【2016년 중증외상연구회 학술대회】

Fluid Management in Multiple Trauma

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History

- 1638 – William Harvey : first described the circulatory system
- 1832 – Physiologic saline due to pandemic cholera
- 1900 – ABO type
- 1960 – Large volume infusion (crystalloid)

Classic concept

- Hypovolemia : insufficient mitochondrial oxidative phosphorylation
- Large amount crystalloid resuscitation
  - a ratio of 3 mL per 1 mL of blood loss
- 2L lactate solution – ATLS 7th edition 1990's
- Continuing replacement until clinical sign s return to normal
- No role defined for colloids in trauma resuscitation
- Recent : consider of adverse effect (ex. Fluid induced dilutional coagulopathy)

Fluid management in patients with trauma: Restrictive versus liberal approach. J Anaesthesiol Clin Pharmacol. 2015 Jul-Sep; 31(3): 308–316.

Pathophysiology

- Capillary permeability increases
- IV fluid ⟹ interstitial space
- Oxygen delivery : cardiac output > blood pressure
- Trauma patients
  - Maintain pulse and blood pressure even after massive blood loss & tissue hypoxia
  - Cardiac output cannot be inferred blood pressure
  - Cryptic shock

The European guideline on management of major bleeding and coagulopathy following trauma: fourth edition. Crit Care. 2016 Apr 12;20(1):100.

The New England
Journal of Medicine

Volume 331 OCTOBER 27, 1994 Number 17

IMMEDIATE VERSUS DELAYED FLUID RESUSCITATION FOR HYPOTENSIVE PATIENTS WITH PENETRATING TORSO INJURIES

Methods. We conducted a prospective trial comparing immediate and delayed fluid resuscitation in 598 adults with penetrating torso injuries who presented with a prehospital systolic blood pressure ≤90 mm Hg. The study setting was a city with a single centralized system of prehospital emergency care and a single receiving facility for patients with major trauma. Patients assigned to the immediate-resuscitation group received standard fluid resuscitation before they reached the hospital and in the trauma center, and those assigned to the delayed-resuscitation group received intravenous cannulation but no fluid resuscitation until they reached the operating room.

Hypotensive Resuscitation

- Randomized trial, penetrating torso trauma, urban center: immediate vs delayed fluids
  - mortality
  - LOS
  - complications in immediate group
- Conclusions:
  - Delayed fluid resuscitation acceptable

Bickell et al: NEJM 1994;331:1005

Hemorrhagic Shock

	Class I	Class II	Class III	Class IV
Blood loss (ml)	Up to 750	750–1500	1500–2000	>2000
Blood loss (% blood volume)	Up to 15 %	15–30 %	30–40 %	>40 %
Pulse rate (bpm)	<100	100–120	120–140	>140
Systolic blood pressure	Normal	Normal	Decreased	Decreased
Pulse pressure (mmHg)	Normal or increased	Decreased	Decreased	Decreased

	Rapid response	Transient response	Minimal or no response
Vital signs	Return to normal	Transient improvement, recurrence of decreased blood pressure and increased heart rate	Remain abnormal
Estimated blood loss	Minimal (10–20 %)	Moderate and ongoing (20–40 %)	Severe (>40 %)
Need for more crystalloid	Low	Low to moderate	Moderate as a bridge to transfusion
Need for blood	Low	Moderate to high	Immediate
Blood preparation	Type and crossmatch	Type-specific	Emergency blood release
Need for operative intervention	Possibly	Likely	Highly likely
Early presence of surgeon	Yes	Yes	Yes

[1]Isotonic crystalloid solution, 2000 ml in adults; 20 ml/kg in children

American College of Surgeons Committee on Trauma. ATLS® Student Manual 9th Edition. Chicago, IL: American College of Surgeons; 2012.

Resuscitation injury

- Massive resuscitative infusion
  - reduces body temperature
  - dilutes clotting factor
  - impairs organ perfusion
  - gastrointestinal and cardiac complication
  - abdominal compartment syndrome
  - cellular dysfunction
  - fluid overload and edema lead to further edema

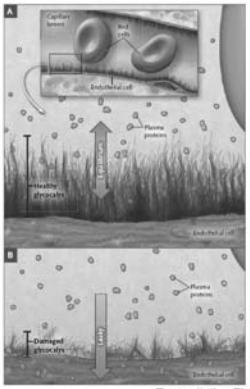
Traumatic hemorrhagic shock: advances in fluid management. Emerg Med Pract. 2011 Nov;13(11):1-19; quiz 19-20.

Hypovolemic resuscitation

- Damage control resuscitation
- Delaying time of administration
- Permissive hypotension
  - 70 ~ 80 mmHg in penetrating trauma
  - 90 mmHg in blunt trauma
- Carefully considered
  - Eldery
  - Hypertension
  - Carotid stenosis
  - Angina

Harris T, et all. Early fluid resuscitation in severe trauma. BMJ.2012 Sep 11;345

Crystalloid or Colloid



Resuscitation Fluids. N Engl J Med 2013;369:1243-51

Goal of resuscitation

- Prevention of traumatic coagulopathy
  - renal injury, lung injury
- Recovery from acidosis, hypothermia, coagulopathy, hypoperfusion
- Reversal of shock
- **Maintenance of homeostatic mechanism**

Ideal fluid

- Safe and cheap
- Effective volume expansion
- Oxygen carrying capacity
- Composition as close as possible to extracellular fluid
- Metabolized and completely excreted without accumulation produce adverse metabolic or systemic effects
- **No ideal resuscitation fluid exists**

Resuscitation Fluids. N Engl J Med 2013;369:1243-51

Fluids

Fluid	pH	Na	Cl	K	Ca	Mg	Buffer	Osmol
Plasma	7.4	141	103	4-5	5	2	Bicarbonate	289
Normal Saline	5.7	154	154				None	308
Lactated Ringer's	6.4	130	109	4	3		Lactate	273
Plasmalyte	7.4	140	98	5		2	Acetate/ Gluconate	295

Fluid	M.W.	Osmotic pressure	Effect	Half life
5% albumin	69,000 Dalton	20 mmHg	0.7-1.3	16 hours
6% Hetastarch	69,000 Dalton	30 mmHg	1.0-1.3	17 days

Principle

- Restriction or liberal (How much?)
- Colloid or crystalloid (which?)
- Route ?
- Speed ?

Crystalloid

- First line fluid, cheap
- Normal saline (0.9% NS)
- Balanced (buffered) solution
  - Lactate Ringer's solution
  - Acetate Ringer's solution
- Hypertonic saline (3.5%, 5%, 7.5%)
- Free in extracellular space
- Fluid distribution
  - 75 % ECF & 25 % Intravascular
  - Plasma expansion effect ??

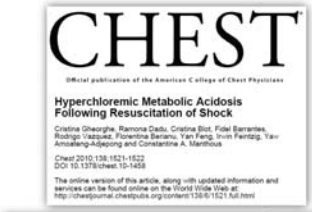
Normal saline

- Used for over 50 years
- Isotonic
  - fluid balance with minimal tonic variation
- Wound irrigation, eye drops
- No overall difference in mortality any other fluids
- Really normal?
  - Neither normal nor physiologic

Normal saline

- Hyperchloremic Metabolic Acidosis
- Uncontrolled hemorrhagic shock in pigs
- Lower fibrinogen and worse coagulopathy
- Interstitial edema
- Systemic inflammatory response

Hyperchloremic Metabolic Acidosis


CHEST

Official publication of the American College of Chest Physicians

Hyperchloremic Metabolic Acidosis Following Resuscitation of Shock

Cristina Gheorghe, Ramona Dadu, Cristina Blot, Fidel Barrantes, Rodrigo Vazquez, Florentina Berianu, Yan Feng, Irvin Feintzig, Yaw Amoateng-Adjepong and Constantine A. Manthous

Chest 2010;138:1521-1522
DOI 10.1378/chest.10-1458

The online version of this article, along with updated information and services can be found online on the World Wide Web at: http://chestjournal.chestpubs.org/content/138/6/1521.full.html

In conclusion, this limited retrospective study suggests that HMA is common during resuscitation of patients with a primary diagnosis of shock, and that HMA is associated with volume of infused saline. The limitations of this retrospective, medical records review preclude precise estimates of frequency and risk of this phenomenon, but the findings suggest hypotheses for a prospective study.

Hyperchloremic metabolic acidosis following resuscitation of shock. Gheorghe C, et al. Chest.2010 Dec;138(6):1521-2.

Hyperchloremic Metabolic Acidosis

- Lactic acidosis
- Depressed myocardial contractility (smooth muscle)
- Diminished peripheral vascular resistance
- Inotropic response to catecholamines
- Arrhythmia
- Platelet dysfunction
- Overall coagulation cascade dysfunction
- Greater blood loss

Hypertonic saline

- Since 1980s
- Volume expansion and restoration of T cell function in animal study
- Control of intracranial pressure, hyponatremia
- Traumatic brain injury
- No difference mortality between hypertonic and normal saline
- Aerosol : inhalation in cystic fibrosis

Hypertonic saline in severe traumatic brain injury: a systematic review and meta-analysis of randomized controlled trials. CJEM.2016 Mar;18(2):112-20.

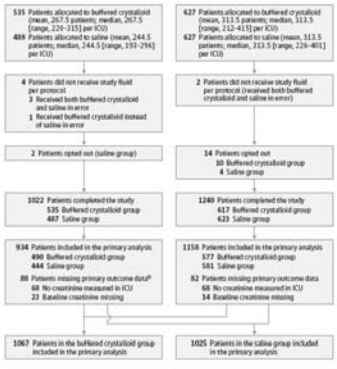
Balanced Solution

- Mild hypotonic solution (Na 130, Osmol 273)
- Instability of bicarbonate containing solutions
  - Buffered by such as maleate, gluconate, lactate or acetate
- Excessive administration
  - Lactate elevation
  - Metabolic alkalosis
  - Hypotonicity
  - Cardiac dysfunction
  - Calcium in the LR adversely affects the anticoagulation

Balanced Solution

- Increasingly recommended as first-line resuscitation fluids
- Decrease in the rate : infection, RRT, transfusion
- Maintenance of electrolyte : esp. magnesium
- Restoration of acid-base homeostasis
- Indication
  - Major surgery
  - Trauma
  - Diabetic ketoacidosis

Effect of a Buffered Crystalloid Solution vs Saline on Acute Kidney Injury Among Patients in the Intensive Care Unit
The SPLIT Randomized Clinical Trial



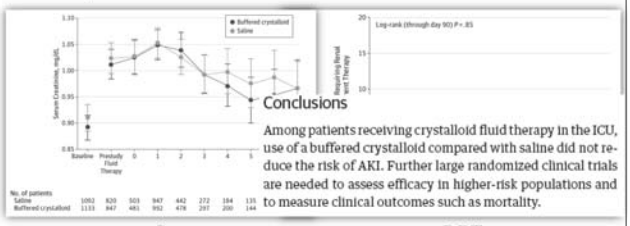
- Primary outcome: AKI (RIFLE criteria)
- Secondary outcomes: Cr, use of RRT, mortality

Young P, et al. JAMA. 2015;314(16):1701-1710

Primary outcome

Variable	No./Total No. (%) Buffered Crystalloid	Saline	Absolute Difference (95% CI)	Relative Risk (95% CI)	P Value
Primary Outcome					
Acute kidney injury or failure[a]	102/1067 (9.6)	94/1025 (9.2)	0.4 (−2.1 to 2.9)	1.04 (0.80 to 1.36)	.77

Secondary outcome

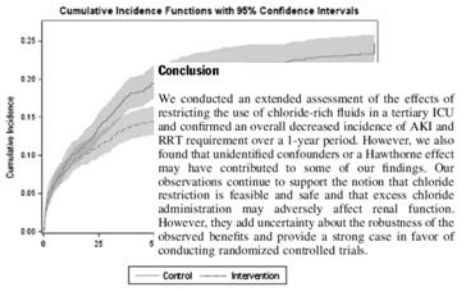


Conclusions

Among patients receiving crystalloid fluid therapy in the ICU, use of a buffered crystalloid compared with saline did not reduce the risk of AKI. Further large randomized clinical trials are needed to assess efficacy in higher-risk populations and to measure clinical outcomes such as mortality.

