2022년
대한외상마취연구회
온라인 세미나

일시 : 2022년 6월 25일(토) 08:50-12:00

장소 : 아주대학교 아주홀 (본관 지하 1층) & ZOOM WEBINAR

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Reference
1. SmPC Volulyte **2.** Base E, Standl T. Crit Care 10(Suppl. 1) (2006) P176 **3.** Silva JM Jr et al. Crit Care. 2013; 17(6):R288

프레지니우스 카비 코리아 [주]
서울특별시 송파구 백제고분로 69 애플타워빌딩 9층 / TEL.02-3484-0900 / FAX.02-3484-0909 / www.fresenius-kabi.co.kr

VOL-2017-8

보건의료전문가용

일성신약(주)

Rapid Reversal Agents of Neuromuscular Blocker,

ILSUNG sugammadex sodium Inj.

신경근 차단의
신속한 역전제

3가지 용량으로
투약 시 선택 용이

프리필드시린지로
안전하고 간편한 사용

Why
sugammadex sodium?

- 발관 시 낮은 잔여 근이완 발생률
- 회복 중 위험 기간 단축
- 우수한 내약성

신경근 차단의 신속한 역전제

일성 슈가마덱스나트륨 주

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인사말

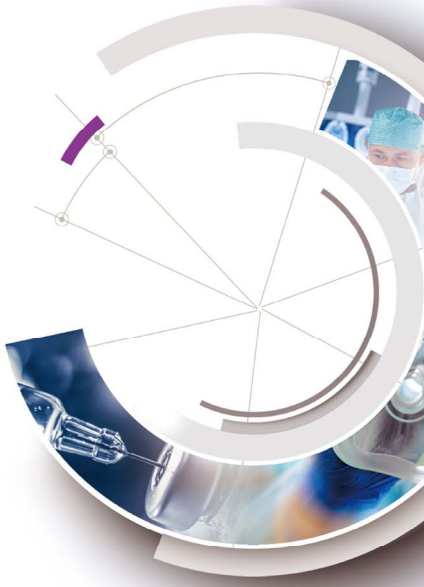
이번 대한외상마취연구회 2022년 세미나는 외상환자 중에서도 특히 중증도가 높아 환자관리가 어려운 두부손상 환자 및 복부손상 환자의 수술과 마취관리 그리고 영상의학적 관리에 관한 내용으로 여러 선생님들께 큰 도움이 될 것으로 생각됩니다.

많은 관심과 참여를 부탁드립니다.

감사합니다.

대한외상마취연구회

회장 문 봉 기



2022년
대한외상마취연구회
온라인 세미나

일시: 2022년 6월 25일 토요일 08:50-12:00

장소: 아주대학교병원 아주홀 (본관 지하 1층) & ZOOM WEBINAR

08:50-09:00	개회사 및 축사	
09:00-10:00	**1부 <Traumatic Brain Injury>**	**좌장: 민경태** (연세의대)
09:00-09:25	Traumatic Brain Injury	유남규 (아주의대 신경외과) • 02
09:25-09:50	Anesthetic Considerations for Traumatic Brain Injury	김해규 (부산의대 마취통증의학과) • 10
09:50-10:00	Q&A	
10:00-10:10	Coffee Break	
10:10-12:00	**2부 <Abdominal Trauma>**	**좌장: 문봉기** (아주의대)
10:10-10:35	Abdominal Trauma	강병희 (아주의대 외상외과) • 18
10:35-11:00	Anesthetic Considerations for Abdominal Trauma	안효은 (아주의대 마취통증의학과) • 25
11:00-11:25	The Role of Interventional Radiology in Traumatic Patients	원제환 (아주의대 영상의학과) • 32
11:25-11:50	Bleeding and Coagulation Management	김태엽 (건국의대 마취통증의학과) • 45
11:50-12:00	Q&A	

1부
Traumatic Brain Injury

좌장: 민경태 (연세의대)

Traumatic Brain Injury — 유남규 (아주의대 신경외과)

Anesthetic Considerations for Traumatic Brain Injury — 김해규 (부산의대 마취통증의학과)

CURRICURUM VITAE

유 남 규

아주대학교 의과대학 신경외과학교실, 아주대학교병원

▌학력 및 경력

1997년~2003년	연세대학교 의학과 학사
2005년~2009년	연세대학교 의학과 석사
2003년~2004년	세브란스 병원 인턴
2004년~2008년	강남 세브란스 병원 전공의
2011년~2012년	세브란스병원 전임의
2012년~2017년	아주대학교병원 신경외과 진료조교수
2017년~현재	아주대학교병원 신경외과 진료부교수

Traumatic Brain Injury
- ICP and Multimodal Monitoring -

Namkyu You

Department of Neurosurgery, Ajou university School of Medicine

Traumatic Brain injury

- A major cause of death and disability
- Traumatic brain injury (TBI) is a **nondegenerative**, **noncongenital** insult to the brain from an external mechanical force, possibly leading to permanent or temporary impairment of cognitive, physical, and psychosocial functions, with an associated diminished or altered state of consciousness
- 외상성 뇌 손상 (TBI)은 **외부의 기계적 힘**으로부터 뇌에 대한 비퇴행성, 비선천성 손상으로 인지, 신체적, 심리 사회적 기능의 영구적 또는 일시적 손상을 초래할 수 있으며, 의식의 저하나 변화가 동반된다.

150 Years of Treating Severe Traumatic Brain Injury: A Systematic Review of Progress in Mortality

JOURNAL OF NEUROTRAUMA 27:1343–1353 (July 2010)

Sherman C. Stein,[1] Patrick Georgoff,[1] Sudha Meghan,[1] Kasim Mirza,[1] and Seema S. Sonnad[2]

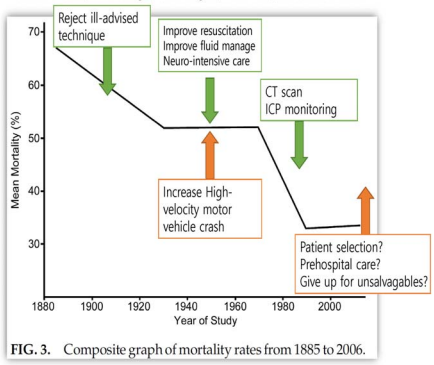
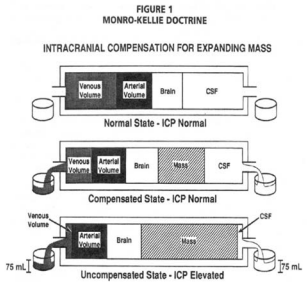
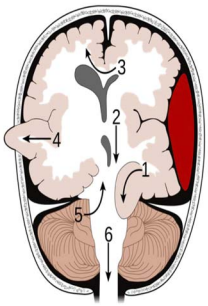


FIG. 3. Composite graph of mortality rates from 1885 to 2006.

MONRO KELLIE DOCTRINE & ICP





Decision making for Surgical treatment

- After initial resuscitation,
- Neurologic examination
- CT scan

Brain Trauma FOUNDATION

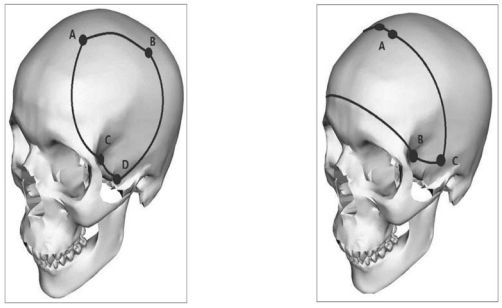
	Should be evacuated (surgery)	Observation (Serial CT scan)	Consideration
Acute EDH	EDH > 30 cm^3	EDH < 30 cm^3	Anisocoric coma (GCS <9)
Acute SDH	10mm thickness MLS 5mm	Should ICP in GCS < 9	GCS decreased 2 more btw injury and admission Anisocoria Dilated and fixed pupil ICP > 20mmHg
Traumatic ICH	GCS 6~8 with frontal contusion > 20 cm^3, MLF > 5 mm and cisternal compression Any lesion > 50 cm^3	No evidence of neurologic compromise Controlled ICD	
Posterior fossa	Mass effect on CT Neurologic deterioration		

Secondary Decompression in TBI

Guidelines for the Management of Severe Traumatic Brain Injury: 2020 Update of the Decompressive Craniectomy Recommendations

- Secondary DC performed for late refra recommended to improve mortality an
- Secondary DC performed for early refractory ICP elevation is not recommended to improve mortality and favorable outcomes.
- A large frontotemporoparietal DC (not less than 12 × 15 cm or 15 cm in diameter) is recommended over a small frontotemporoparietal DC for reduced mortality and improved neurological outcomes in patients with severe TBI.
- Secondary DC, performed as a treatment for either early or late refractory ICP elevation, is suggested to reduce ICP and duration of intensive care, though the relationship between these effects and favorable outcome is uncertain

MEDTHODS OF DECOMPRESSIVE CRANIECTOMY



Ji Won Moon and Dong Keun Hyun. Decompressive Craniectomy in Traumatic Brain Injury: A Review Article. Korean J Neurotrauma. 2017 Apr;13(1):1-8

EARLY vs LATE DC in TBI

Early versus late decompressive craniectomy in traumatic brain injury: A retrospective comparative case study

Nida Fatima[1], Mujeeb-Ur-Rehman[2], Samia Shaukat[1], Ashfaq Shuaib[3], Ali Raza[1], Ali Ayyad[1] and Maher Saqqur[4]

Table 2. Primary and secondary end-point outcomes according to the timing of decompressive craniectomy.

Characteristics	Total	Early DC	Late DC	p
Mortality-30 days	21 (9.8)	17 (10.8)	4 (8.7)	0.39
GCS at discharge				
Median	15	15	15	
Range (IQR)	3–15	3–15	3–15	
<8	32 (11.2)	28 (17.7)	4 (8.7)	0.21
≥9	172 (84.3)	130 (82.2)	42 (91.3)	
Length of hospital stay (days), median (range)	23 (2–44)	21 (2–40)	28 (2–44)	0.20
EDH alone	7 (2–15)	6 (2–14)	8 (2–15)	0.24
EDH ± DAI/contusion	21 (5–34)	20 (5–32)	23 (5–34)	0.21
SDH alone	10 (3–17)	10 (3–14)	9 (3–17)	0.19
SDH ± DAI/contusions	23 (5–39)	21 (5–35)	24 (7–39)	0.20
Parenchymal hemorrhage	27 (10–41)	25 (10–38)	28 (15–41)	0.14
DAI/contusions	27 (11–44)	27 (15–41)	30 (11–44)	0.15
GOSE-60 days				
Median	7	7	6	
Range (IQR)	1–8	1–8	1–8	
Poor outcome (1–4)	54 (26.4)	41 (25.9)	13 (28.3)	0.75
Good outcome (5–8)	150 (73.5)	117 (74.1)	33 (71.7)	

DC: Decompressive Craniectomy; GCS: Glasgow Coma Scale; GOSE: Glasgow Outcome Scale Extended; IQR: Interquartile range.
p-value: Pearson Chi-square test.

Nida Fatima et al. Early versus late decompressive craniectomy in traumatic brain injury: A retrospective comparative case study. Trauma 2021, Vol. 23(2) 127–132

EARLY vs LATE DC in TBI

Early versus late decompressive craniectomy in traumatic brain injury: A retrospective comparative case study

Table 3. Parameters predicting outcome (GOSE-60 days) in decompressive craniectomy according to uni- and multi-regression analysis adjusted for time since surgery.

Variables	Univariate OR (95% CI; p-value)	Multi regression adjusted for time, age, sex		
		OR	p-value	95% CI
Age (<35 /≥35 years)	1.4 (0.66–3.17; 0.35)	–	–	–
Sex (male/female)	0.87 (0.14–5.37; 0.88)	–	–	–
GCS at admission (<9/≥9)	0.07 (0.32–0.18; <0.05)	0.07	<0.05*	0.03–0.16
Mechanism of injury	0.99	–	–	–
Type of DC (HC/BF)	0.99	–	–	–
Indication for DC (EDH alone/others)	3.8 (1.3–11.1; 0.01)	1.75	0.02*	1.09–3.25
Location of mass lesion	13.2 (0.6–261; 0.09)	–	–	–
Type of trauma	1.4 (0.62–3.40; 0.38)			

Note: indicates that the value could not be calculated due to insignificant p-value in univariate analysis. *Indicates significant values.
BF: Bi frontal decompressive craniectomy; DC: decompressive craniectomy; EDH: extradural hematoma; GOSE: Glasgow Outcome Scale Extended; HC: hemicraniectomy.

