperature (°C) and mortality in patients undergoing damage control surgery ($n = 145$).

T <32 ° C => stratégie de damage control futile

3. Acide tranéxamique

Lancet 2011



4. Hémodynamique Lancet 2011

Maintenir un Ta02 minimal

- Hypotension artérielle permissive
  - PAM 60 mmhg ou 50 mmHg **Morrison C J Trauma 2011**
- Remplissage vasculaire modéré et adapté...**Mapstone 2003**

  cristalloides

- Introduction **précoce** de catécholamines associée à un remplissage vasculaire : noradrénaline

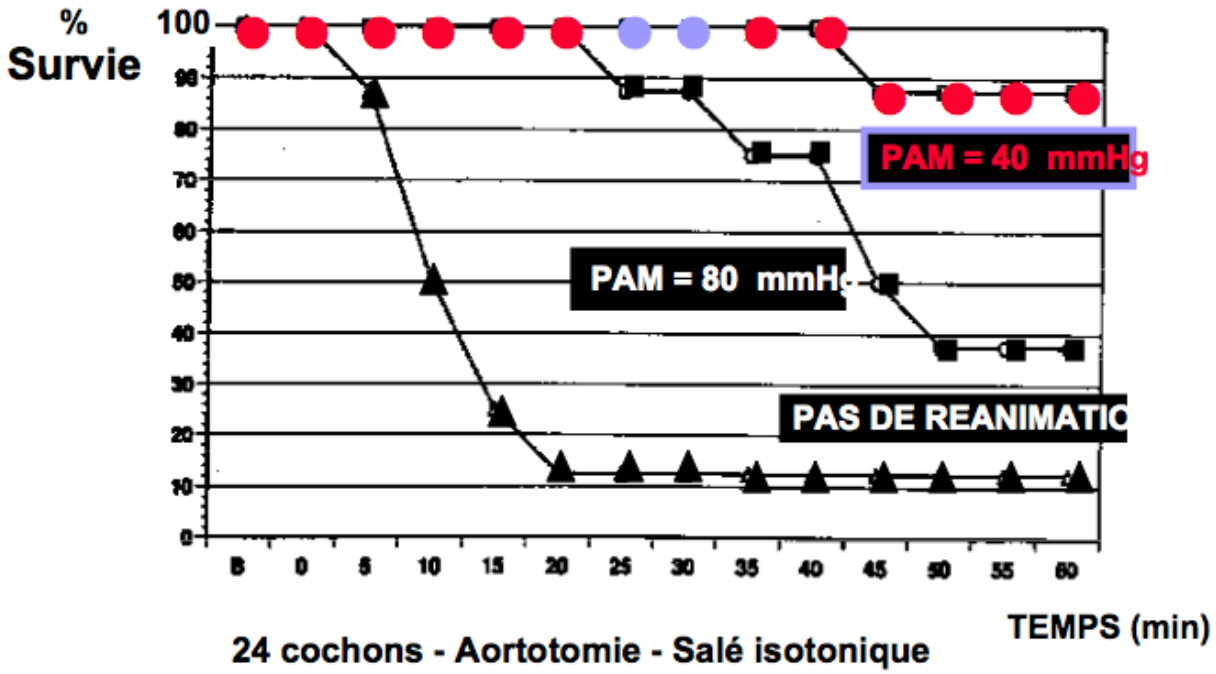
  Poloujadoff MP,Anesthesiology 2007

Ann Fr Anesth Reanim. 2013 Jul-Aug;32(7-8):520-6. doi: 10.1016/j.annfar.2013.07.012. Epub 2013 Jul 31.

The concept of damage control: extending the paradigm in the prehospital setting.

Tourtier JP[1], Palmier B, Tazarourte K, Raux M, Meaudre E, Ausset S, Sailliol A, Vivien B, Domanski L, Carli P.