Cr RRT

Chloride in fluid



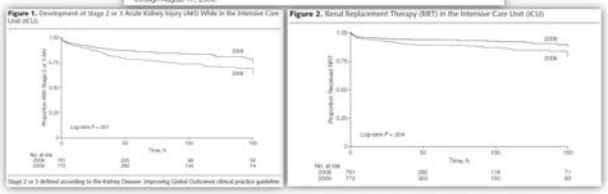
Yunos NM , et al. Chloride-liberal vs. chloride-restrictive intravenous fluid administration and acute kidney injury: an extended analysis. Intensive Care Med. 2015 Feb;41(2):257-64.

Association Between a Chloride-Liberal vs Chloride-Restrictive Intravenous Fluid A… in

Table 3. Incidence of Acute Kidney Injury Stratified by Risk, Injury, Failure, Loss, and End-Stage (RIFLE) Serum Creatinine Criteria

	No. (%) [95% CI] of Patients[a] Control Period (n = 760)	Intervention Period (n = 773)	P Value
RIFLE class			
Risk	71 (9.0) [7.2-11.0]	57 (7.4) [5.5-9.0]	.16
Injury	48 (6.3) [4.5-8.1]	23 (3.0) [1.8-4.2]	.002
Failure	57 (7.5) [5.6-9.0]	42 (5.4) [3.8-7.1]	.10
Injury and failure	105 (14) [11-16]	65 (8.4) [6.4-10.0]	<.001

[a] The control period was from February 18 through August 17, 2008, and the intervention period was from February 18 through August 17, 2009.



- AKI
- RRT

Yunos NM , et al JAMA. 2012;308(15):1566-72

Chloride in fluid

- Supraphysiological concentration of chloride
- Exacerbate hyperchloremia and metabolic acidosis
- Cause renal vasoconstriction and decreased GFR
- Restricting IV Cl administration in ICU : decreased the incidence of acute kidney injury

Colloid

- **Natural**
  - Albumin
- **Artificial**
  - Gelatin
  - Dextran
  - Hydroxyethyl Starches (HES)
    - Pentastarch
    - Hexastarch
    - Tetrastarch

Colloid

- High molecular weight substance
  - Create osmotic pressure → to keep water in the vascular space
- Where the IV fluid goes?
  - 30 % Extravascular
  - 70 % Intravascular Volume

    → Plasma expansion effect↑ , volume sparing effect

Hydroxyethyl starch

- Biological half time : 1.4 hours
- Excretion : renal
- 130 to 200 kDa
- 6% HES 130/0.4 in NaCl
  - concentration/ molecular weight/ molar substitution
- Ideal HES : Low MW, Low degree of substitution
  - 1st generation HES(Hetastach) :450/0.7
  - 2nd generation HES (pentastarch, Pentaspan®) : 200/0.5
  - 3rd generation HES (tetrastarch, Voluven®) :130/0.4

Clinical benefits

- Stabilization of systemic hemodynamics
- Anti-inflammatory response
  - preserve intestinal microvascular perfusion
- Cost effectiveness
  - cheap as compared to albumin
  - comparable volume of expansion
- Maximum allowable volume
  - 6% 130/0.4 : 50 ml/kg
  - more expansion other than colloids

Weak points

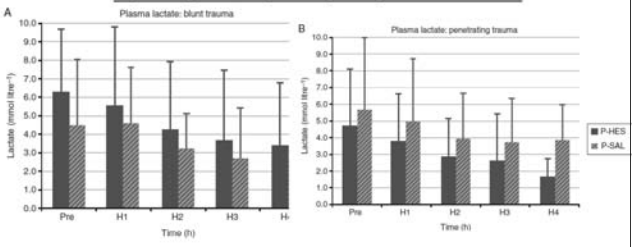
- Anaphylactoid reactions
  - hypersensitivity, flu-like symptom, brady-tachycardia, brochospasm
- Influence on coagulation
  - reduced release of factor VIII, von Willebrand Factor
  - impaired platelet function
- Influence on renal function
  - development of osmotic nephrosis like lesions in both proximal and distal renal tubules
  - Influence on renal function ,glomerular filtration, hyperviscous urine tubular flow dysfunction
  - high MW and/or high MS

British Journal of Anaesthesia 107 (5): 693–702 (2011)
Advance Access publication 19 August 2011 · doi:10.1093/bja/aer229

BJA

Resuscitation with hydroxyethyl starch improves renal function and lactate clearance in penetrating trauma in a randomized controlled study: the FIRST trial (Fluids in Resuscitation of Severe Trauma)

Conclusions. In penetrating trauma, HES provided significantly better lactate clearance



Is Hydroxyethyl Starch Safe in Penetrating Trauma Patients?

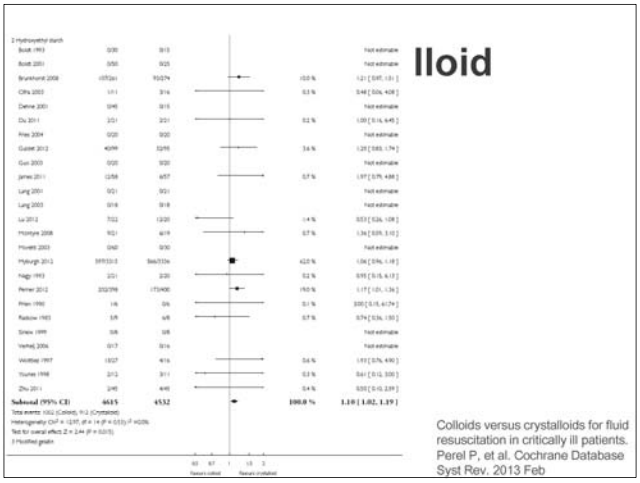
Casey J. Allen, MD; Xiomara D. Ruiz, MD; Jonathan P. Meizoso, MD; Juliet J. Ray, MD; Alan S. Livingstone, MD; Carl I. Schulman, MD, PhD; Nicholas Namias, MD; Kenneth G. Proctor, PhD

- Military setting : Voluven
  - Recommended for battlefield resuscitation, if blood products are not immediately available.
  - Penetrating injury > Blunt injury
  - Smaller volumes are required
  - No increase risk of AKI
  - No increase risk of mortality

Mil Med 2016. 181,5:152

Comparison

Trial	VISEP	CRYSTMAS	6S	CHEST
	Pentaspan	**Voluven**	**Tetraspan**	**Voluven**
	2008	2012	2012	2012
Mortality	No diff (high dose HES ↑)	No diff	HES↑	No diff
RRT/AKI	HES ↑	No diff	HES↑	HES↑
Volume effect	HES ↑	HES↑	No diff	HES↑



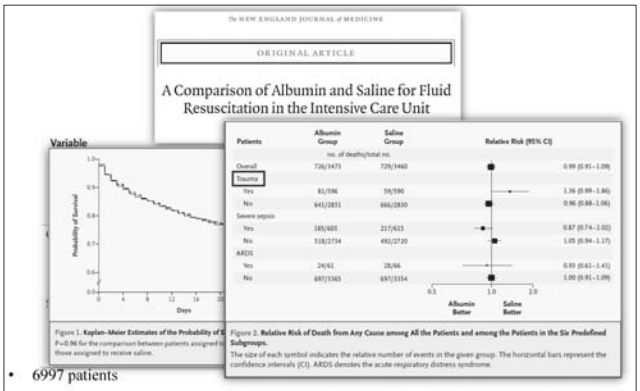
lloid

Colloids versus crystalloids for fluid resuscitation in critically ill patients. Perel P, et al. Cochrane Database Syst Rev. 2013 Feb

Albumin

- Normal range: 3.5 ~ 5 g/dL
- Main protein of human blood plasma
  - 50% of human plasma protein
- Regulate the colloidal osmotic pressure of blood
  - 75%-80% of plasma's normal colloid oncotic pressure
- Transport protein, free radial scavenger, biological buffer
- Related to mortality risk

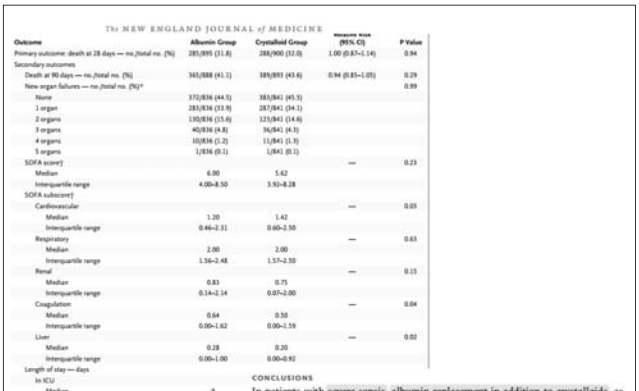
Journal of Clinical Epidemiology 1997;50(6):693–703



A Comparison of Albumin and Saline for Fluid Resuscitation in the Intensive Care Unit

- 6997 patients
- Multicenter, double-blind RCT
- Fluid resuscitation: 4% albumin vs saline
- Primary outcome: 28-day death

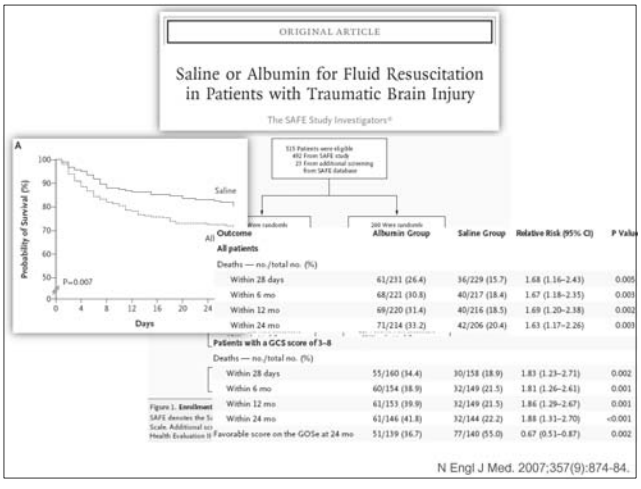
SAFE study NEJM 2004;350:2247



CONCLUSIONS

In patients with severe sepsis, albumin replacement in addition to crystalloids, as compared with crystalloids alone, did not improve the rate of survival at 28 and 90 days. (Funded by the Italian Medicines Agency; ALBIOS ClinicalTrials.gov number, NCT00707122.)