Nida Fatima et al. Early versus late decompressive craniectomy in traumatic brain injury: A retrospective comparative case study. Trauma 2021, Vol. 23(2) 127–132

EARLY DECOMPRESSION FOR SEVERE TBI

- Within 4 hours
- 127 cases

TABLE 3. Postoperative clinical outcomes according to various predisposing factors

Parameters	No. of patients	Expire (%)	Unfavorable outcome (%)	Favorable outcome (%)	p-value
Age					0.001
<29	21	8 (38.2)	12 (57.1)	1 (4.7)	
30~49	43	27 (62.8)	12 (27.9)	4 (9.3)	
>50	63	52 (82.5)	10 (15.9)	1 (1.6)	
Sex					0.687
Male	97	65 (67.0)	27 (27.8)	5 (5.2)	
Female	30	22 (73.3)	7 (23.3)	1 (3.4)	
Injury mechanisms					0.544
Motor vehicle	27	19 (70.4)	8 (29.6)	0 (0)	
Driver TA	14	9 (64.3)	3 (21.4)	2 (14.3)	
Pedestrian TA	28	21 (75)	6 (21.4)	1 (3.6)	
Fall down	20	15 (75)	3 (15)	2 (10)	
Slip down	23	15 (65.3)	7 (30.4)	1 (4.3)	
Rolling down	13	8 (61.5)	5 (38.5)	0 (0)	
Assault	2	0 (0)	2 (100)	0 (0)	
GCS					<0.001
3	27	27 (100)	0 (0)	0 (0)	
4~5	45	37 (82.2)	8 (17.8)	0 (0)	
6~8	55	23 (41.8)	26 (47.3)	6 (10.9)	
Marshall classification					0.42
2	15	9 (60)	5 (33.3)	1 (6.7)	
3	27	24 (88.9)	2 (7.4)	1 (3.7)	
4	85	54 (63.5)	27 (31.8)	4 (4.7)	
Midline shift					0.912
<10 mm	72	52 (72.3)	15 (20.8)	5 (6.9)	
10~20 mm	45	28 (62.2)	16 (35.6)	1 (2.2)	
>20 mm	10	7 (70)	3 (30)	0 (0)	
Time to op					0.43
<4 hrs	60	39 (65.0)	19 (31.7)	2 (3.3)	
>4 hrs	67	48 (71.6)	15 (22.4)	4 (6.0)	

GCS: Glasgow coma scale, TA: traffic accident

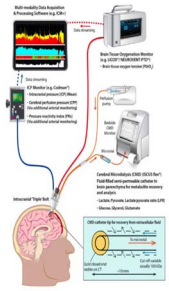
Jun-Hee Park et al. Outcomes of Ultra-Early Decompressive Craniectomy after Severe Traumatic Brain Injury-Treatment Outcomes. Korean J Neurotrauma 2014;10(2):112-118 after Severe TBI

MONITORING

- ICP monitoring
  - Management of severe TBI patients using information from ICP monitoring is recommended to
    reduce in-hospital and 2-week post-injury mortality. (Level II B)
- CPP monitoring
  - Management of severe TBI patients using guidelines-based recommendations for CPP moni toring
    is recommended to decrease 2-week mortality (Level II B)
- ADVANCED monitoring
  - **Jugular bulb monitoring** of arteriovenous oxygen content difference (AVDO2), as a source of
    information for management decisions, may be considered to reduce mortality and improve outcomes at 3 and 6 months post-injury. (Level III)

MULTIMODAL MONITORING

- ICP
- BRAIN TISSUE OXIGENATION
- NIRS
- VENOUS JUGULAR OXYGENATION
- MICRODIALYSIS
- TEMPERATURE
- PUPILOMETRY
- ULTRASOUND (ONSD, TCD)



ICP MONITORING

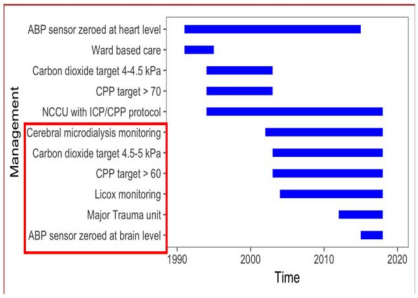
- MOST WIDELY USED
- MOST RELIABLE
- EASY TO APPLY
- CLASSIC MONITORING

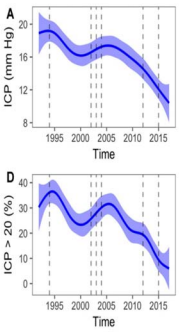
- INVASIVE
- INFECTION
- ZERO DRIFT
- SIDE (LOCATION)

RESEARCH—HUMAN—CLINICAL STUDIES

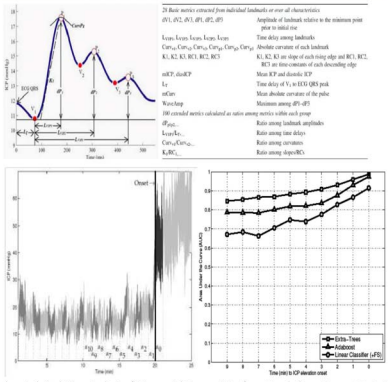
CNS Spotlight

Twenty-Five Years of Intracranial Pressure Monitoring After Severe Traumatic Brain Injury: A Retrospective, Single-Center Analysis





ICP WAVE MORPHOLOGIC ANALYSIS



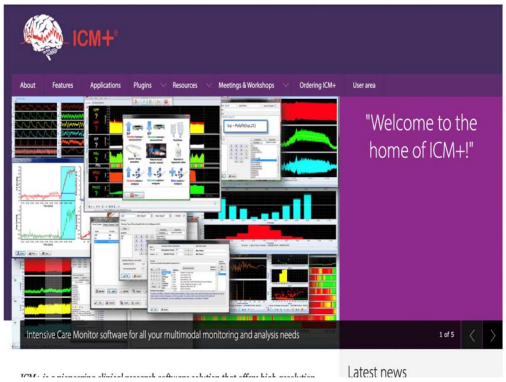
Scalzo et al. Real-Time Analysis of Intracranial PressureWaveform Morphology. Advanced Topics in Neurological Disorders 2012.

CEREBRAL PERFUSION PRESSURE

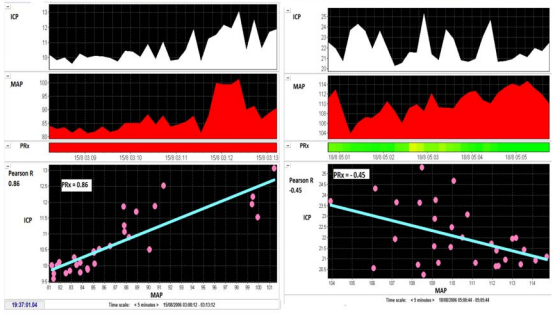
- CPP = MAP - ICP

- AUTOREGULATION
- CPP Targeted management
- Optimal CPP

CEREBRAL PERFUSION PRESSURE



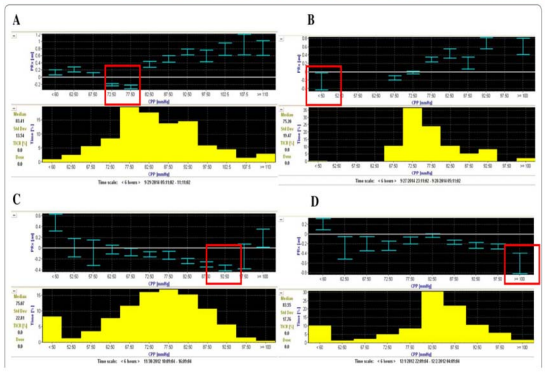
CEREBRAL PERFUSION PRESSURE - pressure reactivitiy (PRx)



Poor pressure reactivity index after traumatic brain injury

Good pressure reactivity after traumatic brain injury

CEREBRAL PERFUSION PRESSURE Optimal CPP



Kramer et al. Continuous Assessment of "Optimal" Cerebral Perfusion Pressure in Traumatic Brain Injury: A Cohort Study of Feasibility, Reliability, and Relation to Outcome. Neurocrit Care (2019) 30:51–61

NEAR INFRARED SPECTROSCOPY

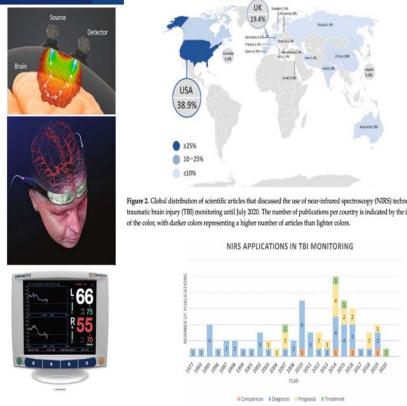


Figure 2. Global distribution of scientific articles that discussed the use of near-infrared spectroscopy (NIRS) technology in traumatic brain injury (TBI) monitoring until July 2020. The number of publications per country is indicated by the intensity of the color, with darker colors representing a higher number of articles than lighter colors.

Roldán et al. Near-Infrared Spectroscopy (NIRS) in Traumatic Brain Injury (TBI). Sensors2021, 21, 1586.

NEAR INFRARED SPECTROSCOPY

Mortality prediction	(Zweifel et al., 2010) [93]	40 (31:9)	NIRO 200, Hamamatsu Photonics U.K. Ltd., Hertfordshire, UK. (SRS; S-D NR)	THx	PRx	THx showed a significant correlation with the validated volume reactivity index PRx.
	(Shafer et al., 2010) [94]	22 (10:12)	INVOS 5100, Medtronic, MN, USA. (CW; S-D NR)	rSO_2	XeCT	The relationship between either the left or right NIRS values and Xe/CT scan was not significant.
	(Diedler et al., 2011) [95]	37 (NR)	NIRO 200, Hamamatsu Photonics U.K. Ltd., Hertfordshire, UK. (SRS; S-D NR)	THx	PRx	The agreement between PRx and THx is a function of the power of slow oscillations in the input signals.
	(Tausisky et al., 2012) [96]	8 (2:6)	Bifrontal NIRS optodes, Casmed, Branford, CT, USA. (CW; S-D 4.5 cm)	rSO_2	CBF	CT perfusion CBF has a significant linear correlation with NIRS derived rSO_2.
Correlation with Other monitoring	(Kim et al., 2014) [97]	10 (7:3)	Inhouse, DCS and NIRS-system, Noncommercial. (SRS; S-D 2.5 cm)	CBF, ΔHbO_2, ΔHb and ΔTHb in 10 TBI patients	CBF, ΔHbO_2, ΔHb and THb in 10 healthy controls	HbO2, Hb, and THb concentration increased significantly in the brain-injured cohort with head-of-bed lowering. Accordingly, DCS/NIRS hybrid device is well-suited to provide non- invasive, continuous hemodynamic monitoring.
	(Highton et al., 2015) [98]	27 (13:14)	NIRO 100, Hamamatsu Photonics U.K. Ltd., Hertfordshire, UK. (SRS; S-D 4 cm)	THx, TOx	PRx, Mx	Significant agreement among PRx and THx, and between Mx and TOx. However, the strength of the interrelationship between ICP or TCD and NIRS-signals, THI or rSo2, limits the degree of agreement between these reactivity indices.
	(Bindra et al., 2015) [99]	19 (12:7)	ForeSight, Casmed, Connecticut, USA. (CW; S-D NR)	nTOx	iTOx	nTOx from Finometer photoplethysmography and NIRS gives a similar measurement of cerebrovascular autoregulation to iTOx.

NEAR INFRARED SPECTROSCOPY

대뇌피질산소포화도감시용 Sensor 급여기준

1. 전신마취시 사용하는 대뇌피질 산소포화도 감시용 Sensor는 뇌 허혈 손상 가능성이 높은 다음의 수술에 요양급여를 인정함.

- 다 음 -

가. 심폐우회로를 이용한 심장수술
나. 심폐우회로를 이용한 대동맥수술
다. 복잡심기형수술 및 관상동맥우회수술
라. 경동맥수술(중재적 시술 포함)

2. 상기 1항의 급여 대상 이외 의학적 필요성이 인정되는 아래의 적응증에 한하여 사용한 치료재료비용은 「요양급여비용의 100분의 100미만의 범위에서 본인부담률을 달리 적용하는 항목 및 부담률의 결정 등에 관한 기준」에 따라 본인부담률을 80%로 적용함.

가. 상기 1에서 정하고 있는 급여범위 이외의 심장수술
나. 심수술 또는 뇌혈관의 중재적 시술
다. 간이식 수술
라. 만 70세 이상의 노인환자에서 3시간 이상의 개복술을 시행하는 경우

(고시 제2016-147호, '16.9.1. 시행)

- Non-invasive. Easy to apply
- Not represent whole brain oxygenation
- Cost, Continuous monitoring

BRAIN TISSUE OXYGENATION

- Measures the amount of Oxygen reaching the brain tissue
  - Partial pressure of brain Tissue Oxygenation($P_{bt}O_2$)
  - Normal $P_{bt}O_2$: 25~35mmHg
- Continuous, realtime measurement

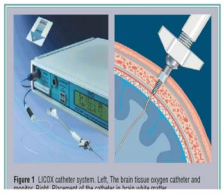
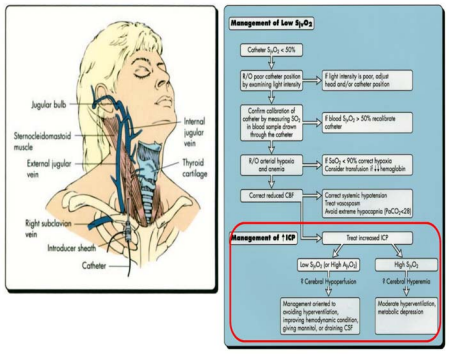
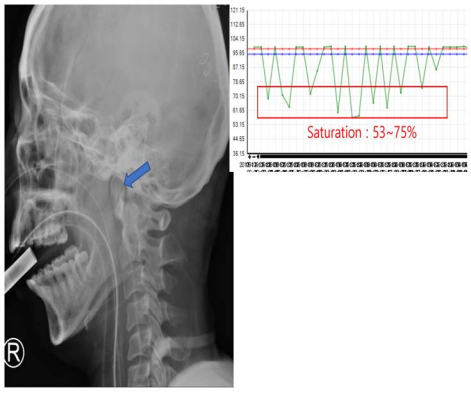


Figure 1 LiCOX catheter system. Left, The brain tissue oxygen catheter and monitor. Right, Placement of the catheter in brain white matter.

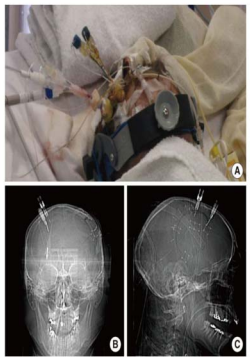
JUGULAR VENOUS OXYGENATION



JUGULAR VENOUS OXYGENATION



INVASIVE CATHETERS in MULTIMODAL MONITORING...



SMART CATHETER FOR MULTIPMODAL MONITORING

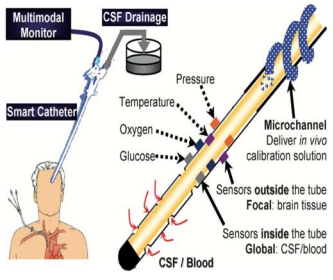
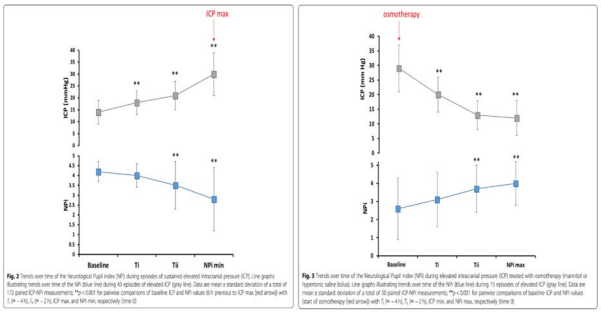


Fig. 1 Conceptual drawing of a novel 'lab-on-a-tube' for multimodal neuromonitoring of patients with traumatic brain injury. The lab-on-a-tube can measure pressure, oxygen, temperature and glucose information as well as drain CSF simultaneously.