Réanimation « à petit volume»



Kowalenko et al. J Trauma 2012

Blood Pressure at which Rebleeding Occurs after Resuscitation in Swine with Aortic Injury

Jill L. Sondeen, PhD, Valerie G. Coppes, BS, and John B. Holcomb MD,

J Trauma 2003 62 cochons

Punch size (mm)	All pigs including non resuscitated		No NE	
	Hem. Vol. (ml/kg)	n	Rebleed MAP (mmHg)	n
1.5	10.5 ± 1.1*	14	62 ± 5	9
2.0	16.6 ± 0.8	38	66 ± 3	20
2.8	19.3 ± 1.4	10	61 ± 5	9

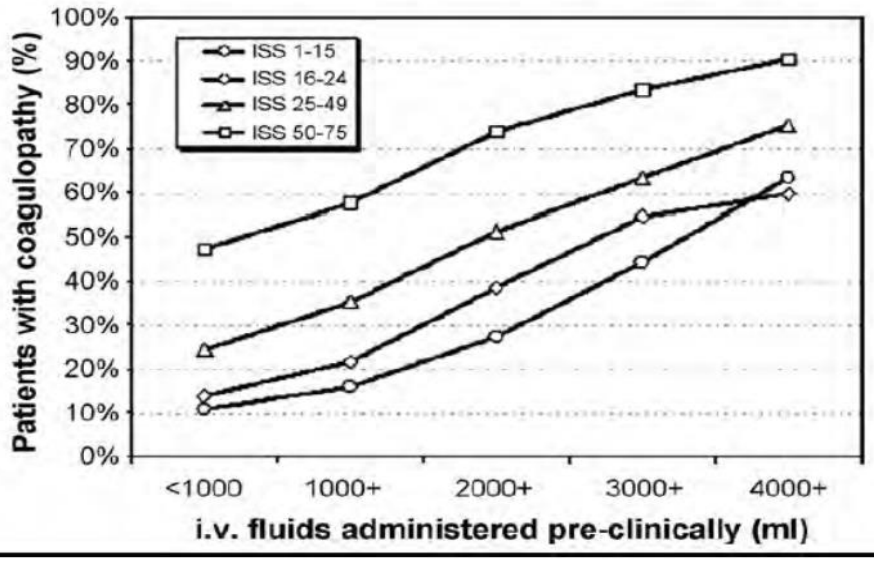
D’après le Pr Tazarourte

Remplissage et coagulopathie

REMPLISSAGE VASCULAIRE

Early coagulopathy in multiple injury: An analysis from the German Trauma Registry on 8724 patients Injury, Int. J. Care Injured (2007) 38, 298–304

Marc Maegele [a,*], Rolf Lefering [b], Nedim Yucel [a], Thorsten Tjardes [a],



D'après le Pr Tazarourte

Conclusion

DC resuscitation

Chirurgie de DC

1. Mesures chirurgicales brèves (bloc opératoire)

2. Stabilisation (réanimation)

3. Reprise chirurgicale (bloc opératoire)

Hémostase externe

Évacuation Trauma center

Prévention de l'hypothermie

Réanimation hypotensive à faible volume

Vasopresseur

Stratégie transfusion

Température

pH

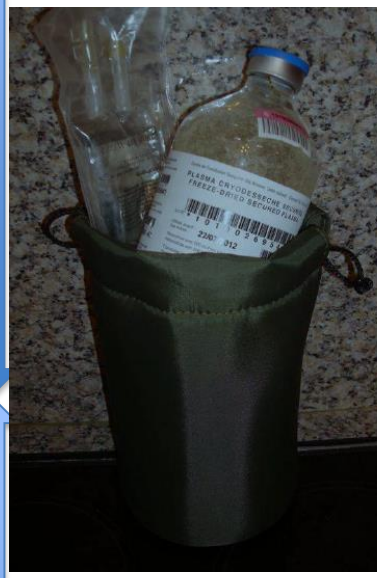
Calcémie

Coagulation

Surveillance abdomen

Ventilation

Préhosp.



Hôpital

Pour en savoir plus …

WILDERNESS & ENVIRONMENTAL MEDICINE, ▮, ▮▮▮–▮▮▮ (2016)

TACTICAL COMBAT CASUALTY CARE: TRANSITIONING BATTLEFIELD LESSONS LEARNED TO OTHER AUSTERE ENVIRONMENTS

Bleeding Control Using Hemostatic Dressings: Lessons Learned