N Engl J Med 2014;370:1412-21

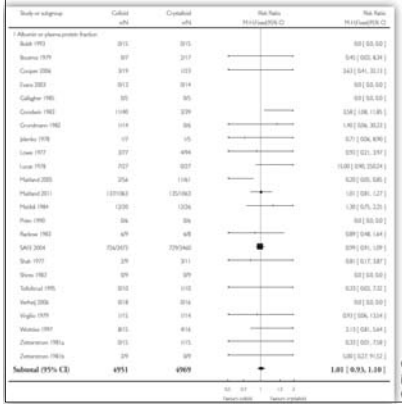


Saline or Albumin for Fluid Resuscitation in Patients with Traumatic Brain Injury

The SAFE Study Investigators*

N Engl J Med. 2007;357(9):874-84.

Albumin vs Crystalloid



Colloids versus crystalloids for fluid resuscitation in critically ill patients. Perel P, et al. Cochrane Database Syst Rev. 2013 Feb

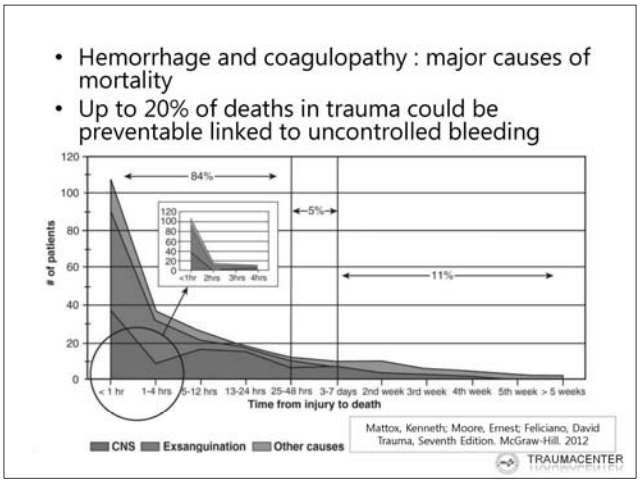
Conclusions

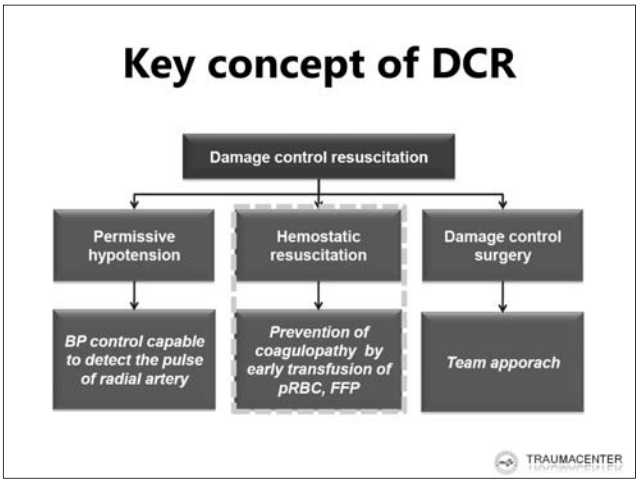
- Type of fluid - no effect on outcome
- Recognition of fluid responsiveness
- Balanced > non-balanced
- Cl : restrictive > rich
- Avoid large volume crystalloid resuscitation
- No conclusion on ideal fluid in trauma resuscitation

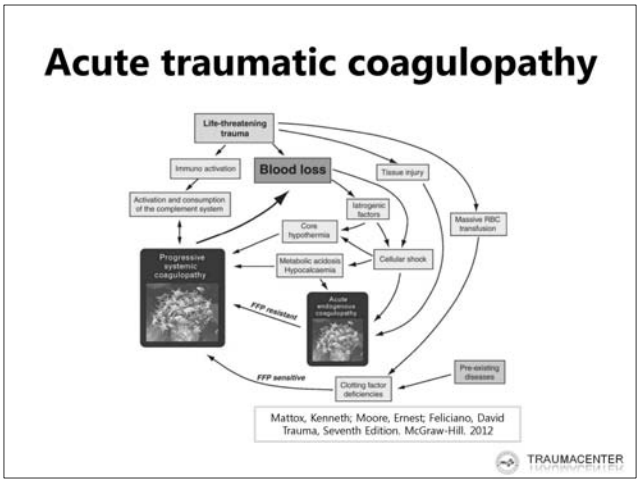
다발성 외상환자의 수상초기 혈액요법
(Hemostatic Resuscitation)

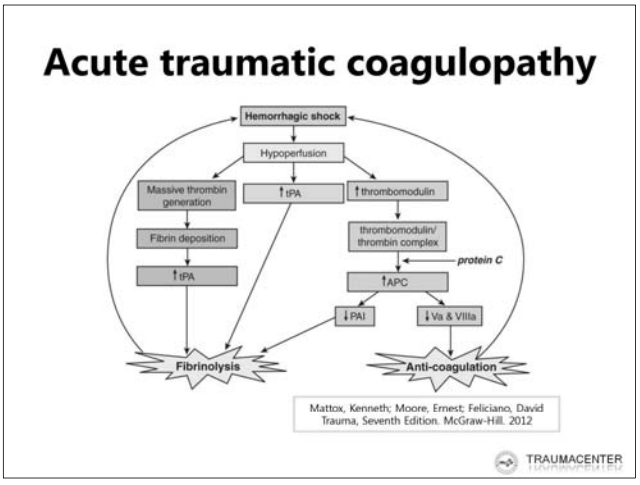
부산대학교 의과대학 부산대학교병원 외상센터

김 선 희









- **Hemodilution**
  - **Colloids**
    - Hespan and Dextran: vWF activity ↓ Platelet adhesion ↓
    - Fibrinogen dysfunction, pathological fibrin polymerization → poor clot stability
  - **Crystalloid**
    - Dilute coagulation factor and platelet
    - Reduction of factor VII inducing a prolongation of the prothrombin time

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- **Hypothermia**
  - Coagulation factor synthesis ↓
  - Coagulation cascade activation ↓
  - Platelet activation ↓ Platelet dysfunction
- **Acidosis**
  - Reduce 50% of activity of factor Xa, factor Va and thrombin generation at a pH of 7.2

Hypothermia + acidosis → significant bleeding despite adequate replacement of blood, plasma, platelet

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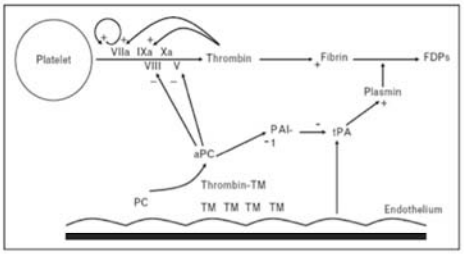
- **Hypoperfusion** : Increase of tissue plasminogen activator (tPA) and thrombomodulin

→ **Hyperfibrinolytic state**



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DCR protocol

- Resuscitation is limited to keep blood pressure at approximately 90 mmHg
- Intravascular volume restoration
  - ➡ FFP:pRBCs 1:1ratio
- Fresh whole blood (FWB) as a resuscitative fluid.
- Additional Components
  - ➡ Platelets, Cryoprecipitate

Holcomb et al. J Trauma. 2007

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Hemostatic Resuscitation

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J Trauma. 2007;63:805–813.

The Ratio of Blood Products Transfused Affects Mortality in Patients Receiving Massive Transfusions at a Combat Support Hospital

Matthew A. Borgman, MD, Philip C. Spinella, MD, Jeremy G. Perkins, MD, Kurt W. Grathwohl, MD, Thomas Repine, MD, Alec C. Beekley, MD, James Sebesta, MD, Donald Jenkins, MD, Charles E. Wade, PhD, and John B. Holcomb, MD

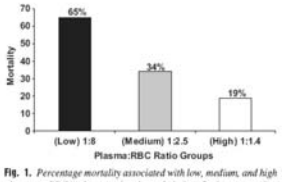

Fig. 1. *Percentage mortality associated with low, medium, and high plasma to RBC ratios transfused at admission. Ratios are median ratios per group and include units of fresh whole blood counted both as plasma and RBCs.*

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(*Ann Surg* 2008;248: 447–458)

Increased Plasma and Platelet to Red Blood Cell Ratios Improves Outcome in 466 Massively Transfused Civilian Trauma Patients

- Multicenter trial, Retrospective, 16 centers

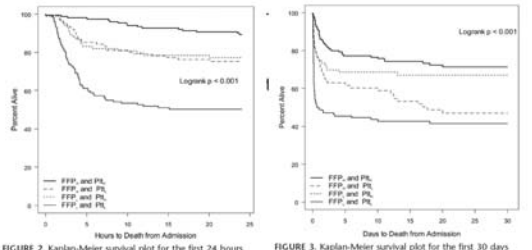

FIGURE 2. Kaplan-Meier survival plot for the first 24 hours after admission for the 4 groups (high plasma (FFP_H) or platelet (Plt_H) to RBC ratio ≥1:2, low plasma (FFP_L) or platelet (Plt_L) to RBC ratio <1:2).

FIGURE 3. Kaplan-Meier survival plot for the first 30 days after admission for the 4 groups (high plasma (FFP_H) or platelet (Plt_H) to RBC ratio ≥1:2, low plasma (FFP_L) or platelet (Plt_L) to RBC ratio <1:2).