PUPILLOMETRY

- Automated pupillometry
- Npi (Neurological Pupil index)

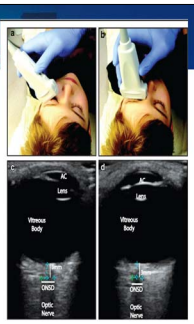
PUPILLOMETRY

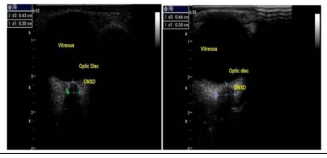


Jahns et al. Quantitative pupillometry for the monitoring of intracranial hypertension in patients with severe traumatic brain injury. Critical Care (2019) 23:155

ULTRASOUND – ONSD

- OPTIC NERVE SHEATH DIAMETER
- NON INVASIVE
- Correlation with ICP
- Emergency Department
- Orbital injury
- Reference value





ICP and $P_{bt}O_2$

	ICP < 22 mmHg	ICP > 22 mmHg
$P_{bt}O_2$ > 20 mmHg	Type A	Type B
$P_{bt}O_2$ < 20 mmHg	Type C	Type D

	Tier1	Tier2	Tier3
A	TIER zero management ICU, Head elevation, Prevent fever, Analgegia/Sedations(not ICP/$P_{bt}O_2$ directed), AED 1weeks, CPP >60mmHg, Hgb>7g/dL, avoid Hyponatremia, ABP monitoring, SpO_2>94%		
B	$PaCO_2$ 35~38mmHg CPP 60-70mmHg Mannitol / HTS intermittent CSF drainage(EVD) EEG monitoring	$PaCO_2$ 32~35mmHg Neuromuscular paralytics MAP challenge (access autoregulation) Raise CPP	$PaCO_2$ 30~32mmHg Pentobarbital/Thiopental coma Mild hypothermia (35~36°C)
C	$PaCO_2$ > 35mmHg CPP 60-70mmHg (max to 70) Increasing FiO_2 to 60% EEG monitoring	PaO_2 as high as 150 mmHg Decrease ICP < 22 mmHg Neuromuscular paralytics CSF drainage MAP challenge (access autoregulation) Increase CPP above 70mmHg	**$PaCO_2$ 45~50mmHg** PaO_2 > 150mmHg pRBC if Hgb<9g/dL
D	$PaCO_2$ > 35mmHg CPP 60-70mmHg (max to 70) Increasing FiO_2 to 60% EEG monitoring CSF drainage(EVD)	PaO_2 as high as 150 mmHg Neuromuscular paralytics MAP challenge (access autoregulation) Increase CPP above 70mmHg	PaO_2 > 150mmHg pRBC if Hgb<9g/dL Pentobarbital/Thiopental coma Secondary Decompressive craniectomy

Chestnut et al. A management algorithm for adult patients with both brain oxygen and intracranial pressure monitoring: the **Seattle International Severe Traumatic Brain Injury Consensus Conference (SIBICC)** Intensive Care Med (2020) 46:919–929

THRESHOLD

- Blood pressure
  - Maintaining **SBP at ≥100** mm Hg for patients 50 to 69 years old or at ≥110 mm Hg or above for patients 15 to 49 or over 70 years old may be considered to decrease mortality and improve outcomes. (Level III)
- ICP
  - Treating ICP above **22** mm Hg is recommended because values above this level are associated with increased mortality. (Level II B)
  - A combination of ICP values and clinical and brain CT findings may be used to make management decisions. (Level III)
- CPP
  - The recommended target cerebral perfusion pressure (CPP) value for survival and favorable outcomes is between **60 and 70 mm Hg**. Whether 60 or 70 mm Hg is the minimum optimal CPP threshold is unclear and may depend upon the patient's autoregulatory status. (Level II B)
  - Avoiding aggressive attempts to maintain CPP above 70 mm Hg with fluids and pressors may be considered because of the risk of adult respiratory failure. (Level III)

TREATMENT

- DECOMPRESSIVE CRANIECTOMY (update 2020)
- Prophylactic Hypothermia
  - Early (within 2.5 hours), short-term (48 hours post-injury) prophylactic hypothermia is not recommended to improve outcomes in patients with diffuse injury (Level II B)
- Hyperosmolar therapy
  - Although hyperosmolar therapy **may lower intracranial pressure**, there was insufficient evidence about effects on clinical outcomes to support a specific recommendation, or to support use of any specific hyperosmolar agent, for patients with severe traumatic brain injury (Level I, II, and III)

TREATMENT

- CSF drainage (Level III)
  - An EVD system zeroed at the midbrain with continuous drainage of CSF may be considered to lower ICP burden more effectively than intermittent use.
  - Use of CSF drainage to lower ICP in patients with an initial Glasgow Coma Scale (GCS) <6 during the first 12 hours after injury may be considered.
- Ventilation therapy
  - Prolonged prophylactic hyperventilation with partial pressure of carbon dioxide in arterial blood (PaCO2) **of 25 mm Hg or less** is not recommended (Level II B)

TREATMENT

- Anesthetics, Analgesics, and Sedatives (Level II B)
  - Administration of barbiturates to induce burst suppression measured by EEG as prophylaxis against the development of intracranial hypertension is not recommended.
  - High-dose barbiturate administration is recommended to control elevated ICP **refractory to maximum standard medical and surgical treatment**. **Hemodynamic stability** is essential before and during barbiturate therapy.
  - Although **propofol** is recommended for the control of ICP, it is not recommended for improvement in mortality or 6-month outcomes. Caution is required as high-dose propofol can produce significant morbidity.
- **Steroids** (Level I)
- Early tracheostomy is recommended to reduce mechanical ventilation days when the overall benefit is felt to outweigh the complications associated with such a procedure. However, there is no evidence that early tracheostomy reduces mortality or the rate of nosocomial pneumonia. (Level II A)

HYPEROSMOLAR THERAPY

- HYPERTONIC SALINE vs MANNITOL

Table 1
Comparison of mannitol and sodium chloride

Mannitol	Sodium Chloride
Molecular weight: 182.17 g/mol	Molecular weight: 58.45 g/mol
Reflection coefficient: 0.9	Reflection coefficient: 1.0
Sodium content: none	Sodium content
Osmolarity:	• 0.9%: 154 mEq/L
• 20%: 1100 mOsm/L	• 3%: 513 mEq/L
• 25%: 1375 mOsm/L	• 7.5%: 1283 mEq/L
	• 23.4%: 4004 mEq/L
	Osmolarity
	• 0.9%: 308 mOsm/L
	• 3%: 1026 mOsm/L
	• 7.5%: 2565 mOsm/L
	• 23.4%: 8008 mOsm/L

HYPERTONIC SALINE

- 3~23.4% infusion via central line, within 15~30min
- Regular infusion < **intermittent infusion**
- Limit : serum Na <155~160 mMol/L or Serum Osmol < 320 mOsm/L

HTS is superior to mannitol in the treatment of intracranial hypertension after severe TBI

TABLE 3. ICP and CPP Burden Comparisons Between HTS and Mannitol Groups in 1:2 Matched Group

	HTS (n = 24)		Mannitol (n = 48)		
	Mean ± SD	Med (IQR)	Mean ± SD	Med (IQR)	*P*-value
ICP monitoring duration (days)	6.6 ± 2.6	5.5 (4.5-9.5)	7.1 ± 2.70	8 (5-10)	.46
No. of days with $ICP_{high} + CPP_{low}$	0.7 ± 0.8	0 (0-1)	2.2 ± 2.1	1.5 (0.5-4)	<.01*
% days with $ICP_{high} + CPP_{low}$	9.2 ± 10.7	0 (0-20)	30.2 ± 26.7	23.6 (5-50)	<.01*
Total hours with $ICP_{high} + CPP_{low}$	11.54 ± 14.26	7 (1-18)	32.98 ± 35.56	17 (8.5-49)	<.01*
No. of days with CPP_{low}	2.0 ± 1.8	1 (1-3)	3.6 ± 2.6	3 (2-5)	.01*
% of days with CPP_{low}	32.1 ± 24.1	27.5 (20-41.4)	57.1 ± 52.6	50 (21.1-80)	.01*
Total hours with CPP_{low}	9.21 ± 12.03	6 (1-15)	18.85 ± 19.19	12 (4-28.5)	.01*
Averaged daily duration of CPP_{low} (hours)	1.5 ± 2.2	0.7 (0.3-1.9)	3.4 ± 5.1	1.9 (0.6-4)	.01*

HTS, hypertonic saline; SD, standard deviation; IQR, interquartile range; ICP, intracranial pressure; CPP, cerebral perfusion pressure. *$p < .05$.

Mangat et al. Hypertonic Saline is Superior to Mannitol for the Combined Effect on Intracranial Pressure and Cerebral Perfusion Pressure Burdens in Patients With Severe Traumatic Brain Injury. Neurosurgery 86:221–230, 2020

CURRICURUM VITAE

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Anesthetic Considerations for Traumatic Brain Injury

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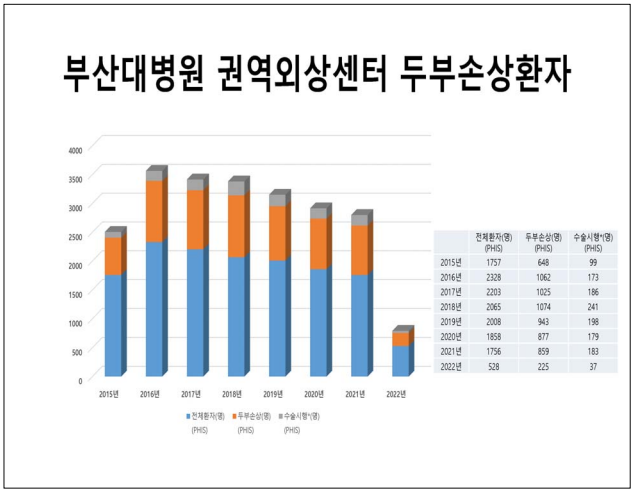

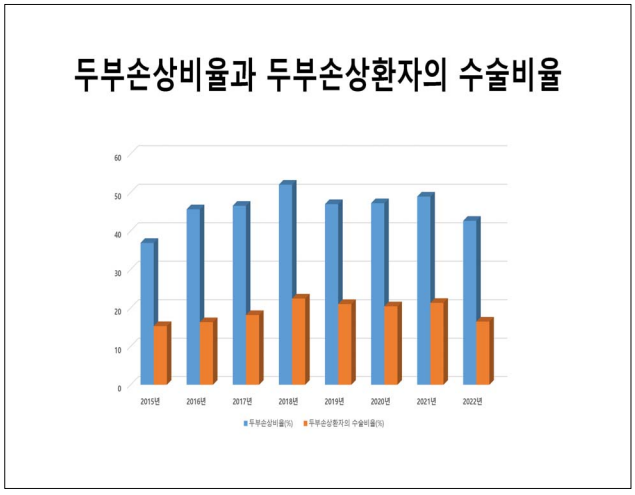

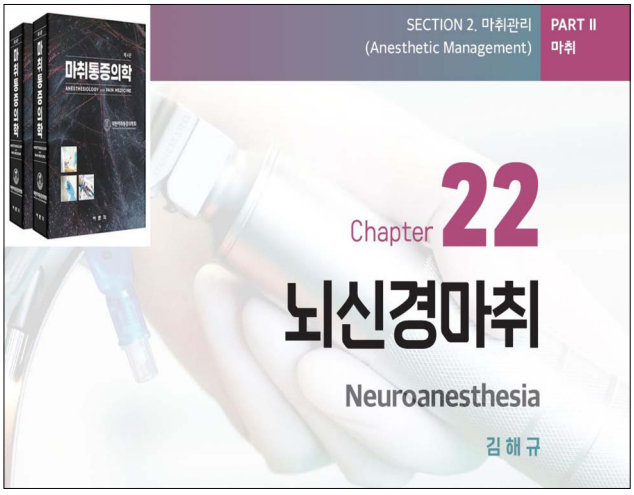

KJA
Korean Journal of Anesthesiology

Review Article
pISSN 2005-6419 • eISSN 2005-7563

Management of traumatic brain injury patients

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Brain Trauma FOUNDATION

Qureshi et al. Clin Med Rev Case Rep 2017, 4:159
DOI: 10.23937/2378-3656/1410159
Volume 4 | Issue 3
Open Access

Clinical Medical Reviews and Case Reports

ORIGINAL REVIEW

Anesthetic Management of Traumatic Brain Injury

*Hashim Qureshi[1], Hussain Mithaiwala[1], Jacob Ezell[1] and Marco Maurtua[2]**

Pathophysiology of TBI

- Primary injury
  - The initial injury due to physical or mechanical forces on the brain parenchyma and skull
  - Leads to an inflammatory cascade cerebral edema, axonal injury, decreased cerebral perfusion pressure
- Secondary injury
  - Electrolyte abnormalities, hypoxemia, glycemic imbalance, hypotension, increased intracranial pressure, hyper or hypocarbia

Preoperative management

- Should avoid hypercarbia related to the administration of hypnotic agents or sedatives such as benzodiazepines, narcotics, etc., prior to induction of anesthesia.

Evaluation of TBI patients

- Careful airway assessments
- Thorough neurological examination to determine baseline sensation, motor function, and the presence of new focal neurological deficits to establish degree of TBI or cervical spine injury severity.
- Other traumatic related injuries such as bleeding, pneumothorax, cardiac tamponade, etc.

CSI after TBI

- Early assessment of cervical spine integrity is essential to rule out a hidden cervical spine fracture, especially in the TBI patient.

TABLE 4. Association between GCS and C-spine injury

Injury Severity (GCS score)	Total Number of Trauma Admission	Number of Pts[a] with C-Spine Injury (%)
13–15	14,088	198 (1.4)
9–12	383	26 (6.8)
≤8	667	68 (10.2)

[a] Pts, patients.

Demetriades, et al. J Trauma Inj Infect Crit Care 48: 724-727, 2000.

Initial management of a TBI patient with possible CSI

- Prevention of further neurological injury: Critical
- Stabilizing the cervical spine
  - Use of cervical collar
    - Interfere with direct laryngoscope during intubation
    - Removal of only the anterior portion of cervical collar prior to intubation
- Maintaining spinal alignment
  - Manual In-Line Immobilization (MILI)
    - Application of cricoid pressure
    - Removal of anterior half of the cervical collar
    - Manual posterior cervical spine support

- **Manual In Line Immobilization (MILI)** of the cervical spine Approach from the head of the bed.
- MILI of the cervical spine. Approach from the lateral side of the patient to facilitate airway management from the head of the bed.
- In addition to MILI, if the clinician is going to apply cricoid pressure, manual posterior cervical spine support is recommended to decrease cervical spine movement.

Keep airway

- **Orotracheal intubation** after rapid sequence induction and direct laryngoscopy, video laryngoscopes, or fiberoptic bronchoscopes with MILI
- **Nasotracheal intubation** with flexible bronchoscopy
  - Contraindication in suspected basal skull fracture
  - Trauma to the nares and epistaxis
- Awake fiberoptic approach
  - Experienced practitioner
  - Maintains cervical spine in a neutral position, preserves airway reflexes, allows simultaneous neurological assessments.
- LMA
  - Downward pressure produce a potential displacement of the upper cervical spine.
- Surgical airway, cricothyroidotomy

Muscle relaxants

- **Succinylcholine** is choice for rapid sequence induction
  - Negative effect: a transient increase in ICP
  - Positive effect: rapid onset and short duration of action, prevention of coughing during direct laryngoscopy
  - Prevent its side effect by a defasciculating dose of a non-depolarizing muscle relaxant.
- **Rocuronium** 0.9-1.2 mg/kg
  - Intubation conditions at 60-90 seconds
  - No transient increase in ICP
  - Muscle paralysis last for 30-40 minutes.

Ventilation in TBI

- **Goals of Intubation**
  - Prevention of aspiration of gastric contents
  - Prevention of hypoxia and hypercarbia
    - Tissue hypoxia leads to release of catecholamines which further dilate cerebral veins and increase ICP
    - Hypercarbia: cerebral veins dilate, causing an increase in ICP
- Avoid a PaO_2 less than 60 mmHg
- Maintain an oxygen saturation greater than 90%
- Excessive hyperventilation can lead to cerebral vasoconstriction and oxygen deprivation.

Induction agents

- **Ketamine**
  - Positive effects : the blockade of reuptake of catecholamines, which can prevent hypotensive episodes by maintaining MAP and CPP within normal range.
  - Logically ketamine should be avoided in hypertensive TBI patients due to the risk of further elevating BP and consequently increasing ICP.
  - In TBI patients with suspected elevated ICP and low-to-normal blood pressure, ketamine use might be indicated to preserve normotension during induction of anesthesia.
- **Etomidate**
  - another appropriate induction agent choice in hemodynamically unstable patients.
  - Negative effects: a dose dependent inhibition of 11-beta-hydroxylase and 17-alpha-hydroxylase leading to adrenal suppression.
    - This complication can occur after a single dose and may cause maximal adrenal suppression 4 to 6 hours after its administration.

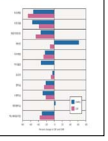
- **Propofol**
  - Positive effects
    - Quick onset and offset of action
    - Decrease neuronal oxidative stress.
  - Negative effects
    - Sympathetic blockade resulting in hypotension.
    - Propofol infusion syndrome. This condition occurs generally if propofol is delivered for more than 48 hours, at doses above 4 mg/kg/hr.
    - Although propofol is recommended for the control of ICP, it is not recommended for improvement in mortality or 6-month outcomes. High dose propofol can produce significant morbidity (Level IIB)
  - Indicated in the treatment of refractory status epilepticus with a recommended starting loading dose of 1 mg/kg.

- **Dexmedetomidine**
  - Alpha-2 receptor agonist, it exerts its effects in the locus coeruleus.
  - Despite its sedative and anxiolytic action it preserves adequate respiratory function when compared with benzodiazepines or narcotics. This property makes it an ideal agent in the non intubated TBI patient.
  - In the Intensive Care Unit (ICU) setting dexemedetomidine has proved to decrease the incidence of delirium. Further research is needed to determine the impact of dexemedetomidine in the outcomes of TBI patients, however the data presented makes it suitable alternative to propofol for sedation purposes.

- **Opioids**
  - Positive effect
    - Suppress airway reflexes, decrease required dose of induction agents and inhalation anesthetic maintenance as well as to blunt the sympathetic response to direct laryngoscopy.
  - Negative effect
    - hypotension secondary to a reduction in sympathetic tone and potential histamine release
  - Fentanyl, sufentanil, and remifentanil are commonly used in TBI patients.
  - Careful opioid titration should be observed to avoid hypotension.

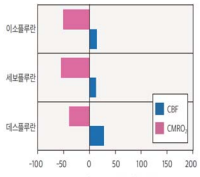
Maintenance of anesthesia

- Intravenous anesthetics (**sodium thiopental**, etomidate, midazolam and propofol)
  - decrease CBF, CBV, $CMRO_2$ and ICP under controlled ventilation conditions.
  - They achieve these effects by producing cerebral vasoconstriction and acting at the neurons' GABA receptors to open chloride channels.
  - Do not use barbiturates to induce burse suppression measured by EEG as prophylaxis against the development of intracranial hypertension (Level IIB)
  - Use high-dose barbiturates to control elevated ICP refractory to maximum standard medical and surgical treatment (Level IIB)



Intraoperative management

- Choice of anesthetic drugs: no ideal anesthetics
- The BTF clinical guidelines (should avoid)
  - Hypoxemia
    - PaO_2 below 60 mmHg,
    - Oxygen saturation below 90%,
  - Hypercarbia
  - Hypotension (systolic blood pressure below 90 mmHg)



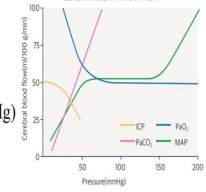
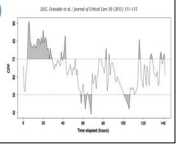


그림 22-2. 두개내압(ICP), 동맥혈산소분압(PaO_2), 동맥혈이산화탄소분압($PaCO_2$), 평균동맥압(MAP)의 변화에 따른 뇌혈류의 변화

Blood pressure

- The current recommendations are to keep the systolic blood pressure above 90 mmHg and the CPP between 50 and 70 mm Hg to avoid further brain ischemia.
  - Maintaining SBP at ≥100mmHg for patients 50-69 or at ≥110mmHg for patients 15-49 or over 70 years old may be considered to decrease mortality and improve outcomes (Level III).
  - The recommended target CPP value for survival and favorable outcomes is between 60 and 70mmHg; however, the optimal threshold is unclear and may depend upon the patient's autoregulatory status (Level IIB)



Management of hypotension

- Incidence of hypotension in TBI patients of around 34.6%, but what was of great concern is that in this subset of patients there was a 150% mortality increased.
- Sookplung, et al. examined patients with severe TBI who received phenylephrine, norepinephrine, or dopamine.
  - Based on this study, phenylephrine had the greatest increase in MAP and CPP.
  - It was unclear whether the improved MAP and CPP improved CBF and oxygenation.
  - In conclusion, the best choice of vasopressor for patients with TBI remains unclear.

Neurocrit Care. 2011 August ; 15(1): 46–54.

Management of hypertension

- The ideal medication for treatment of hypertension should be one that is easily titratable and should not cause cerebral vasodilatation such as nitroglycerine, nitroprusside, and hydralazine to avoid further increase in ICP.
- Therefore the antihypertensive drugs recommended include propranolol, esmolol, labetalol, and nicardipine.

Robertson CS, et al. J Neurosurgery 59: 455-460, 1983.

Management of ICP

- The Brain Trauma Foundation states that ICP > 20 mmHg is associated with increased mortality and worse outcomes.
- **The fastest way** to decrease ICP > 20 mmHg is to allow Cerebrospinal Fluid (CSF) drainage from a CSF drain if present.
- **Another relatively quick and effective alternative** is to elevate the patient's head and maintain the neck in a neutral position, to improve venous blood return.
- **Less rapid methods** include slow administration of 0.25-1 gm/kg of mannitol in stable patients over 15 minutes. (Level II in 3rd Edition)
  - This can result in an ICP reduction, a transient increase in oxygen transport, and an increase in cerebral blood flow.
  - Additional dosing at a rate of 0.25-0.5 gm/kg can be repeated every six to eight hours.
  - Importantly, when using mannitol, it is important to monitor and replace urinary loses to prevent intravascular volume depletion and hypotension.
- **Hypertonic saline**: an average reduction in ICP ranging from 20-60% with time to peak effect range between 10 minutes and 5 hours post infusion.
- **Hyperventilation** can temporarily treat intracranial hypertension.
  - Maintaining a normal $PaCO_2$ of 35-40 mmHg is recommended in TBI patients to improve cerebral perfusion unless signs and symptoms of increased ICP are present

Fluid resuscitation for TBI

- Hypotonic solutions are contraindicated because they add free water that might lead to cerebral edema and worsened ICP in a TBI patient.
- 0.9% normal saline solutions are indicated because they are more isotonic than Ringer's lactate.
- Glucose containing solutions should be avoided, unless hypoglycemia is present.
- Fluid resuscitation with albumin was associated with a higher mortality as compared with patients receiving normal saline (33% vs. 20%). This risk was even more pronounced in those with severe TBI (42% vs. 22%).

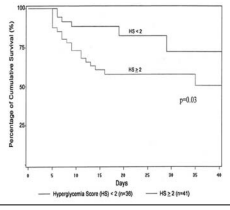
J Neurotrauma 2013; 30(7): 512–518.

Coagulopathy and hemoglobin level

- INR in TBI patients should be maintained less than or equal to 1.4 and the platelet count maintained above 75 k/uL.
- Hemoglobin levels should be maintained at or above 7 g/dl to avoid a decrease in brain oxygen delivery.

Glycemic control

- The presence of hyperglycemia might produce an increase in neuronal metabolism and increase neuronal death after TBI. These events occur due to increased tissue acidosis through anaerobic metabolism, the creation of free radicals, and increased blood brain barrier permeability. Therefore the ideal blood glucose level should range from 80-180 mg/dl.



J Trauma 2005; 58: 47-50.

Thermoregulation

- No benefit of induced hypothermia on mortality or neurological outcomes after TBI. (Clifton, et al. Lancet Neurol 2011; 10: 131-139.)
  - it is important to remember that fever worsens the severity of brain injury by increasing cerebral metabolic rate.
  - In addition, early hyperthermia after TBI has been found to be a possible predictor of paroxysmal sympathetic hyperactivity (Hinson HE, et al. J Head Trauma Rehabil. 2017 Sep-Oct; 32(5): E50–E54)
- The final BTF recommendation : to avoid hyperthermia and to maintain normothermia with antipyretics and surface cooling devices.
  - Early (within 2.5 hours), short-term (48 hours post-injury) prophylactic hypothermia is not recommended (Level IIB)

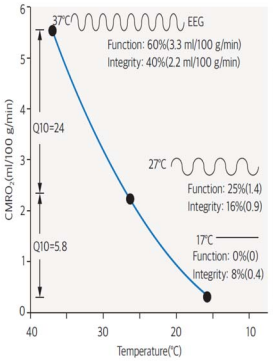


그림 22-1. 체온과 뇌대사율($CMRO_2$)의 관계

Outcome and mortality rates

	Poor outcome			Died		
	n (%)	RR (95% CI)	p value	n (%)	RR (95% CI)	p value
Primary analysis						
All patients (n=97)	56 (58%)	–	–	20 (21%)	–	–
Hypothermia (n=52)	31 (60%)	1·08 (0·76–1·53)	0·67	12 (23%)	1·30 (0·58–2·89)	0·52
Normothermia (n=45)	25 (56%)	–	–	8 (18%)	–	–
Subgroup analysis						
Diffuse brain injury (n=69)	42 (61%)	–	–	13 (19%)	–	–
Hypothermia (n=37)	26 (70%)	1·44 (0·95–2·17)	0·09	10 (27%)	2·88 (0·87–9·57)	0·08
Normothermia (n=32)	16 (50%)	–	–	3 (9%)	–	–
Surgically removed haematomas (n=28)	14 (50%)	–	–	7 (25%)	–	–
Hypothermia (n=15)	5 (33%)	0·44 (0·22–0·88)	0·02	2 (13%)	0·35 (0·08–1·50)	0·16
Normothermia (n=13)	9 (69%)	–	–	5 (39%)	–	–

Data are number (%). RR=relative risk.

Clifton, et al. Lancet Neurol 2011; 10: 131-139.

Maintenance of parameters in general

- MAP > 80 mmHg or SBP > 100 mmHg
- Hb > 7 g/dl
- PaO_2 60-100 mmHg
- $PaCO_2$ 35-40 mmHg
- PLT > 50,000/mm^3 , A greater PLT count would be advisable in emergency neurosurgery
- PT/aPTT < 1.5 normal control
- If massive transfusion, start with 1 RBCs/1 Plasma/1 PLTs
- TEG/ROTEM, if available
- Osmotherapy in case of impending cerebral herniation or cerebral edema
- CPP ≥ 60 mmHg

Picetti et al. World Journal of Emergency Surgery (2019) 14:53

Take Home Message

- Recognizing CSI
- Control
  - Hypoxia
  - Hypocarbia
  - Hypotension
  - ICP

2부
Abdominal Trauma

좌장: 문봉기 (아주의대)

Abdominal Trauma — 강병희 (아주의대 외상외과)

Anesthetic Considerations for Abdominal Trauma
안효은 (아주의대 마취통증의학과)

The Role of Interventional Radiology in Traumatic Patients
원제환 (아주의대 영상의학과)

Bleeding and Coagulation Management — 김태엽 (건국의대 마취통증의학과)

CURRICURUM VITAE

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2016년~2017년	아주대학교병원 전임의
2017년~2018년	아주대학교병원 진료조교수
2018년~현재	아주대학교병원 조교수

Abdominal Trauma

강 병 희

아주대학교병원 경기남부 권역 외상센터 외상외과

AJOU TRAUMA CENTER 경기남부 권역외상센터

- 의사는 질병이 아닌 환자를 치료해야 합니다.
- **외상외과 의사는 질병이 아닌 바이탈을 치료해야 합니다.**

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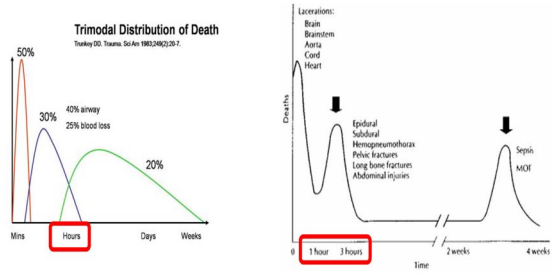

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Source of Bleeding (Hemorrhagic Shock)

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- Chest / **Abdomen/Pelvic** / Extremity / External

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Abdominal Trauma

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- Internal Organ
  - Solid Organ
  - Hollow Viscus
- Major Vessel
- Muscle / Soft tissue
- Bone (Spine/Pelvic)

Life-Threatening Injury

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Abdominal Trauma

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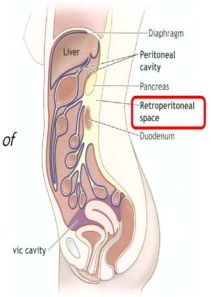
Injuries to
the retroperitoneal visceral structures
are difficult to recognize
because the area is remote from physical examination,
and injuries do not initially present with signs or symptoms of peritonitis.



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TREATMENT

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Definite diagnosis ?