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JAMA Surg. 2013;148(2):127-136. Published online October 15, 2012. doi:10.1001/2013.jamasurg.387

ONLINE FIRST

The Prospective, Observational, Multicenter, Major Trauma Transfusion (PROMMTT) Study

Comparative Effectiveness of a Time-Varying Treatment With Competing Risks

- earlier use of higher amounts of plasma and platelets(1:1:1)
- Improved survival during the first 6hours after admission
- Second study : No benefit after adjusting for another factors
  - J Trauma Acute Care Surg 2013; 75: S31–9

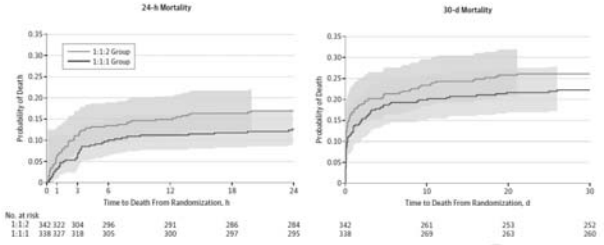
TRAUMACENTER

Original Investigation *JAMA*. 2015;313(5):471-482. doi:10.1001/jama.2015.12

Transfusion of Plasma, Platelets, and Red Blood Cells in a 1:1:1 vs a 1:1:2 Ratio and Mortality in Patients With Severe Trauma

The PROPPR Randomized Clinical Trial

- Blood products prepared and delivered to the bedside within 10 minutes
  - 6U plasma, 1 dose platelet(pool of 6U), 6U RBCs



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The PROPPR trial

	1:1:1 group (N=338)	1:1:2 group (N=342)	P-value
24-h mortality	43(12.7)	58(17.0)	0.12
30-d mortality	75(22.4)	89(26.1)	0.26
Achieved hemostasis	291(86.1)	267(78.1)	0.006

- Mortality due to exsanguination in the first 24 hr
  - 1:1:1 group 9.2% vs 1:1:2 group 14.6% (P=0.03)
- No significant differences in mortality at 24 hours or at 30 days
- No difference in complication including ARDS, MOF
- No other safety differences

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Summary of optimal ratio

Citation	Patient Cohort	Study Center /Period	FFP/PRC Ratio	Recommendation
Kashuk et al	N=133 trauma patients	Level I Trauma center 2001–2006	1:1, 1:2, 1:3, 1:4, <1:5	1:2
Maegele et al	N =713 trauma patients	German Trauma Registry 2002–2006	>1:1, 1:1, <1:1	1:1
Holcomb et al	N= 467 trauma patients	Multicenter study 2005–2006	>1:2, <1:2	1:1
Borgman et al	N =246 trauma patients	Combat support 2003–2005	1:1.4, 1:2.5, 1:8	1:1.4
Gunter et al	N=259 trauma patients	Level I Trauma Center	0:1–1:2.9, 1:3–1.49, 1:5–	2:3

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Hemostatic Resuscitation

- General consensus:

Early use of RBC + plasma + platelets offers best chance of limiting coagulopathy

➡ **1 : 1 : 1**

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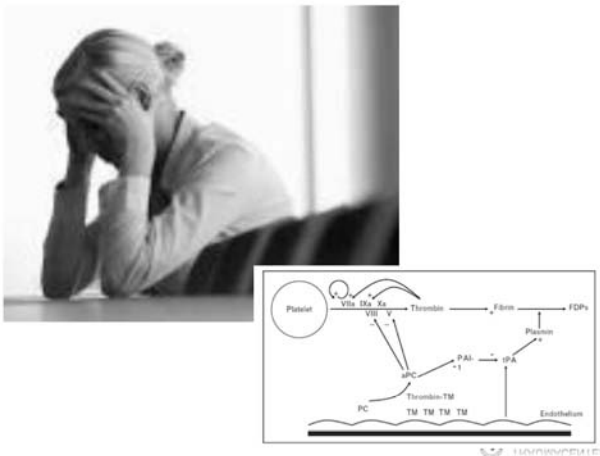

Cryoprecipitate

- **Fibrinogen :** Essential substrate for clot formation
- platelet aggregation and formation of a stable fibrin clot
- Normal level : 150 – 277 mg/dL
- Cryoprecipitate (FVIII, vW factor, and FXIII, fibrinogen)
- Some studies show benefit (**esp. battle field**)
- But Lack of strong evidence

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Cryoprecipitate

- In 2007, the European Guideline
- cryoprecipitate if bleeding + fibrinogen level ≤ 100 mg

- In 2013
- functional fibrinogen deficit (in TEG)
- fibrinogen level of ≤ 150~200mg

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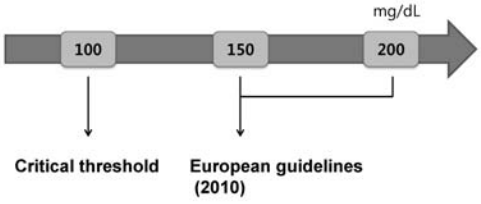
Recommendation for fibrinogen



Not maintained using FFP, replacement using cryoprecipitate or fibrinogen concentrate

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Tranexamic acid

- In Hyperfibrinolysis condition
- The CRASH-2 trial with over 20 000 patients included examined the effect of tranexamic acid
- All-cause mortality was reduced
- administered within the first 3 h

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Prothrombin complex concentrate

- both three-factor (USA) and four-factor (Europe) PCCs that are recommended for emergent reversal of oral anticoagulants
- PCCs in trauma patients leads to a considerable reduction in the use of blood products
- should be aware of a possible thrombotic risk
- recent recommendations by the FDA focuse to use within 3 hrs

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Recombinant activated factor VII

- Risks and benefits of a treatment with rFVIIa have to be carefully evaluated and economic aspects
- no strong evidence to support rFVIIa use in the standard treatment

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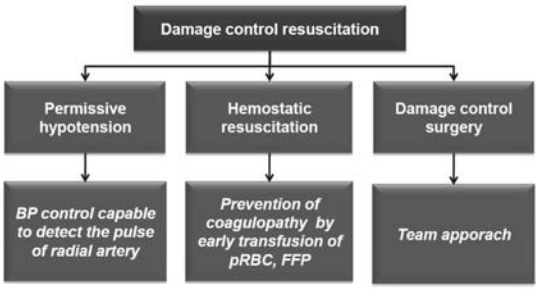
Key concept of DCR



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Goals for Resuscitation before Hemorrhage controlled

Parameter	Goal
Blood pressure	Systolic 80 mmHg; mean 50±60 mmHg
Heart rate	<120 beats/min
Oxygenation	SPO2 >96%
Urine output	>0.5 ml/kg /hr
Mentation	Following commands accurately
Lactate level	<1.6 mmol/l
Base deficit	>-5
Hg, Hct	>9.0 g/dl, 30%

McCunn M, et al. Curr Opin Anaesthesiol 2000
Nolan J. Cur Opin in Anaesthesiol 2000

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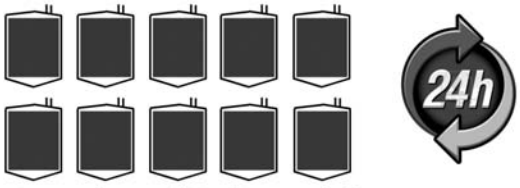
Massive transfusion ?

- Replacement of **10 pRBC** units within **24 hours**



- **Recent change of Massive Transfusion**

Administration of 10 or more units of RBC in 4~6hours

Emphasize critical period of first **4~6hou**r course

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Therapeutic goal of MTP

- Close monitoring of bleeding and coagulation
- Goal-directed transfusions
- Reduces the exposure to blood products
- Reduces costs
- Improve clinical outcome

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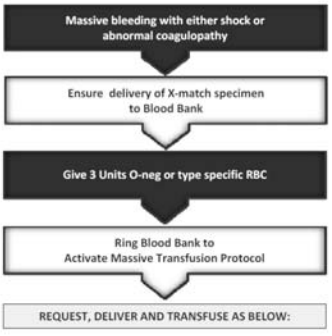
Massive transfusion protocol example



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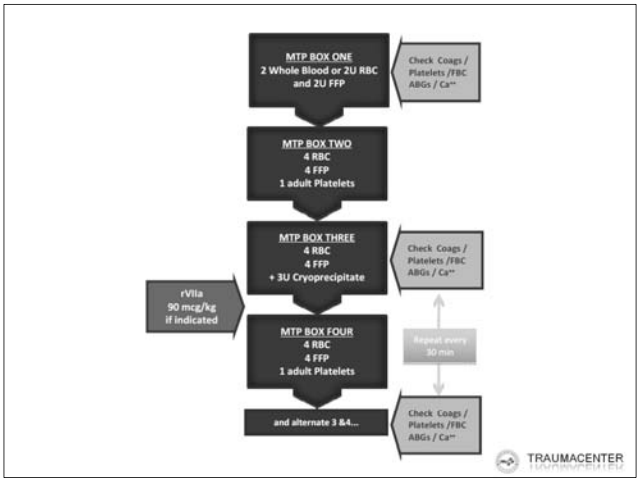
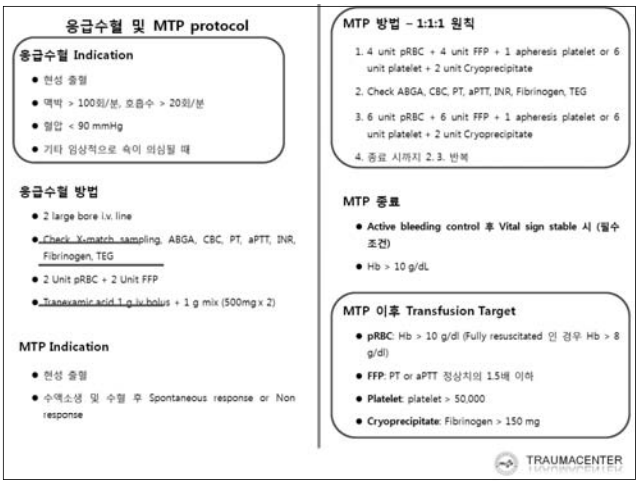
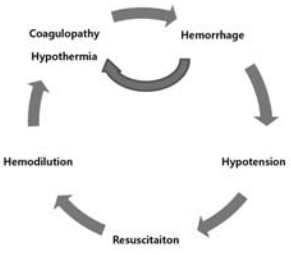




Complication of transfusion



Infectious complication
- HAV, HBV, HCV, CMV, HIV etc....
- Bacterial contamination

Non-infectious complication
- Febrile Transfusion Reaction
- Transfusion-associated Circulatory Overload(TACO)
- TRALI(Transfusion related acute lung injury)
- Allergic Reactions
- Hemolytic Transfusion Reaction
- Transfusion related Immunomodulation(TRIM)
- Posttransfusion purpura

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Goal-directed transfusion

- **APTT and PT**
  - Lack of consensus on the definition of traumatic coagulopathy and the cut-off values
  - Time these results take to 45–75 min which is far too long
  - Acute hyperfibrinolysis cannot be detected

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Thromboelastography TEG

- Within 5–10min information on the initiation of coagulation
- Clot strength as well as coagulation factors, fibrinogen, platelets
- Hyperfibrinolysis as part of acute traumatic coagulopathy

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Thromboelastography TEG

- A high correlationexists between thrombin generation and thrombus formation
- Differentiate between low fibrinogen and reduced platelet function
- ▶ ***Individualized coagulopathy therapy***

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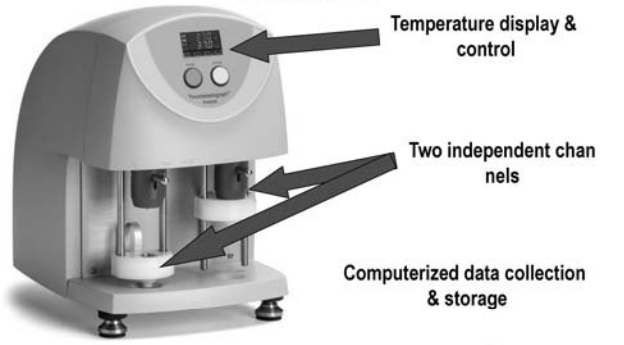
TEG® Analyzer *Features*



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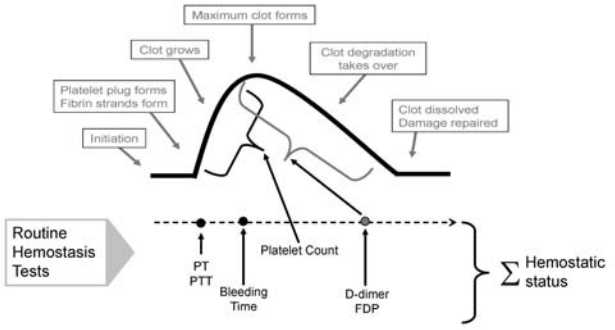
Monitoring the hemostatic process



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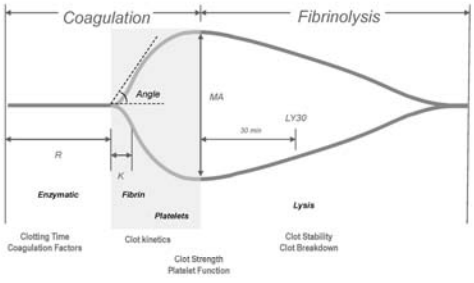
Coagulation and Fibrinolysis



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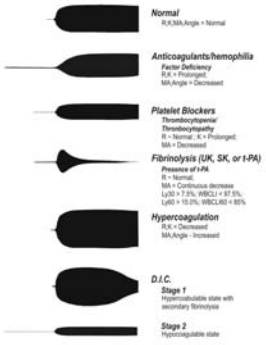
Tracing Shapes Aid



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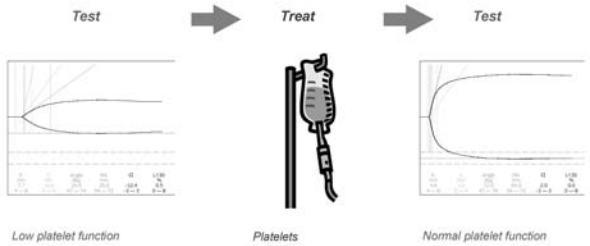
Treatment using TEG



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RESEARCH Open Access

Effect of thromboelastography (TEG®) and rotational thromboelastometry (ROTEM®) on diagnosis of coagulopathy, transfusion guidance and mortality in trauma: descriptive systematic review

Luis Teodoro Da Luz[1], Bartolomeu Nascimento[2], Ajith Kumar Shankarakutty[3], Sandro Rizoli[4] and Neill KJ Adhikari[1*]

- diagnostic accuracy were inconsistently
- predictive performance was not consistently superior to routine tests
- suggested that a TEG-based transfusion algorithm reduced blood-product transfusion
- not associated with lower mortality in most studies

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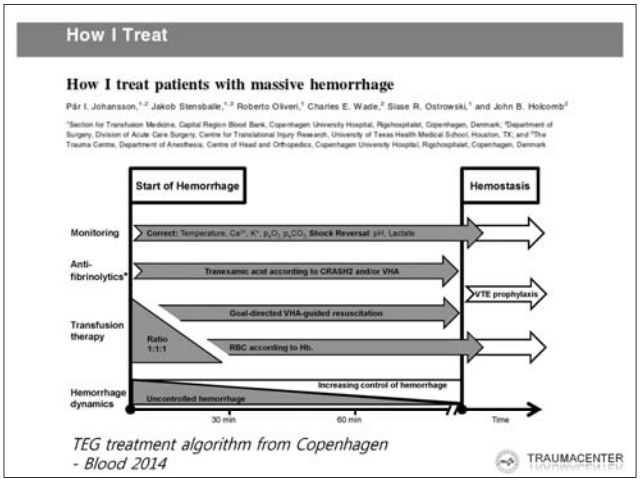
How I Treat
How I treat patients with massive hemorrhage
Start of Hemorrhage
Hemostasis
Monitoring
Correct: Temperature, Ca2+, K+, pvO2, pvCO2; Shock Reversal: pH, Lactate
Anti-fibrinolytics*
Tranexamic acid according to CRASH2 and/or VHA
VTE prophylaxis
Transfusion therapy
Goal-directed VHA-guided resuscitation
Ratio 1:1:1
RBC according to Hb.
Hemorrhage dynamics
Increasing control of hemorrhage
Uncontrolled hemorrhage
30 min
60 min
Time
TEG treatment algorithm from Copenhagen - Blood 2014
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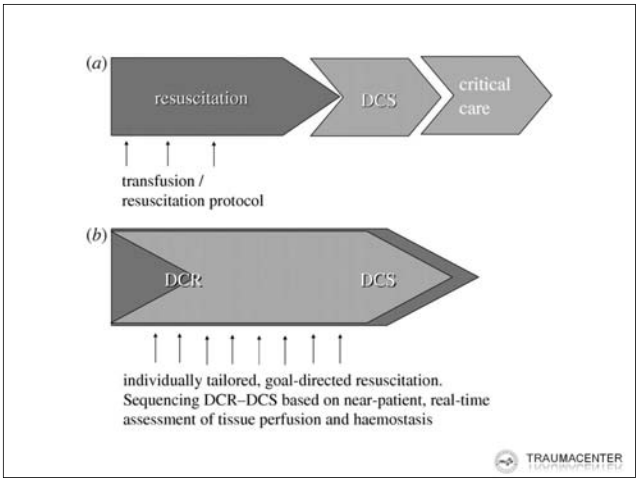
(a)
resuscitation
DCS
critical care
transfusion / resuscitation protocol
(b)
DCR
DCS
individually tailored, goal-directed resuscitation.
Sequencing DCR–DCS based on near-patient, real-time assessment of tissue perfusion and haemostasis
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THANK YOU
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Resuscitative Thoracotomy

단국대학교병원 흉부외과학교실

장 성 욱

개 요

흉부손상 환자에게서 자주 관찰되는 늑골 골절, 기흉 또는 혈흉의 경우 흉관삽입술을 비롯한 대증적인 치료에 대부분 좋은 치료 효과를 나타낸다. 그러나, 응급처치 후 반드시 개흉술을 비롯한 수술적 치료가 필요할 수도 있다. 여러 보고에 따르면, 흉부손상이 의심되는 외상성 심정지 환자에게는 손상 현장에서 즉시 양측에 폐쇄식 흉관삽입술을 시행하여 병원전단계 흉부감압(prehospital chest decompression)을 시행하는 동시에 심폐소생술을 하면서 병원으로 이송하는 것이 환자의 생존율을 높인다고 알려져 있다.

초기평가

흉부단순촬영을 통하여 기흉, 혈흉, 종격동 기종, 심장 비대 등을 확인할 수가 있다. 그리고, 흉부단순촬영만으로 확진이 어려울 경우에는 E-FAST (extended focused assessment with sonography for trauma)가 유용하게 이용된다.

진단에는 조영증강 흉부컴퓨터단층촬영(contrast-enhanced chest computed tomography, CT scan)이 출혈 위치, 폐실질을 포함한 장기 손상여부 등을 진단함에 있어 유용하고, 대동맥을 포함한 혈관손상에 대하여 좀 더 자세히 진단하기 위해서는 혈관조영 단층촬영(CT angiography)이 시행되기도 한다. 그러나, 심정지가 발생한 경우에는 적응증에 합당하면 검사 없이 소생개흉술이 시행되기도 한다.

소생개흉술의 목적

- 심장눌림증을 개선 시켜 정맥 환류를 원활하게 할 수가 있음.
- 효과적인 심장 압박이 이루어지기 어려운 환자의 경우에는 개흉심장마사지를 통한 보다 효과적인 소생을 기대할 수 있음.
- 생명을 위협하는 흉강내 출혈의 경우에는 빨리 손상 부위의 접근을 가능하게 하여 빠른 치료를 가능하게 함.
- 심장의 관통손상 또는 폐혈관 손상이 된 환자의 경우에는 폐혈관으로의 혈액흐름을 막아 공기색전증으로 진행되는 것을 방지하고 예방함.
- 복강내 또는 후복강내 과다출혈을 동반하는 환자의 경우에는 흉부 대동맥교차클램프를 통하여 하부몸통의 출혈양을 줄일 수 있고 대뇌와 관상동맥의 관류를 향상시켜 보다 효과적인 소생술을 가능하게 할 수 있음.

등이다.

소생개흉술을 시행하는 시기

Time	Immediate/Emergent	Urgent	Delayed
Condition	Acute cardiac tamponade Cardiac rupture/heriation Acute/massive blood loss Ventilatory disruption	Potentially life threatening condition Prevent the deterioration, injury or infection	Injured but controlled aortic injury For stabilization or treatment of other injury

소생개흉술의 일반적인 적응증과 금기증

소생개흉술의 적응증과 금기증은 손상 기전에 따라 차이가 있다.

먼저, 관통 손상 환자에 해당하는 적응증을 살펴보면,

- 첫째, 병원전단계 혹은 병원단계에서 외상에 의한 심정지가 목격자에 의하여 목격이 된 경우.
- 둘째, 충분한 수액과 약물치료에도 불구하고 수축기 혈압이 60-70mmHg로 반응을 보이지 않는 경우.
- 셋째, 총이나 칼 등에 의하여 심장의 관통손상 또는 폭발 등에 의한 흉부 손상이 있으며 과다한 출혈을 동반한 경우

등이다. 또한, 관통손상에 의한 심정지 환자의 경우에는 응급실 도착 당시 맥박이 없고 살아있다는 증거가 없다하더라도 소생개흉술이 환자의 생존과 신경학적 성적(outcome)에 도움이 된다고 알려져 있다.

둔상의 경우에도 관통상과 마찬가지로 심정지가 목격자에 의하여 목격된 환자, 충분한 수액과 약물치료에도 불구하고 수축기 혈압이 60-70 mmHg로 반응을 보이지 않으면서, 흉관을 통한 혈액의 배액이 갑작스럽게 1500ml이상이 관찰되면 적응증이 된다고 할 수 있다.

수술 술기

1) 환자의 자세

대부분 앙와위를 취한다. 물론, 수건이나 베게 등을 이용하여 좌측 또는 우측 가슴을 약간 높이거나, 어깨 받침을 하여 목을 뒤로 젖히는 등의 자세변형은 흔히 있을 수 있다. 팔은 통상적으로 머리를 향하여 들어 올린 자세가 가장 많이 추천된다.