↓

Proper Treatment

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Planned Operation

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- CT
- Enteroscopy / Biopsy
- PET-CT / MRI

절제 범위
재건 범위
해부학적 변이
타과적 진료

- Pre-operative evaluation for G/A

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Hemorrhagic Shock

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- Airway
- Breath
- Circulation
  - IV line / Fluid / Transfusion (MTP?)
- Disability
- Exposure
  - Temperature control

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Hemorrhagic Shock

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No **time** for evaluation

Source of bleeding

어느 장기가 문제인데? (간? 비장? 장간막?)

어느 체계가 문제인데? (간쪽? 좌하복부?)

어느 부분이 문제인데? (가슴? 배? 골반?)

피가 나는 것은 맞아? (신경학적 쇼크?)

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Injury Mechanism

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- Why is the mechanism of injury important?

TABLE 5-1 ■ Truncal and Cervical Injuries from Restraint Devices

RESTRAINT DEVICE	INJURY
Lap Seat Belt • Compression • Hyperflexion	• Tear or avulsion of mesentery • Rupture of small bowel or colon • Thrombosis of iliac artery or abdominal aorta • Chance fracture of lumbar vertebrae • Pancreatic or duodenal injury
Shoulder Harness • Sliding under the seat belt ("submarining") • Compression	• Intimal tear or thrombosis in innominate, carotid, subclavian, or vertebral arteries • Fracture or dislocation of cervical spine • Intimal tear or thrombosis in subclavian artery • Rib fractures • Pulmonary contusion • Rupture of upper abdominal viscera
Air Bag • Contact • Contact/deceleration • Flexion (unrestrained) • Hyperextension (unrestrained)	• Corneal abrasions • Abrasions of face, neck, and chest • Cardiac rupture • Cervical or thoracic spine fracture • Cervical spine fracture



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Diagnostic Methods

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- Physical Examination
- X-ray
- Ultrasonography
- Diagnostic peritoneal lavage
- **Computed tomography**

Diagnostic Methods (CT)

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- Computed Tomography (**BEST** if possible)

Diagnostic methods (CT)

AJOU TRAUMA CENTER 경기남부 권역외상센터

- 화물차 운전자로 교통사고 이후 핸들에 끼인 채 발견
- 구급대 접촉 시 혈압 130mmHg 이었으나 곧 60mmHg로 감소, 산소포화도 측정되지 않음
- 사고 기준 1시간 이후 병원 도착, 의식은 alert, 복통 호소 BP86/58 - HR 114
- 내원 14분 후 두부, 흉부, 복부 CT 시행 위하여 CT실 이동하였으며 촬영 중 지속적으로 불안정한 모습 보여 Ativan 및 etomidate 투여
- 내원 45분 이후 혼수 상태로 빠져 기관 내 삽관 시행하였으며 내원 55분 후 C-line insertion, pRBC 2pint 수혈 시작함.
- 지혈압 지속되었으며 내원 1시간 25분 후 수술실 이동하여 소장 절제 및 혈관 결찰술 시행함. 수술은 4시간 정도 걸렸으며 이후 DIC, shock 등으로 승압제, 수혈 등에도 반응 없어 사망함

2018 경기도 예방가능사망률 조사

Diagnostic methods

AJOU TRAUMA CENTER 경기남부 권역외상센터

- Physical Examination
- X-ray
- Ultrasonography
- Diagnostic peritoneal lavage
- Computed tomography

FAST

AJOU TRAUMA CENTER 경기남부 권역외상센터

- Advantage
  - FAST
  - Non-invasive
- Disadvantage
  - Operator-dependent
  - Bowel gas / emphysema
  - Missed bowel/pancreas/solid organ injury

Diagnostic Peritoneal Lavage

AJOU TRAUMA CENTER 경기남부 권역외상센터

- Advantage
  - FAST
  - Detect Bowel injury
- Disadvantage
  - Invasive
  - Low specificity
  - Missed retroperitonealinjury

Hemorrhagic Shock

AJOU TRAUMA CENTER 경기남부 권역외상센터

No **time** for evaluation

Source of bleeding

어느 장기가 문제인데? (간? 비장? 장간막?)

어느 체계가 문제인데? (간쪽? 좌하복부?)

어느 부분이 문제이다 (배)

피가 나는 것은 맞는 것 같다

Bleeding 만 확인
손상 부위/정도는 알 수 없음

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Indication of Laparotomy

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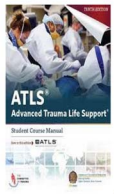
- Hypotension + FAST/DPL (+)
- **Hypotension without another source of bleeding**
- Hypotension + penetrating injury
- Evisceration
- GI bleeding + penetrating injury
- Peritonitis
- Free air or rupture of hemidiaphragm
- CT → indication of laparotomy
- DPL → GI content or vegetable fiber



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Laparotomy

AJOU TRAUMA CENTER 경기남부 권역외상센터

- Bleeding control
- Contamination control
- Definite surgery if possible
- **DAMAGE CONTROL SURGERY**

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Explo-laparotomy Is it accurate?

AJOU TRAUMA CENTER 경기남부 권역외상센터

- Intra-peritoneum
  - Blood stained
- Retroperitoneum
  - Duodenum / pancreas
  - Major vessel
- Solid organ
  - Intra-organ damage

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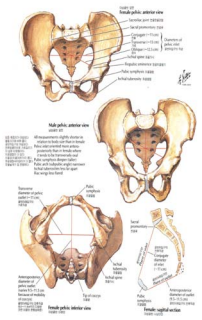
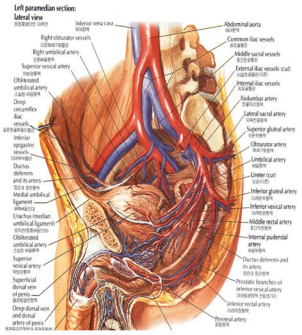
Pelvic Trauma

AJOU TRAUMA CENTER 경기남부 권역외상센터





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Pelvic trauma

AJOU TRAUMA CENTER 경기남부 권역외상센터

High mortality

Multi-disciplinary approach

Rapid response

High Resources

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Diagnosis

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- X-ray
- Computed tomography

Pelvic fracture and injuries

AJOU TRAUMA CENTER 경기남부 권역외상센터

- Blood loss
  - Fractured bone surfaces
  - Pelvic venous plexus
  - Pelvic arterial injury
  - Extrapelvic sources

X-ray로 출혈의 원인까지는 확인 불가능

Preperitoneal packing (PPP)

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Mechanical stabilization

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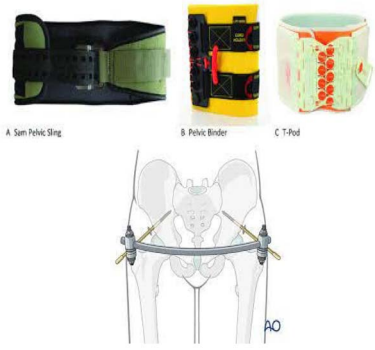

Angiography

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Resuscitative Endovascular Balloon Occlusion of Aorta (REBOA)

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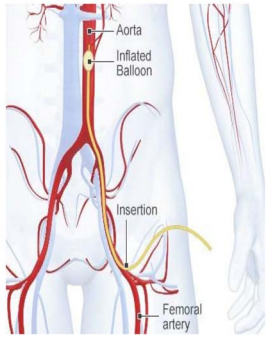
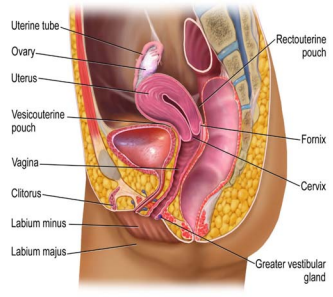


Pelvic fracture associated Injury

AJOU TRAUMA CENTER 경기남부 권역외상센터



The Female Reproductive System

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Conclusion

AJOU TRAUMA CENTER 경기남부 권역외상센터

- Early Resuscitation
- Early Treatment
  - Great Threat First
  - Definite Diagnosis Later

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CURRICURUM VITAE

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2015년-2019년	아주대학교병원 전공의
2019년-2020년	아주대학교병원 전임의
2020년-2022년	아주대학교병원 진료조교수

Anesthetic Considerations for Abdominal Trauma

Hyo Eun Ahn

Department of Anesthesia and Pain Medicine, Ajou University Hospital, Ajou University School of Medicine

Anesthetic management of abdominal trauma

✓ Classification of abdominal injuries

✓ Hospital resuscitation

✓ Diagnostic studies

✓ Preoperative preparation

✓ Intraoperative anesthetic management

✓ Acute postoperative considerations

Classification of abdominal injuries

▪ Knowledge of the trauma mechanism

➔ Prediction of the pattern and the severity of injury to abdominal organs and vascular structures

➢ Blunt trauma

➢ Penetrating trauma

1) Blunt abdominal trauma

▪ Mechanism of injury
- Compression by fixed object (ex. safety belt, steering wheel)
  → bowel rupture and tears or hematomas of solid organs
- Deceleration result in injury to mesentery, large vessels, and solid organ capsule

▪ Diaphragm rupture and major pelvic fractures are associated with increased risk of intraabdominal organ injury

▪ Incidence of organ injury : spleen > liver

2) Penetrating abdominal trauma

▪ Magnitude of injury related to its kinetic energy
- Step wounds, low velocity
- Gunshot wounds, high velocity

▪ Incidence of organ injury
- Liver is the most commonly injured solid organ
- Related to the volume occupied by the organ

Anatomic compartments of abdomen

- Intrathoracic abdomen
  - Diaphragmatic rupture ; accompany major abdominal injuries in 90%
  - Right lower rib fractures ; suspected liver injury
  - Left lower rib fractures ; suspected spleen injury
- Hallow viscus
- Pelvic abdomen
  - Posterior element fractures ; associated with retroperitoneal hemorrhage
  - Anterior element fractures ; associated with genitourinary injuries
  - Hypotension in the patient with pelvic fractures
  → Need for pelvic stabilization or angiographic evaluation and treatment
- Retroperitoneal abdomen

Hospital resuscitation

- Prehospital personnel reports are helpful including mechanism of injury, vital signs, Glasgow Coma Scale (GCS) score.
- Once the patient arrives at the hospital, the "primary survey" is initiated to identify and treat life-threatening injuries.

Diagnostic studies

- Focused assessment with sonography for trauma (FAST)
  - Rapid, noninvasive, and sensitive for visualizing free intraperitoneal fluid and pericardial fluid
  - Initial imaging modality of choice for pregnant trauma patients
  - Detect solid organ injuries
  - Poor visualization of hallow structures such as bowel and retroperitoneal bleeding
- Computed tomography (CT)
  - Most common objective techniques for evaluating abdomen
  - Identification of hemoperitoneum, solid organ, and retroperitoneal injury
  - In hemodynamically *stable* patients

Preoperative preparation

✓ Establishing or confirming a definitive airway

✓ Intravenous access

✓ Review of preoperative diagnostic evaluations

✓ Operating room setup

1) Securing airway

- Establishing a definitive airway is the first priority
- Rapid sequence induction (RSI) and intubation
  - Generally indicated due to the high risk of aspiration
- If predictably difficult, consider awake intubation
  - Preferably utilizing a fiberoptic bronchoscope

2) Intravenous access

- Significant bleeding requiring large-volume resuscitation is common in abdominal trauma
- Placement of two large-bore *upper-extremity* intravenous (IV) catheters
  → Located in venous systems drain into the superior vena cava (SVC)
  - Utilization of high-capacity fluid warming devices for the rapid administration of blood products into tributaries of the SVC can be life-saving
- Administration of IV fluid to maintain a systolic blood pressure of 90-100mmHg, which ensures adequate perfusion of the major organs
  - Mean arterial pressure (MAP) 80mmHg in patients with known or suspected traumatic brain injury (TBI) or spinal cord injury

2) Intravenous access – Central line

- Subclavian vein
  - Remains patent in shock
  - Can be cannulated in patients wearing a cervical collar
  - Lowest infection rate
- Internal jugular vein
  - Helpful for both volume administration and central venous pressure monitoring
  - Cannot be accessible in a patient with a cervical collar
- Femoral vein
  - Avoids the potential for pneumothorax, hemothorax, or arrhythmias
  - Can be accessed during cardiopulmonary resuscitation
  - Unsuitable if there are extensive abdominal or lower extremity injuries

3) Review of preoperative diagnostic evaluations

- Hematocrit, serum chemistry, coagulation studies
- Electrolyte imbalance must be corrected
- Chest and cervical spine radiographs should be reviewed prior to induction
- Evaluation of preoperative volume status by measuring blood pressure, heat rate, and systolic pressure variability (SPV)

➔ Determination of anesthetic technique, monitoring, and postoperative plans for the traumatized patient

4) Operating room setup

- Properly functioning anesthesia machine, oxygen supply source, and suction with Yankauer tip
- Various types of prepared airway
- Pressure bags for rapid volume expansion and nasogastric/orogastric tubes for stomach decompression should be available
- Preassembled kits for intravenous catheters, arterial lines, and central venous lines
- Equipment for blood transfusion, including a fluid warmer and blood filter with blood tubing attached to a pump
- Rapid transfusion device with fluid warming should be ready and primed
- Convective forced air warming blankets and warming pads

4) Operating room setup - Monitoring

- Patient's oxygenation, ventilation, circulation, and temperature should be continually evaluated.
  - Pulse oximetry, non-invasive blood pressure monitoring, capnography, electrocardiography, core temperature monitoring
- Arterial and central venous access
- Dynamic monitors of fluid bolus responsiveness
  - Systolic pressure variation (SPV), pulse pressure variation (PPV), stroke volume variation (SVV)

4) Operating room setup - Monitoring

- Exhaled gas CO_2 and nitrogen concentration for screening of air emboli
- Awareness monitoring – bispectral index (BIS)
- Transesophageal echocardiography (TEE)
  - Hemodynamic monitor and a diagnostic device (e.g., to detect pericardial tamponade)

Anesthetic considerations

- Anesthetic plan ; based on knowledge of the patient's injuries, age, known preexisting conditions, response to initial resuscitation, and surgical interventions.
- Communication with the surgeon is key with regard to how the surgery is progressing.
- Anesthesiologist should expect and be prepared for damage control procedure based on injury pattern and patient hemodynamics.