2) 기도삽관

일반적인 기도삽관 시 사용되는 기관내관(endotracheal tube)을 주로 이용한다.

3) 코위관 삽입

반드시 필요한 것은 아니지만, 이미 코위관이 삽입되어 있는 환자에서 대동맥교차클램프(Aortic cross clamp, ACC)를 시행할 경우에는 식도와 대동맥의 구분을 용이하게 하여 도움을 준다.

4) 수면진정제와 근육이완제

심정지가 온 환자라 하더라도 중재적 시술을 비롯한 소생개흉술을 시행할 경우에는 가능하면 약물을 사용하도록 하는 것이 나을 수 있다.

5) 수술전 피부소독과 준비(skin preparation and draping)

이러한 준비가 수술을 늦추어서는 안 된다.

6) 절개

A. 정중흉골절개술(median sternotomy)은 심장 수술에서 가장 많이 사용되는 절개법으로 쇄골중간선보다 내측에 발생한 관통손상 환자의 경우에는 중심혈관의 손상 가능성이 높기 때문에 정중흉골 절개가 가장 좋은 절개법일 수가 있고, 쇄골상부로 확장(supraclavicular extension)을 하기에도 용이하기 때문에 자주 사용되기도 한다.

B. 뚜껑문(Open book or Trapdoor) 절개술 역시 심장을 비롯한 절개측의 흉강 상부와 상부 종격동을 노출시키기에는 유리하지만 소생개흉술에는 잘 사용되지 않지만 소생개흉술 후 확정수술(definitive surgery)을 위해서 사용되기도 한다.

C. 후측방개흉술(posterolateral thoracotomy)은 폐, 식도, 대동맥 등을 노출시키기에는 적당한 절개법이지만, 환자의 자세를 잡을 수 있는 수술용 침대가 있어야 하고 심장, 상행대동맥으로의 접근에는 한계가 있을 수 있으므로 소생개흉술에서 많이 사용되지는 않는다.

D. 전측방개흉술(anterolateral thoracotomy)은 응급소생개흉술에서 가장 많이 사용되는 절개법으로 전방 종격동과 절개 측의 흉강 전방과 중앙을 노출시키기에는 유리하다. 보통 4-5번째 갈비뼈사이공간을 통하여 이루어진다. 이때 흉골연부터 정중 겨드랑이선 바깥, 대흉근의 하연까지 절개창을 내는 것이 일반적이다.

E. Clamshell 개흉술은 좌/우측 전측방 개흉술에 흉골가로절개를 접목한 절개법이다. 흉골은 큰 가위나 Gigli saw를 이용하여 가로 분할을 시행하고 이때 흉골 외측에는 내흉동맥 있으므로 결찰을 시행하여 출혈을 최소화해야 한다.

사망률

둔상에 의한 심정지 환자에게서 시행된 응급소생개흉술의 생존률은 0-2.5%로 알려져 있다. 반면에 관통손상에 의한 심정지의 경우에는 18-33%까지 보고되어 둔상보다는 높은 생존율을 나타낸다. 관통손상 중에서 총이나 폭발에 의한 것 보다는 칼 등에 의한 관통손상이 보다 높은 생존율을 보인다. 또한, 일반적으로 심장 관통손상에 의한 심정지의 경우에는 다발성 방실(chamber)의 손상보다는 단일 방실의 손상 환자가 생존율이 높고, 폐혈관을 포함한 대혈관 손상이 동반되어 있는 경우에는 상대적으로 사망률이 높은 것으로 알려져 있다.

결 론

소생개흉술의 적응증을 정확히 인지하고 생존에 필요한 순환혈액량을 유지할 수 있도록 출혈을 줄이면서, 수술실로 환자가 빨리 이송될 수 있도록 하거나, 필요시 장소에 구애받지 않는 소생개흉술을 포함한 빠른 치료결정을 함과 동시에 시행할 수 있다면 환자 생존에 도움이 될 것이다.

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Resuscitative Endovascular Balloon Occlusion of the Aorta

GMC Trauma Center

Dae Sung Ma

CONTENTS

- Background and History
- Concepts of REBOA
- Studies for REBOA
- Devices and Techniques
- Risk and limitations

WHY ?

- Provide a window of opportunity for resuscitation and definitive hemorrhage control.
- Temporal occulsion of aorta

HISTORY

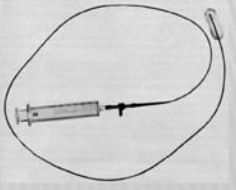
USE OF AN INTRA-AORTIC BALLOON CATHETER TAMPONADE FOR CONTROLLING INTRA-ABDOMINAL HEMORRHAGE IN MAN

LIEUTENANT COLONEL CARL W. HUGHES, MEDICAL CORPS, UNITED STATES ARMY, WASHINGTON, D. C.

(From the Division of Surgery, Army Medical Service Graduate School, Walter Reed Army Medical Center)

Surgery 1954;36(1):65

- Two critically injured Korean soldiers



HISTORY

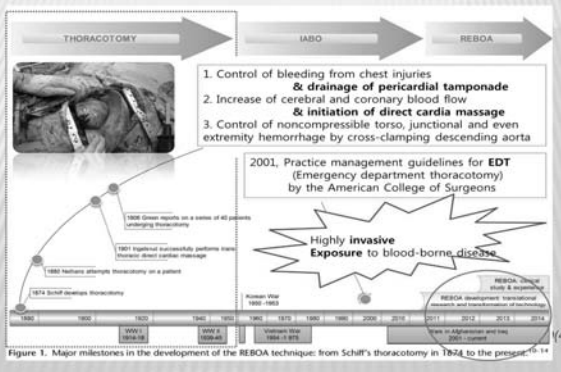


Figure 1. Major milestones in the development of the REBOA technique: from Schiff's thoracotomy in 1874 to the present. (4)

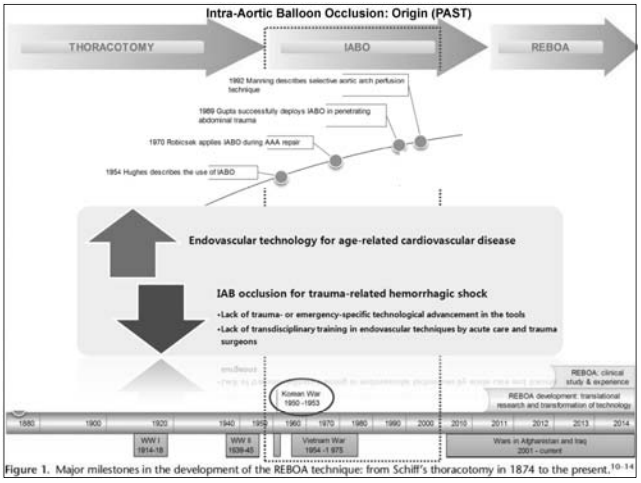


Figure 1. Major milestones in the development of the REBOA technique: from Schiff's thoracotomy in 1874 to the present.[10-14]

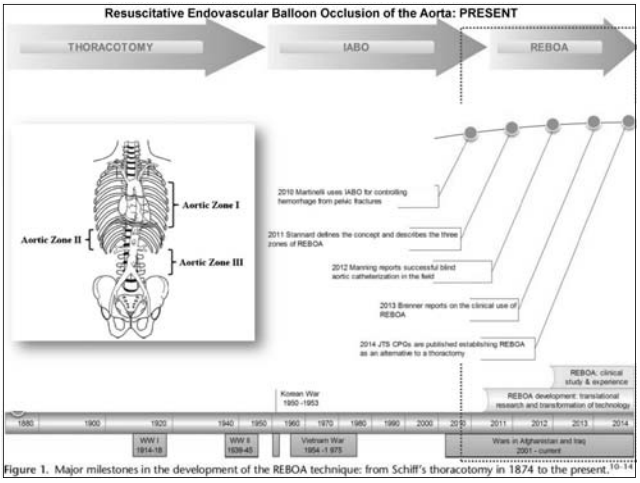
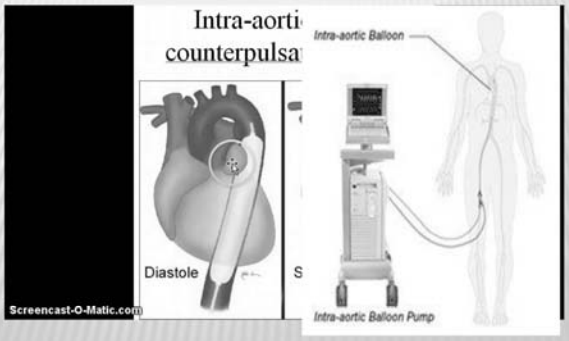
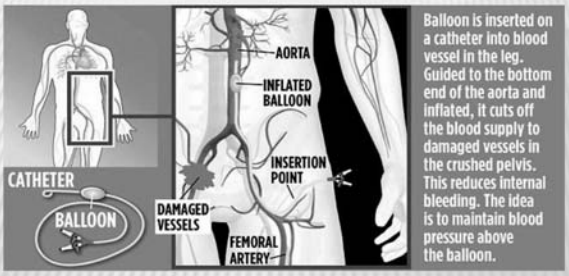


Figure 1. Major milestones in the development of the REBOA technique: from Schiff's thoracotomy in 1874 to the present.[10-14]

CONCEPTS OF REBOA



CONCEPTS OF REBOA



STUDIES FOR REBOA

STUDIES

Implementation of resuscitative endovascular balloon occlusion of the aorta as an alternative to resuscitative thoracotomy for noncompressible truncal hemorrhage

Laura J. Moore, MD, Megan Brenner, MD, Rosemary A. Kozar, MD, PhD, Jason Pasley, DO, Charles E. Wade, PhD, Mary S. Baraniuk, PhD, Thomas Scalea, MD, and John B. Holcomb, MD, *Houston, Texas*

- Two level I TC, Memorial Herman and Adams Cowley STC
- 18-month study period
- 72 RT pts. And 24 REBOA pts.
- No differences in demographics, $AIS_{chest,abd}$, ...

J Trauma 2015; 79(4)

Evaluation of the safety and feasibility of resuscitative endovascular balloon occlusion of the aorta

Nobuyuki Saito, MD, Hisashi Matsumoto, MD, PhD, Takanori Yagi, MD, Yoshiaki Hara, MD, Kazuyuki Hayashida, MD, Tomokazu Motomura, MD, Kazuki Mashiko, MD, Hiroaki Iida, MD, Hiroyuki Yokota, MD, PhD, *and* Yukiko Wagatsuma, MD, MPH, DrPH, *Inzai, Japan*

- 24 pts REBOA, blunt, ISS 47.5, age 59.5
- BPF, hemoperitoneum impending arrest with pulsation
- Percutaneous insertion in 95.8%
- 30-day survival 29.2%
- Complication 3: limb ischemia
- Reboa is feasible for trauma resuscitation

J Trauma 2015; 78(5)

Resuscitat
aorta (REE
trauma pa

Edward Benjami
Ricardo Mondon
Antoinette Edwa
Jan Olaf Jansen

Method: retrospect
patients presenting

Study period : 201

Conclusion :

resource intensive
amenable to REBO

planned evaluation
hospitals.

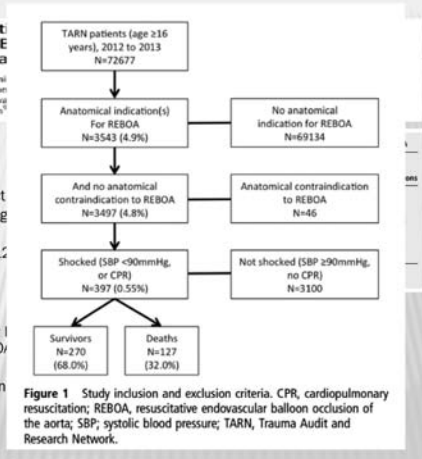


Figure 1 Study inclusion and exclusion criteria. CPR, cardiopulmonary resuscitation; REBOA, resuscitative endovascular balloon occlusion of the aorta; SBP; systolic blood pressure; TARN, Trauma Audit and Research Network.

Survival of severe blunt trauma patients treated with resuscitative endovascular balloon occlusion of the aorta compared with propensity score-adjusted untreated patients

Tatsuya Norii, MD, Cameron Crandall, MD, *and* Yusuke Terasaka, MD, *Albuquerque, New Mexico*

REBOA treatment is associated with higher mortality compared with similarly ill trauma patients who did not receive a REBOA.
The higher observed mortality among REBOA-treated patients may signal "last ditch" efforts for severity not otherwise identified in the trauma registry.

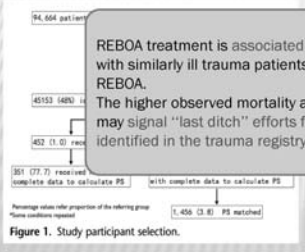


Figure 1. Study participant selection.

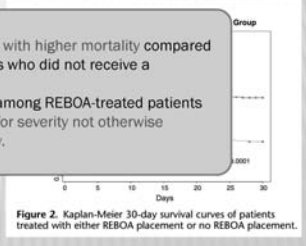


Figure 2. Kaplan-Meier 30-day survival curves of patients treated with either REBOA placement or no REBOA placement.

J Trauma Acute Care Surg. 2015;78: 721Y728.

CASE OF REBOA

CASE OF REBOA

the third person to undergo – and the second to survive – a procedure that involves inserting a balloon into a vein in the leg, passing it up through into the pelvis and inflating it, cutting off the blood supply in order to stem fatal bleeding.

16 June 2015.
By Nikki Murfitt For
The Mail On Sunday

CASE OF REBOA

Fig. 1. Inserted 12 Fr. sheath for REBOA. REBOA: resuscitative balloon occlusion of the aorta.

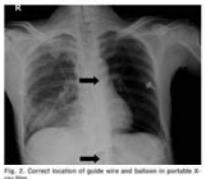


Fig. 2. Correct location of guide wire and balloon in portable X-ray film.

CASE OF GMC

- 29/M, Motorbike accident
- Alert mentality
- 초기 V/S 70/40-147-38-35, SaO2 100%
- 07:00 O+ 3 unit 종료, SBP 75mmHg -> 60mmHg
- FAST: abd. fluid +/-

PROGRESS AT TER

07:08		REPUP	Mental state : drowsy
			Pupil size & reflex : Rt(4 mm/ +), Lt(4 mm/ +)
			V/S : 75/46-131-40
	N		EM Dr 입채연 morphine stop
07:10	N		Cefazedone 1g AST done
07:13	N		V/S: 74/36-122-34
07:21	N		환자 혈액형 A+혈으로 확인됨
07:23	N		TD staff 마대섭 Lt femoral REBOA catheter insert
	N		V/S: 118/83-109-27-low SpO2 99% check
07:25	N		Cefazedone 1g AST negative check
	N		Cefazedone 1g + N/S 100ml mix IV connected
07:28		REPUP	Mental state : alert
			V/S : 138/115-103-18 SpO2 99% check
	N		send to 영상의학과
	N		- ABDOMINOPELVIST CT, CHEST CT, BRAIN CT, X-ray
	N		• O2 3L/min inhalation via nasal prong
	N		• monitoring & EM Dr 입채연 keep
07:30	N		보호자(모) 내원 함
	N		TD staff 마대섭, 박영은 보호자에게 환자상태 설명함
	S		응근수혈 O+ 5pint 수혈 종료함 (부작용 없음)
07:50		REOU	TD 과로 입원 결정하여 입원장 나감
07:58	N		return to TER
		REPUP	Mental state : alert
			V/S : 111/61-136-23
08:00	N		EM Dr 입채연, TD staff 마대섭 T-POD apply
08:02	S	DTRAS	혈액검사
	S		Hb/Platelet / 11.2 g/dl / 259 x10~3/mm~3)

PROBLEM LIST

AFTER REBOA

- Radiologic Work-up
  - Brain CT, Thoracic CT, Abdominopelvic CT
- Emergency laparotomy
  - small bowel segmental resection, liver gause packing
- Preperitoneal packing
- Embolization
  - superior gluteal artery,bilateral. internal pudendal artery,bilateral, Rt. deep circumflex iliac artery

DEVICES AND TECHNIQUES

TABLE 2. Examples of Endovascular Tools (Wires, Sheaths, and Balloons) Used To Accomplish REBOA

	Description	Size	Length (cm)
Wire	Amplatz Stiff Wire Guide (Cook Medical)	0.035 inch	260
Sheaths	Initial (starter)	5–6 Fr	8–15
	Delivery and support	12–14 Fr	45–60
Balloons	Coda balloon (Cook Medical)	14 Fr (32–40 mm diameter)	120
	Reliant (Medtronic)	12 Fr (10–46 mm diameter)	100
	Berenstein (Boston Scientific)	6 Fr (11.5 mm diameter)	80

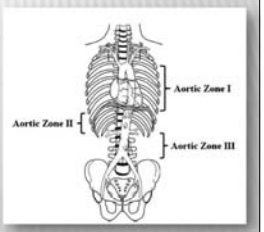
J Trauma 2011; 71(6)

CODA BALLOON

CATHETERS

INFLATION OF THE BALLOON

- Measure externally
  - Zone 1 to the xiphoid, Zone 3 just above the umbilicus
- Remove air
- Balloon test
- 20cc NS, 10cc contrast
- Until resistance goes moderate: 12-22ml



DEFLATION AND REMOVAL

- Deflate the balloon slowly
- Prolonged inflation: reperfusion syndrome
- Intermittent balloon inflation and deflation
- Direct arterial repair after removal

Retrospective study of the effectiveness of Intra-Aortic Balloon Occlusion (IABO) for traumatic haemorrhagic shock

Takayuki Irahara[1], Norio Sato[2*], Yuuta Moroe[3], Reo Fukuda[3], Yusuke Iwai[3] and Kyoko Unemoto[3]

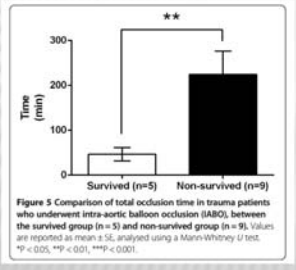


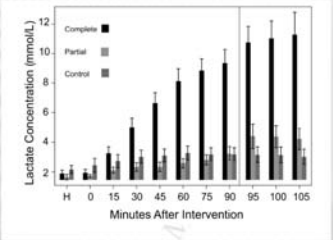
Figure 5 Comparison of total occlusion time in trauma patients who underwent intra-aortic balloon occlusion (IABO), between the survived group (n = 5) and non-survived group (n = 9). Values are reported as mean ± SE, analysed using a Mann-Whitney *U* test. *P < 0.05, **P < 0.01, ***P < 0.001.

The survived group
a significantly shorter total occlusion time
(46.2 vs. 224.1 min, P = 0.002)

J Trauma Acute Care Surg. 2013;75: 122-128.

Partial Resuscitative Endovascular Balloon Occlusion of the Aorta in a Swine Model of Hemorrhagic Shock

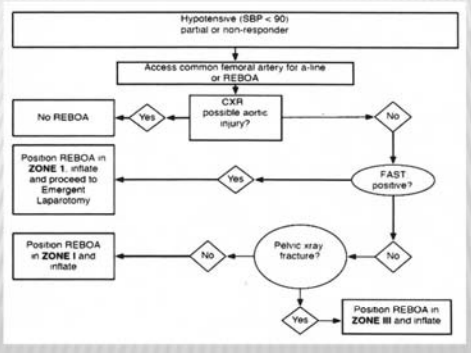
Rachel M. Russo, MD, Lucas P. Neff, MD, Christopher M. Lamb, FRCS, Jeremy W. Cannon, MD, Joseph M. Galante, MD, Nathan F. Clement, MD, J Kevin Grayson, DVM, PhD, Timothy K. Williams, MD



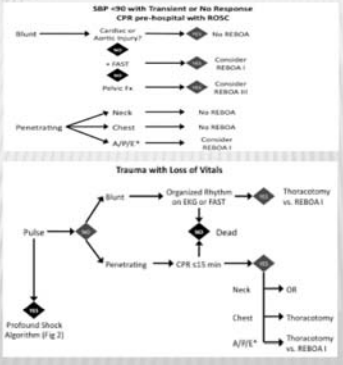
Journal of the American College of Surgeons

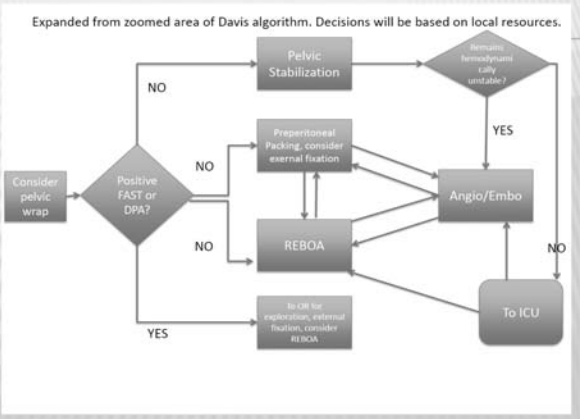
INDICATIONS AND ALGORITHMS

ALGORITHM - STC



ALGORITHM- JOINT THEATER TRAUMA SYSTEM GUIDELINE





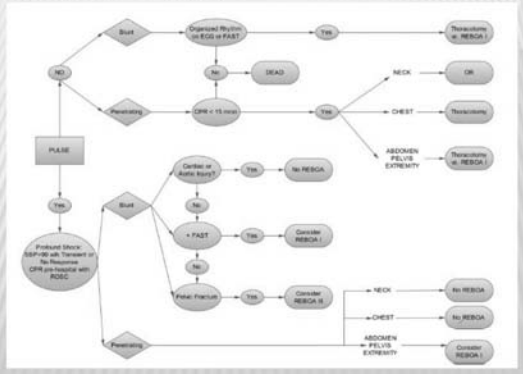
Nonoperative management of hemodynamically unstable abdominal trauma patients with angioembolization and resuscitative endovascular balloon occlusion of the aorta

Takayuki Ogura, MD, Alan T. Lefor, MD, MPH, Minoru Nakano, MD, PhD, Yoshimitsu Izawa, MD, *and* **Hideo Morita, MD,** *Gunma, Japan*

- Isolated abd. solid organ injury
- 36 pts. 2008-2013, 16 was survived
- 10 pts.: catheter inserted but not inflated
- 7 solid organ injury

J Trauma 2014; 78(1)

NEW CLINICAL PRACTICE GUIDELINE



ALGORITHM- JICHI UNIVERSITY

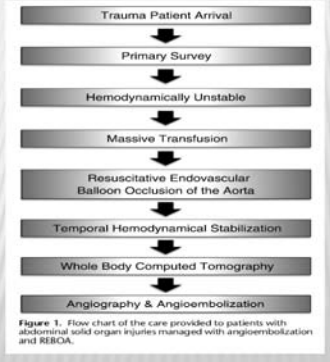


Figure 1. Flow chart of the care provided to patients with abdominal solid organ injuries managed with angioembolization and REBOA.