Induction of anesthesia

- Comatose patients in severe shock, and especially in complete cardiopulmonary arrest on admission
  - ➔ Require nothing more than oxygen and possibly a neuromuscular blocking drug
    - — until the patient's blood pressure and heart rate rebound
- Etomidate is the best induction drug in awake traumatized hypovolemic patients ; 0.1-0.2mg/kg
- Ketamine is also a suitable induction drug
- Propofol and thiopental are available if hemodynamically stable
- Succinylcholine (1–2 mg/kg IV) and rocuronium (1.0–1.2 mg/kg IV) (or vecuronium) should be available for neuromuscular blockade

Induction of anesthesia

- Analgesia and amnesia should be provided once the hemodynamic status becomes stable enough to tolerate anesthetic drugs
  - To prevent recall
  - Amnestic drugs include midazolam and scopolamine
  - If the patient is hypotensive and unstable, scopolamine (0.4 mg IV) is used for amnesia
- Spinal and epidural anesthesia are contraindicated in the unstable abdominal trauma patient
  - Impractical, takes time to set up, can result in several deleterious side effects

Maintenance of anesthesia

- Maintained with inhalational agents or with intravenous drugs such as propofol, with opioid supplementation
- Inhaled drugs are typically less expensive and possess equally satisfactory anesthetic results
- Depending on the degree of hemorrhage, minimum alveolar concentration (MAC) may be decreased by as much as 25%
- All volatile anesthetics produce dose-dependent depression of myocardial contractility
  - Desflurane, isoflurane, and sevoflurane maintain cardiac output better than older agents
- Sevoflurane : best reserved for brief periods of administration in the multiply injured trauma patient
- Nitrous oxide (N_2O) : avoided to limit bowel and closed-space gas accumulation

Replacing blood loss

- Massive transfusion protocol (MTP)
  - ➔ To insure rapid and timely administration of blood products, including coagulation factors
- Use autologous blood salvage devices (cell saver) with non-contaminated intra-abdominal blood
- Adverse consequences of massive transfusion
  - Coagulopathy, hypothermia, hypocalcemia, hyperkalemia, and hemolysis
  - Coagulopathy following massive transfusion in seriously injured patients ; predicted by persistent hypothermia, acidosis, hypotension, and Injury Severity Score (ISS).

Thermal management

- Hypothermia increase morbidity and mortality in severely injured patients
  - Affects the platelet coagulation process, promotes platelet sequestration
  - Reduces drug metabolism
  - Induces vasoconstriction
  - Combined hypothermia and acidosis, reflect a decrease in cardiac output and tissue perfusion.
- Moderate hypothermia (35.5-34.5℃) is neuroprotective.
  - Tolerated in certain conditions, especially when clinical manifestations of bleeding are absent

Neuromuscular blockade

- Muscle relaxation facilitates exposure during exploratory laparotomy.
- Rocuronium is often used in trauma patients due to its rapid onset.
- Vecuronium is often used because of its minimal effects upon the hemodynamic system.

Acid-base management

- Acidosis impairs myocardial contractility in response to both endogenous and exogenous catecholamines.
- Lactic acidosis should be treated by improving oxygen delivery including fluid replacement.

Antibiotics

- Preoperative (empiric/prophylactic) antibiotic therapy begins with broad-spectrum coverage of both Gram-positive and Gram-negative bacteria.
  - Especially anaerobes and enterobacteriacea
- A third- or fourth-generation cephalosporin in combination with metronidazole is recommended by the American College of Surgeons.
- If the patient has sustained gross spillage of gut contents, or has received a massive transfusion, antibiotics should be repeated more frequently.
- Tetanus prophylaxis must be considered in every trauma patient.

Considerations related to the surgical approach

- Diagnostic laparoscopy
  - Less invasive, but limited visualization
  - Complications related to pneumoperinoteum ; tension pneumothorax, decreased venous return and cardiac output
- Exploratory laparotomy
  - Ultimate diagnostic modality
  - Hemodynamically unstable or difficult hemorrhagic control, the area is packed again, and anesthetic "catch-up" is allowed, with infusion of blood products and/or pressors
  - Complex hepatic injuries (grades Ⅲ-Ⅴ) generally require temporary portal triad occlusion (Pringle maneuver) to gain operative visibility and vascular control
    → decreased right heart venous return

Resuscitation principles for damage control surgery

- In unstable, severely injured patients with metabolic derangements
- Hypotensive resuscitation:
  - Give warm IV fluid or blood with close attention to the rate of surgical bleeding
  - Maintain systolic blood pressure (SBP) at 80–90 mmHg until major bleeding has been controlled in patients without head trauma.
- Maintenance of blood composition and chemical equilibrium:
  - Initiate massive transfusion protocol with PRBCs, plasma, and platelets in a ratio close to 1:1:1.
  - Reduce the volume of crystalloids, especially hypotonic solutions; avoid colloids
  - Target hemoglobin of 7 to 9 g/dL; platelets >$50x10^9$ per liter

Resuscitation principles for damage control surgery

- Preservation of homeostasis:
  - Restoration of end-organ perfusion:
    — pH >7.25, arterial carbon dioxide <50 mmHg and decreasing lactate level
  - Maintaining normothermia
- Analgesia and sedation should be continued in spite of hemodynamic instability:
  - Analgesia can be achieved with incremental doses of fentanyl.
  - Small boluses of ketamine and midazolam are also advocated.
  - Tracheal extubation is not expected at the end of surgery.

Considerations related to the surgical approach

- Abdominal compartment syndrome
  - Increased intraabdominal pressure results in impairment circulation, decreased tissue perfusion, and organ dysfunction.
  - ⬇Thoracic venous return, cardiac output, and renal function
  - ⬇Tidal volume, ⬆ventilatory pressures, and atelectasis
  - Cause venous hypertension and elevate intracranial pressure

→ Post-decompression,
- Release of lactate and subsequent hypotensive hemodynamic changes
- IV fluid loading before abdominal decompression
- Vasopressors ; phenylephrine, norepinephrine, vasopression
- Acidosis is treated by increasing minute ventilation
- Sodium bicarbonate, calcium chloride

Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA)

- Aortic occlusion balloon is placed into the aorta over a wire via the common femoral artery.
- Inflation of the endovascular balloon : similar to aortic cross-clamping
  → Increasing afterload and maintaining perfusion above the balloon, most importantly, to the heart and brain
- Anesthesiologist must be familiar with the physiologic implication of REBOA and be prepared to provide general anesthesia, neuromuscular blockade, and resuscitation.

Postoperative ICU considerations

- After transport to the intensive care unit (ICU), the focus is on continued fluid resuscitation, aggressive warming measures, control of coagulopathic bleeding, and normalization of acidosis.
- Prevention of ongoing bleeding and shock, coagulopathy, hypothermia, abdominal compartment syndrome, acute lung injury, deep venous thrombosis and pulmonary emboli, and sepsis.

Goals for anesthetic management for abdominal trauma

✓ Re-establish and maintain normal hemodynamics
- For hypotension, fluid first, then vasopressors
- Frequent evaluation of base deficit, hematocrit, urinary output
- Titration of additional anesthetics if robust blood pressure

✓ Maximize surgical exposure and minimize bowel edema
- Limit fluids according to needs
- Limit blood loss by allowing anesthetic catch-up
- Muscle relaxation should be optimized
- Nasogastric or orogastric tube to decompress bowel
- Avoid nitrous oxide (N_2O)

Goals for anesthetic management for abdominal trauma

✓ Limit hypothermia
- Monitor core temperature
- Warm all intravenous fluids and blood
- Keep patient covered and warm the operating room (>28℃)
- Apply convective warming blanket and warming mattress

✓ Help limit blood loss and coagulopathy
- Encourage surgeon to stop and pack if blood loss excessive
- Frequently monitor hematocrit, ionized calcium, coagulation studies
- Provide calcium for large citrated product administration
- Administer plasma, platelets, cryoprecipitate, and factor VIIa or prothrombin complex concentrate (PCC), as clinically indicated.

Goals for anesthetic management for abdominal trauma

✓ Limit complications to other systems
- Monitor intracranial pressure, maintain cerebral perfusion pressure > 70mmHg
- Monitor peak airway pressure and tidal volumes
- Employ protective lung ventilation strategy
- Measure urine output
- Monitor peripheral pulses

CURRICURUM VITAE

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The Role of Interventional Radiology in Traumatic Patients

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외상팀에서 영상의학과 의사의 역할

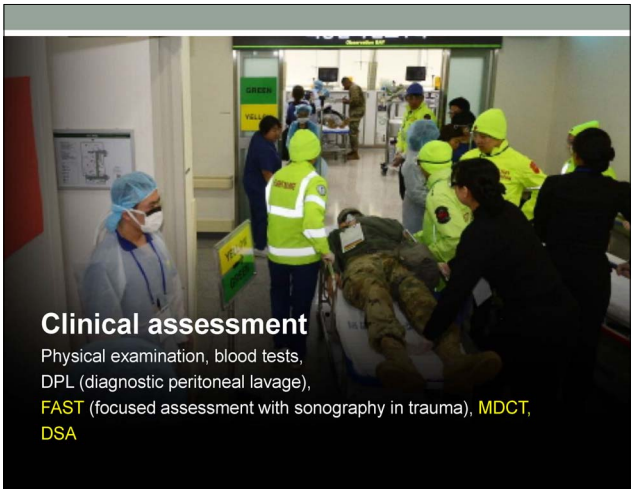
- Focused assessment with sonography for trauma (FAST)
- Set imaging process up and imaging study interpretations
- Interventional treatment

Intervention in trauma center

- Bleeding control : Blunt trauma of solid organ
- Blunt traumatic aortic injury
- Vascular injuries

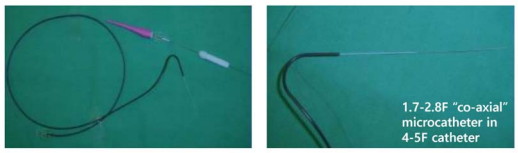
Blunt trauma

- **원인**
  교통사고 / 추락사고 (Fall injury)
- **기전**
  감속손상 Deceleration (shearing force)
  압착손상 Crushing injury
  외부압박 External compression
- **Frequently injured organs**
  Spleen
  Liver
  Bowel/mesentery
  Pancreas
  Adrenal glands



Endovascular Procedure

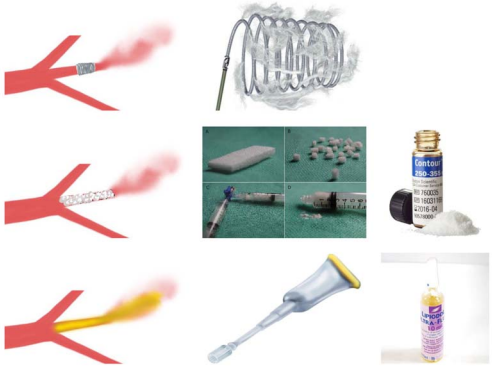
- Strategy
  - Anatomical location: terminal branch VS major artery injury
  - Type of procedure: stent-graft VS embolization
- Embolization technique
  - Superselective, co-axial technique
  - Avoid non-target embolization



Embolic material

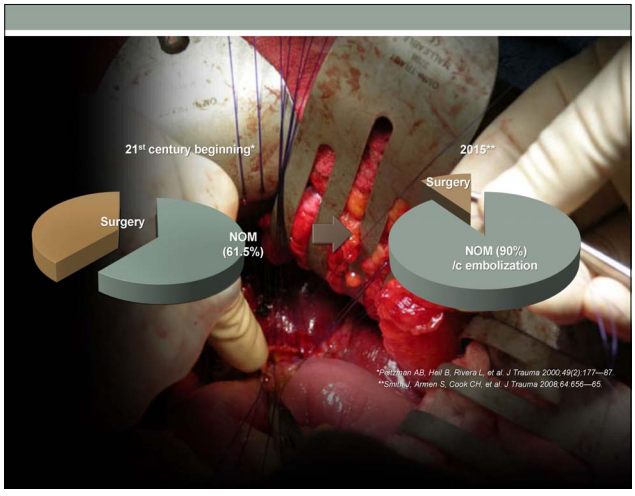
- Gelfoam (slurry)
  - Readily available, cheap, easy to use
  - Transient embolic effect, usually sufficient to induce coagulation
- Coil
  - May be used alone or together with other embolic materials
  - Difficult to deploy in small terminal branches
  - May be ineffective in patients with coagulopathy (e.g. DIC)
- Glue (N-butyl cyanoacrylate; NBCA)
  - Rapid cast formation
  - Careful handling needed to avoid non-target embolization.
  - Less dependent on patient's coagulation capability

Terminal artery embolization



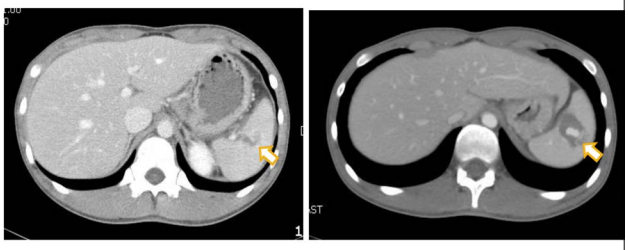
Spleen 비장

- 복부둔상 환자에서 가장 흔하게 손상을 받는 복강내 장기
- 빈도: ~40%
- 비장의 수술적 절제 후 면역기능 저하, 패혈증 등 합병증에 대한 보고가 많아지면서 점차 비수술적 치료가 각광 받게 됨
- 과거 비수술적 치료(NOM: non-operative management)의 개념과 달리 필요시 transcatheter embolization을 보조적으로시행하면서 NOM의 성적을 향상시킬 수 있음



M/16

Blood pressure 115/65, hgb/hct 12.9/37.8
CT: intraparenchymal Extravasation



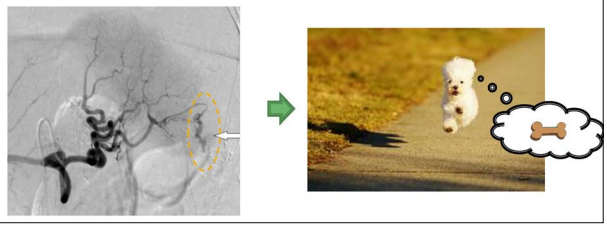
Initial

10 days later

Pseudoaneurysm: selective embolization

Extravasation

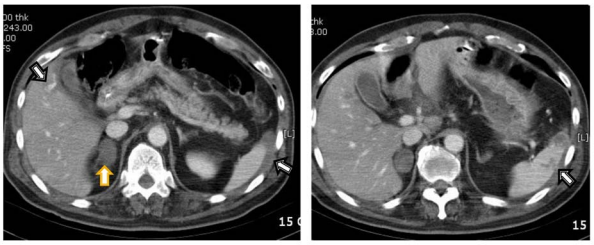
- A "definite target" for interventional radiologists
- Superselective co-axial technique can be applies to avoid non-target embolization



Liver

- Spleen 다음으로 두 번째로 흔한게 손상받는 복부내 장기
- 빈도: 25-40%
- 간우엽 > 간좌엽 손상
- 간 손상 환자의 70-80%는 손상이 심하지 않거나 출혈이 멎어 있어 수술적 치료가 필요 없음
- 큰 혈관 또는 간문부 근처 혈관 손상이 있는 경우 출혈이 멈추지 않을 수 있음

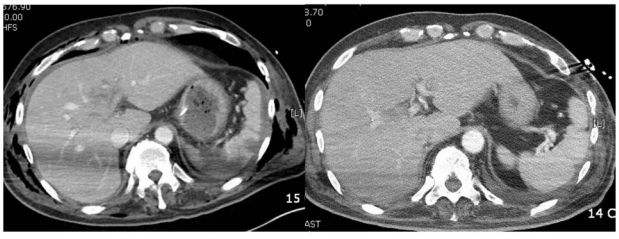
Polytrauma M/46 Decreasing hgb/hct



DSA

Selective embolization

Follow-up CT



Complications

- Liver has dual supply but ischemic complication can occur
  - Associated portal vein injury?
- Misselbeck et al. (*J Trauma*. 2009;67:769-773)
  - Parenchymal necrosis requiring debridement: 16%
  - Gallbladder ischemia needing cholecystectomy: 16%

Kidney 신장

- 관통상 > 둔상(국가/지역에 따라 빈도의 차이가 있음)
- 간 또는 비장의 손상이 동반된 경우가 많다
- 후복강에 위치하고 있어 수술적 치료를 요하는 경우는 많지 않다
- Shattered kidney를 제외하고 대부분 비수술적 치료로 충분하며 근래 들어 색전술의 역할이 부각됨

"Forgiving" characteristics of the kidney

- True "end-artery" 구조(collateral backflow가 없다)
- 대부분 segmental injury 양상(신장동맥의 segmental branching pattern 때문)
- 후복강은 구조적으로 closed space이다
- 공팥에는 다량의 tissue factor가 존재한다

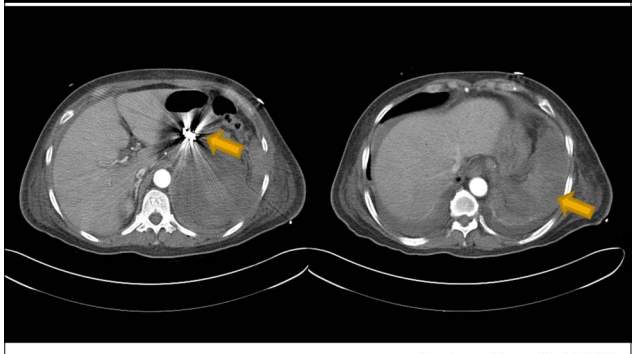
AAST (American Association for the Surgery of Trauma)

Grade (AAST)	Laceration	Hematoma	Vascular	Common treatment
Grade I	None	Subcapsular hematoma		Conservative
Grade II	Superficial (<1cm)	Non-expanding perirenal hematoma		Conservative
Grade III	>1cm laceration, intact collecting system			Endovascular
Grade IV	Extension through cortex/medulla/collecting system	Expanding subcapsular hematoma compressing kidney	Main renal A or V injury with contained hemorrhage	Endovascular
Grade V	Shattered kidney		Avulsion, thrombosis ("devascularization")	Immediate surgery

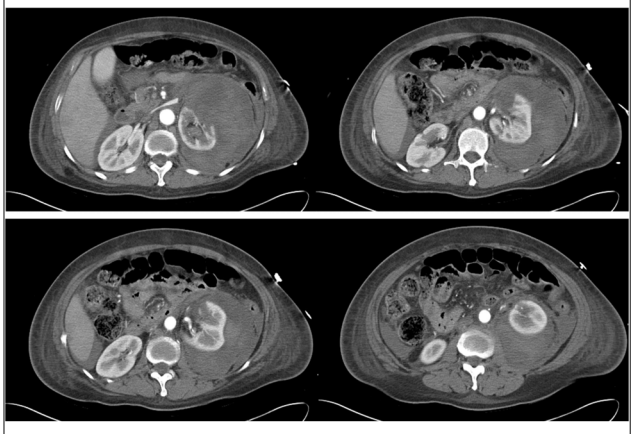
Outcome

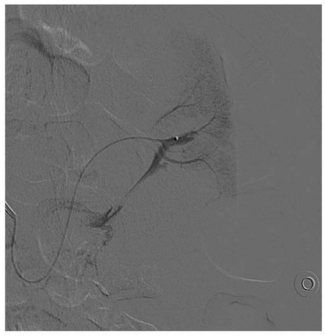
- Hemostasis
  - Technical success: 90%
  - Clinical success: 79%
- Complications
  - Renal infarction:
    - Least forgiving organ (irreversible nephron loss)
    - Superselective technique is important!
  - Acute tubular necrosis:
    - Hypovolemic shock + embolization-related ischemia + contrast-induced nephropathy

Case 1. F/63 Motor Vehicle Accident

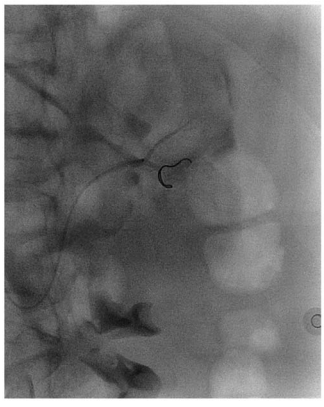


Courtesy of Song SY at HUMC

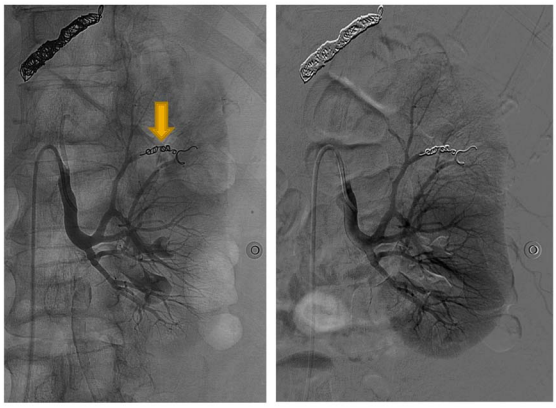




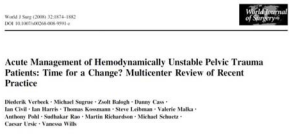
Arteriovenous fistula



Pseudoaneurysm



Pelvic Trauma



Acute Management of Hemodynamically Unstable Pelvic Trauma Patients: Time for a Change? Multicenter Review of Recent Practice

Diederik Verbeek · Michael Sugrue · Zsolt Balogh · Danny Cass · Ian Civil · Ian Harris · Thomas Kossmann · Steve Lehman · Valerie Malka · Anthony Pohl · Sudhakar Rao · Martin Richardson · Michael Schuetz · Caesar Ursic · Vanessa Wills

Table 2 Primary cause of death ($n = 69$)

Diffuse hemorrhage	22 (31.9%)
Pelvic hemorrhage	20 (29.0%)
Traumatic brain injury	15 (21.7%)
Respiratory	5 (7.2%)
Multiple organ dysfunction syndrome	3 (4.3%)
Sepsis	2 (2.9%)
Cardiac arrest	2 (2.9%)

- 11,109 major blunt trauma (mortality 14.7%)
  - 1,050(10%) major pelvic fracture (mortality 17.0%)
    - 217(20%) hemodynamically unstable
      - 69(30%) death
        - 52(75%) within 24 hours
          - 42(80%) hemorrhage is primary cause of death

Principle of treatment

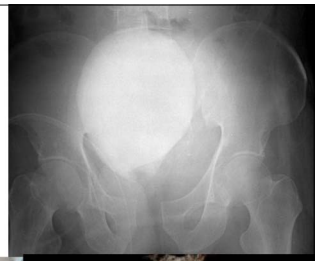
- **Decrease pelvic volume**
  - External stabilization (sheet wrapping, C-clamp, external fixator)
  - Sponge packing (tamponade) 단점:
    - Risk of infection and compartment syndrome
    - Can only control venous and smaller arterial bleeding
- **Treat bleeding focus**
  - Surgical exploration and ligation 단점:
    - Difficult to control bleeding (localization, extensive collateral network...)
    - Can relieve compartment syndrome
    - Reduces tamponade effect → may increase bleeding risk
  - Embolization

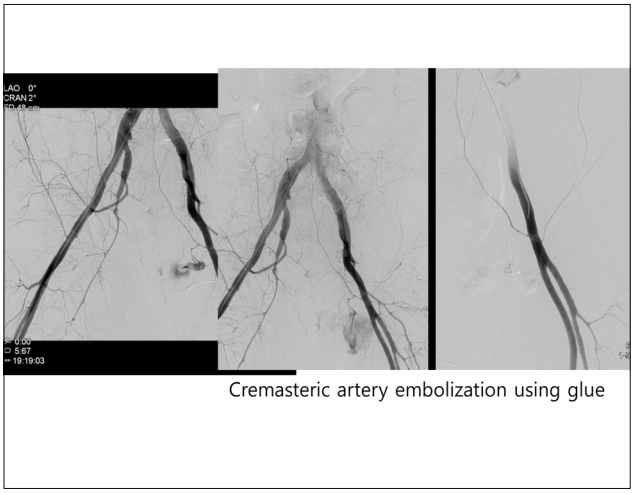
Embolization

- Persistent hypotension시 문헌에 따라 57~75%까지 active arterial bleeding이 있다고 보고
- Hemodynamically unstable 환자에서 일차적인 pelvic stabilization, packing 등 응급조치 후 필요시 embolization 시행
- Hemodynamically stable 환자에서 CT상 arterial bleeding이 발견되면 primary modality로 embolization 시행
- 문헌에 따라 임상적 성공율이 85 – 100% 정도로 보고됨

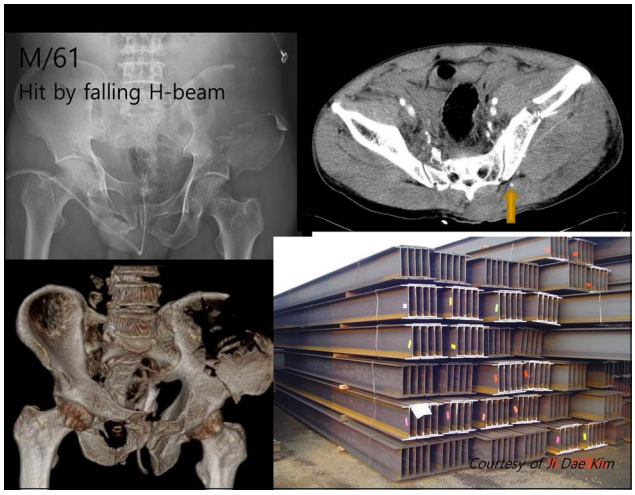
M/51

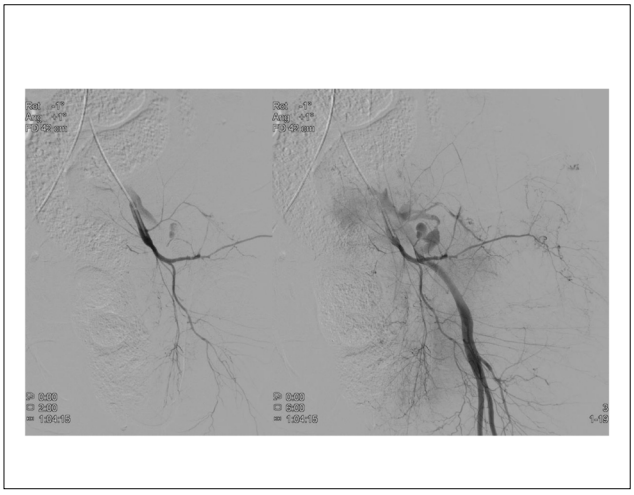
유압기에 깔림

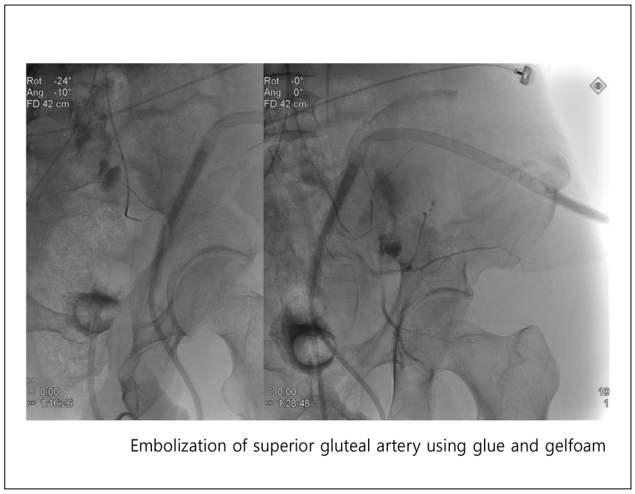




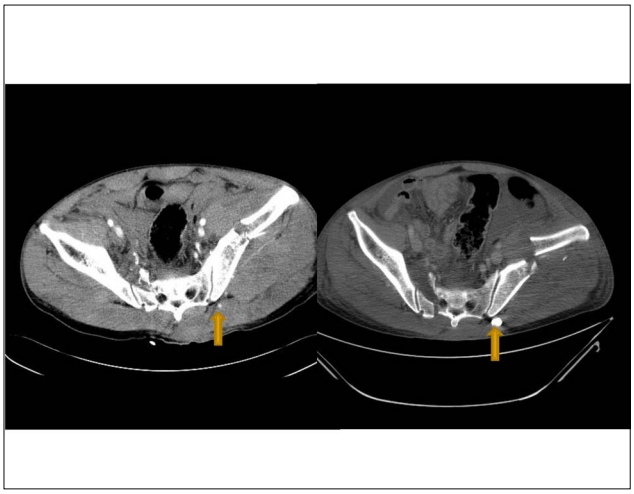
Cremasteric artery embolization using glue







Embolization of superior gluteal artery using glue and gelfoam



Embolization in blunt trauma

- **Supportive role** in conservative management and surgery
- **Expanding indications:**
  - Hemodynamically stable VS unstable patients
  - Definitive treatment VS bridge to surgery
  - Rebleeding after surgery
  - Polytrauma setting
- **Increasing role** in trauma setting due to advancements in co-axial devices and technique

Reality issues for IR: Time & Interest

- IR interest in traumatology is key!!
- IR standby:
  - Better outcomes in institutions with 24 hours/day, 365 days/year on-call support from IR
- The faster the intervention, the better the prognosis
  - Embolization < 3 hours --> increased survival (Agolini et al. 1997)
  - Embolization < 1.5 hours --> decreased mortality (Balogh et al. 2005)

Etiology of Blunt Traumatic Thoracic Aortic Injury

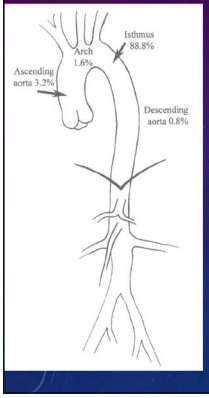
- Overall incidence : < 0.5%
  - Traffic accidents : 0.3%
  - High-level falls : 0.1%
- Mechanism
  - Motor vehicle crash (70%)
  - Motorcycle crash (13%)
  - Fall from heights (7%)
  - Auto vs pedestrian (7%)
- BTAI incidence : age ↑ / pediatric population ↓
  - <16 yrs -> 7 times lower than in adults

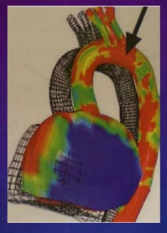
NATURAL HISTORY

- Prehospital mortality : 70-80%
- Patients arriving to the hospital alive, 50% died within 24 hrs
  - Scene (57%)
  - < 4 hrs of admission (37%)
  - >4 hrs of admission (6%)

Emerg Med J 2004;21:414–4

DISTRIBUTION OF AORTIC INJURIES

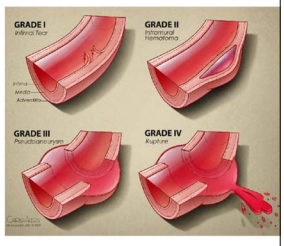




- In computer simulation and cadaver studies, showed that at the time of the crash the intra-aortic pressure increases to a mean of 1,449 mmHg.
- This high pressure combined with rotational forces, exerts a highly focused stress at the isthmus.
- In addition, the tensile strength at the isthmus was found to be only 63% of that of the proximal aorta.