J Trauma 2014; 78(1)

RISK AND LIMITATIONS

- Limitations (vs. EDT)
  - Relief of pericardial tamponade or tension pneumothorax
  - Cardiac repair
  - Open chest cardiac massage
  - Temporal procedure
  - Limitation of resources
- Risks
  - Inflation
    - Undiagnosed upper body vascular injuries → more rapid loss
    - Sudden upper HTN, lower-body ischemia → irreversible organ damage
      (approximately 90 min.)
  - Deflation
    - Cardiovascular collapse

ADVANTAGES OF REBOA

- Less invasive procedure
- More easy procedure vs aorta clamping
- Similar effect vs aorta clamping
- Vouch the next procedure in Traumatic shock

PROBLEM IN KOREA

- Limited resources
- Medical insurance fee
- Little experience of NCTS in Trauma

- More accumulation of data and cooperation with goverment

늑골골절 치료의 설문 조사

부산대학교 의과대학 부산대학교병원 흉부외과학교실

황 정 주

서 론

늑골골절은 흉부외상에서 가장 흔한 손상이나 아직까지도 치료에 관한 확실한 표준 진료 지침이 없는 상태로 각 병원 및 담당의사에 따라 치료가 서로 다르고 표준화 되어있지 않습니다. 특히 고령의 환자에서 심한 다발성 늑골골절이 동반되거나 비교적 젊은 연령에서도 동요흉이 발생한 경우에는 호흡기 합병증으로 인한 사망률이 매우 높은(10-36%) 편이지만 이러한 고위험군에 대한 치료조차도 대부분 보존적 요법으로 치료결과가 약 40년 전과 비슷한 상태입니다.

늑골골절에 대한 치료로 고정술에 필요한 플레이트가 2014.7월로 보험적용이 되고 있습니다. 따라서 보다 합리적으로 치료 기준을 정하여 고정술의 오남용을 막고 바른 치료가 이루어 질 수 있도록 현재 우리나라에서 시행되고 있는 외상성 늑골골절 환자에 대한 치료 실태 조사를 시행하고 이를 바탕으로 효과적인 표준 진료지침 개발하고자 합니다.

조사방법

대한 흉부심장혈관외과학회 회원들을 대상으로 하여 늑골골절의 진단 및 치료에 대해 37가지의 설문을 발송하였으며 약 2주간의 기간을 통해 설문에 응해주신 답신을 바탕으로 하였습니다. 총 42개 병원에서 48분이 답신을 주었습니다.

결 과

근무 형태는 대학병원 38 (79%)/종합병원 10 (21%)였습니다. 경력은10년 이상이 33명(68.8%)이었으며 외상팀을 운영하고 있는 병원은 31개(73.8%)였습니다. 늑골골절을 입원 치료하는 병원내 과는 흉부외과 외에 응급의학과(12.5%), 일반외과(10.4%) 순이었습니다. 확진검사 및 진단서 작성을 위한 검사로 가슴전산화 단층 촬영을 가장 많이 사용하였으며(62.7%), 일반 단순 가슴촬영(17.6%), 전신골촬영(WBBS)(15.7%)순이었습니다. 진단 주수는 하나의 골절이라도 있으면 2-5주 이상으로 다양하게 주었고 동요흉이 있는 경우에 86%에서 단순 골절에 비해 2주 정도 더 진단 주수를 주는 것으로 파악되었습니다. 진단에 초음파를 이용하는 경우는 16.7%로 아직 많이 이용되고 있지 않은 실정이었고 늑연골의 골절 진단에는 가슴전산화 단층 촬영이 52.1%에서 사용하고 있었으며 그 외 초음파(12.5%), 신체검사(20.8%)를 이용하거나 WBBS (41.7%)을 이용한다고 답하였습니다. 수술적 치료를 이용한 경험이 있는 경우가(41명,85.4%)에서 있었으며 29명(60.4%)에서는 10례 이상의 경험이 있었고 100례 이상 수술적 치료 경험도 6명(12.5%)에 있었습니다. 수술적 치료의 적응증으로 동요흉, 심한 통증, 폐손상을 주는 심한 전위, 동반 손상이 있는 경우 순으로 제시하여 주셨습니다. 보존적 치료 시에 통증 치료 기간은 2-4주를 43.8%에서 선택하여 가장 많이 선호하였고 외래 추적 기간은 3달 이내가 43.8%로 가장 많이 제시해 주셨습니다.

결 론

본 설문을 통하여 국내 늑골골절의 치료 현황에 대해 이해도가 올라가게 되었으며 다양한 의견이 나온 부분에 대해서는 학회 차원의 문헌 고찰 및 전향적 연구를 통해서 표준을 제시하도록 해야겠습니다.

늑골 골절의 보존적 치료

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문 종 환

늑골 골절은 많은 이환율과 사망률과 관련되어 있다. 외상에 의한 늑골 골절의 발생률은 7-40%까지 다양하게 보고되고 있으며 약 70%는 둔상에 의해 발생하고 나머지 30%정도는 관통상에 의해 발생한다고 알려져 있다. 둔상으로 인한 늑골 골절은 단독으로 발생하는 것 보다 다른 장기의 손상과 동반되는 경우가 많기 때문에 늑골 골절은 손상의 중증을 나타내는 지표가 된다. 가장 많이 골절되는 부위는 4-9번 늑골이며 1-2번 늑골 손상 시 쇄골하동맥과 대동맥 등의 혈관 손상이 동반될 수 있으며 9-12번 늑골 골절 시에는 비장이나 간 등의 복부 장기 손상이 동반될 수 있다.

늑골 골절과 관련된 이환율과 사망률은 통증으로 인한 저환기, 늑골 골절과 동반된 폐 손상에 의한 가스 교환의 장애, 그리고 호흡 메카니즘의 변화 등의 원인에 의하여 발생한다. 늑골 골절에 의한 통증은 일회호흡량(tidal volume)을 줄이며 무기폐를 만들고 객담 배출을 지연 시켜서 폐렴 등의 합병증을 발생시키는 원인이 된다. 늑골 골절과 함께 발생한 폐 손상은 폐 출혈과 괴사를 동반한 폐 부종을 야기하며 이것들은 가스의 교환을 저하시키고 폐내 단락(intrapulmonary shunting)과 동맥혈산소분압(PaO2)을 저하시키게 된다. 동요 가슴의 발생은 흉곽의 모순운동(paradoxical movement)을 만들며 이는 폐 팽창을 방해하고 결과적으로 일회호흡량(tidal volume)의 감소, 동맥혈산소분압(PaO2) 저하 등을 발생시킨다.

폐렴은 늑골 골절의 가장 흔한 합병증 중에 하나이며 늑골 골절로 입원하는 환자의 약 6%정도에서 발생한다고 알려져 있다. 나이와 늑골 골절의 개수에 따라서 폐렴의 발생률은 증가하는 경향을 보인다. 골절의 불유합은 소수에서 나타나지만 발생시 오랜 기간의 통증과 호흡 기능 저하를 발생시킬 수 있다. 늑골 골절만으로도 만성 통증과 오랜 기간 동안의 장애를 만들 수 있다. 한 연구에 따르면 약 22%에서 만성 흉벽 통증이 발생하며 약 53%정도에서 장기적인 장애를 일으킨다고 보고하였고 늑골 골절이 발생하고 2달 후에 약 64%에서 통증을 호소하며 약 66%에서 호흡 장애를 호소한다는 보고도 있다. 이외에도 늑골 골절은 잔류혈흉(retained hemothorax), 농흉(empyema), 급성호흡부전증후군(ARDS) 등의 합병증을 일으킬 수 있다.

늑골 골절의 일차적인 치료 목표는 통증의 조절과 폐 용적을 확장시키는 것이다. 늑골 골절과 관련된 통증을 치료하는 것은 어려운 일이다. 그러나 초기에 효과적인 통증 치료는 저환기를 예방하고 심호흡과 기침을 가능하게 하여 호흡기 분비물의 제거를 도와주어서 늑골 골절에 의해 발생하는 폐렴, 무기폐, 호흡 부전 등의 이차적인 합병증 발생을 줄여줄 수 있다. 통증 조절은 환자의 통증 정도에 따라서 경구를 통한 비마약성 진통제와 마약성 진통제의 투여에서부터 정맥주사를 통한 여러 종류의 진통제를 상황에 맞게 투여할 수 있다. 이 외에도 국소마취(regional anesthesia)을 통하여 환자의 통증을 줄여줄 수 있다. 지속적인 경막외 주입술(continous epidural infusion), 척추옆신경차단술(paravertebral block), 늑간신경차단술(intercostal nerve block), 흉강내주입술(intrapleural infusion), 거상면 차단술(serratus plane block)등이 널리 쓰이고 있다.

늑골 골절 환자는 폐 용적 증가를 위해 기침, 심호흡, 유발폐활량측정기(incentive spirometry), 비침습적 양압환기(non-invasive ventilation)등을 통해 호흡기 분비물을 감소시키고 무기폐를 예방하는 치료가 필요하다. 적극적인 통증 조절과 폐 용적 증가를

위한 여러 방법에도 호흡 부전이 진행을 한다면 기도 삽관을 통한 인공호흡기 치료가 시행되어야 한다.

현재 늑골 골절의 치료에 대한 많은 프로토콜들이 나오고 있다. 늑골 골절에 대한 치료는 쉽지 않지만 이러한 치료법들을 적절하게 이용하여 초기에 적극적인 치료를 한다면 늑골 골절에 의한 이환율과 사망률을 낮출 수 있을 것으로 생각된다.

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늑골 골절의 수술적 치료

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