Classifications of traumatic aortic injury

- Grade I
  - Intimal tear or flap
- Grade II
  - Intramural hematoma w/o external contour change
- Grade III
  - Pseudoaneurysm
    - with external contour change
    - w/o extravasation of contrast
- Grade IV
  - Full-thickness tear with extravasation of contrast



J Vasc Surg 49(6): 1403-1408

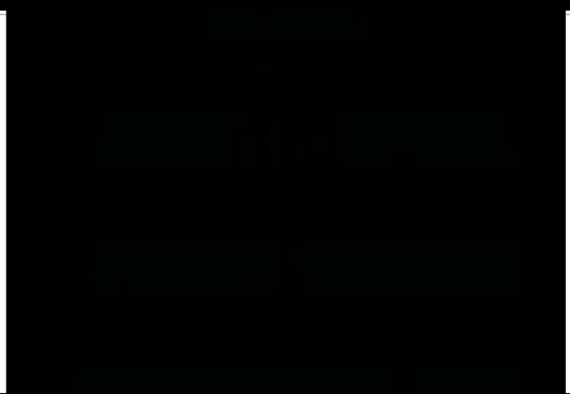
INDICATION

- **2011 SOCIETY FOR VASCULAR SURGERY® DOCUMENTS**

- GR I -> not repaired
- GR II – IV -> should be repaired

- **Non-operative management of TBAI…**

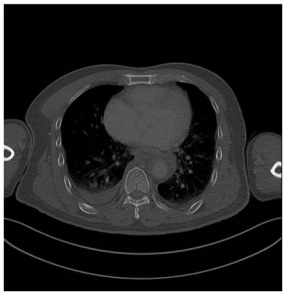
Thoracic endovascular aortic repair (TEVAR)



CASE PRESENTATION

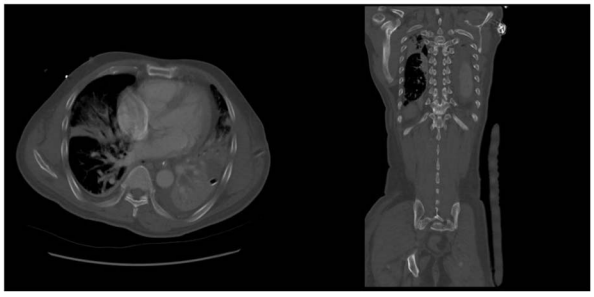
- M/45
- Autovehicle TA
- Multiple trauma
  - Traumatic SDH
  - Intraperitoneal organs
  - Pelvic bone Fx

2018-7-6 Aorta CT(outside institution)



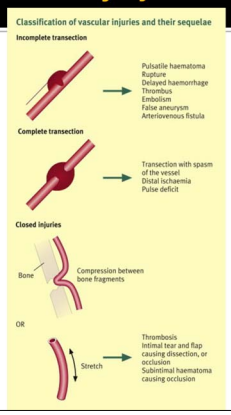
2018-7-7 TEVAR

2018-7-16 Aorta CT



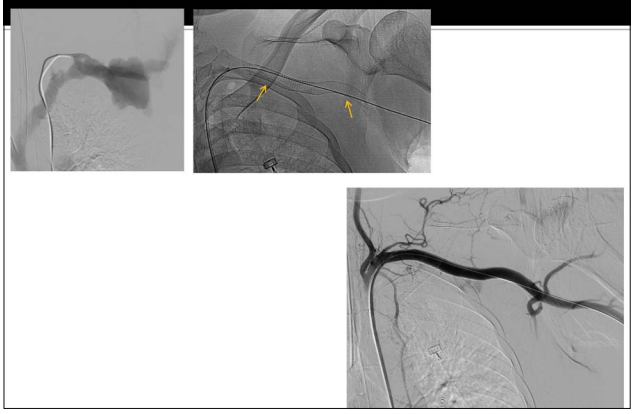
Traumatic Peripheral vascular Injury

- Type of vascular injury
  - Dissection
  - Thrombotic occlusion
  - Rupture
  - Transection

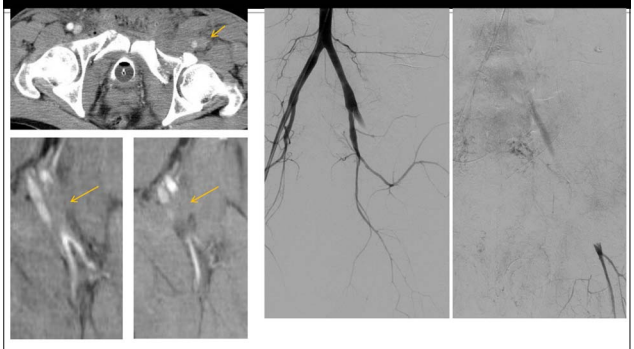


Surgery (Oxford). Volume 27, Issue 8, August 2009, Pages 331-336

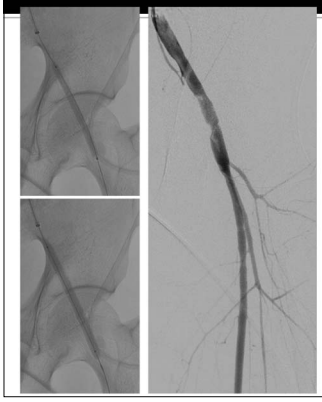
Results : Case 1.



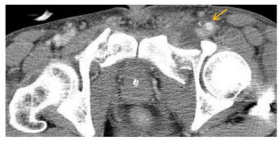
Results : Case 2.



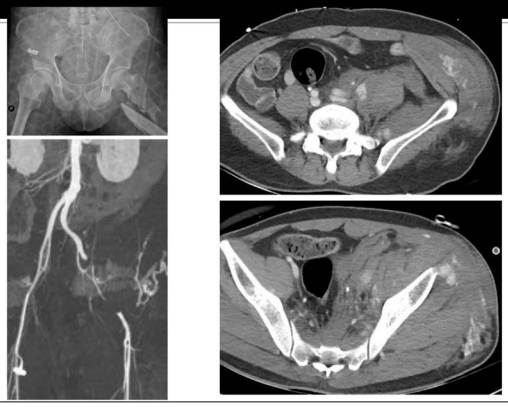
Results : Case 2.



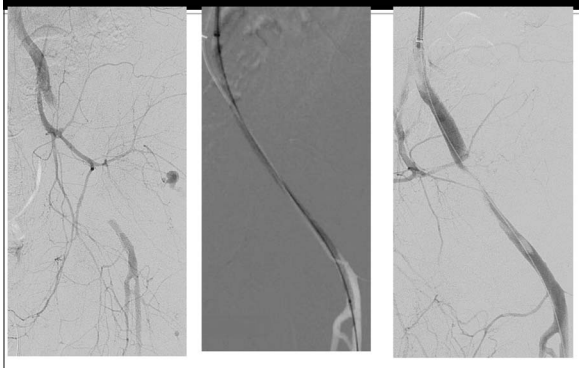
F/U after 8 days



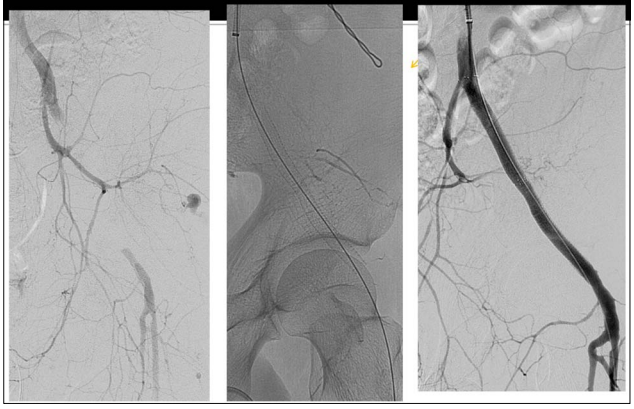
Results : Case 3.



Results : Case 3.



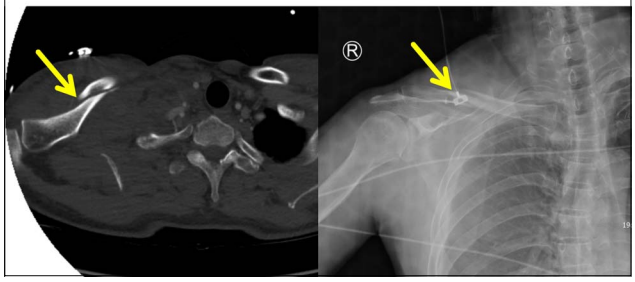
Results : Case 3.



Results : Case 3.

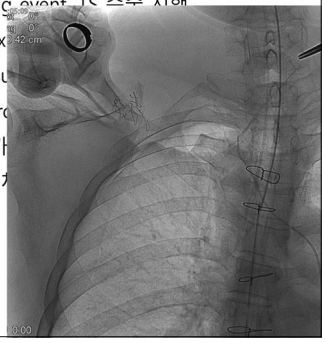
M/48

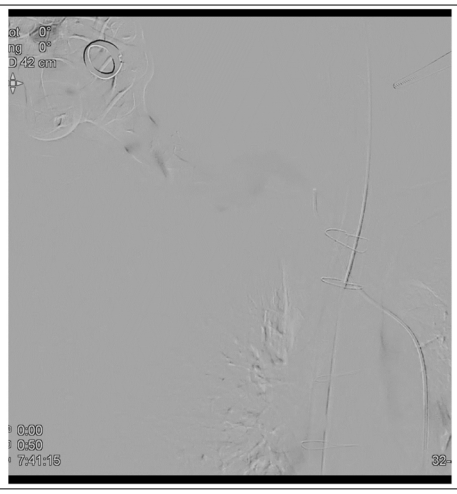
- C/C: 자전거로 비탈길 내려가다가 넘어짐.

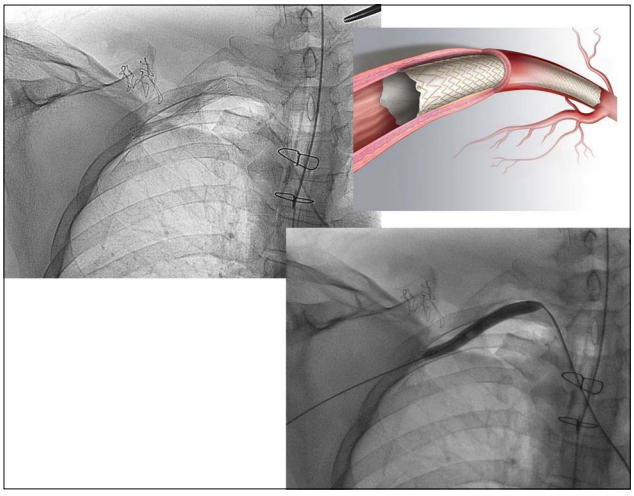


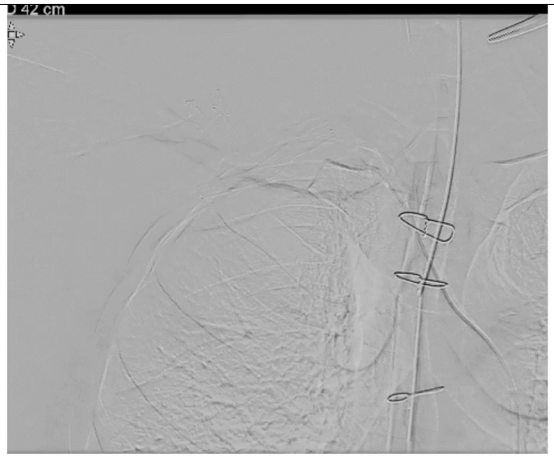
D13, ORIF for Rt clavicular fracture

- OS 수술 중 massive bleeding event, TS 스승 시행
- Rupture 부위가 clavicle prox
  부위여서 rupture site exposu
  후 Rt subclavian artery의 pr
- Bleeding이 너무 많아 시야가
- Finger compression 유지한 채









Summary

- Embolization is now an everyday practice in trauma centers. Patient selection is important for outcome
- Thoracic stent-graft can be performed for Blunt Traumatic Thoracic Aortic Injury
- Endovascular treatment is useful for revascularization and exclusion of bleeding in the emergent setting
- IR should be integrated into multidisciplinary trauma teams to establish guidelines and protocols

CURRICURUM VITAE

김 태 엽

건국대학교병원 마취통증의학과

▌학력 및 경력

전남의대졸업 (1990) 석사 박사
전남대학교병원 인턴
국립의료원 마취과 전공의
서울아산병원 마취과 전임의
성균관의대 삼성창원병원 조교수
피츠버그대학병원 마취과 Full-time faculty (2003-2005)
건국대학교병원 마취통증의학과 부교수 (2005-2009)
건국대학교병원 마취통증의학과 교수 (2009-현재)

대한노인마취통증학회 회장
대한환자혈액관리학회 회장
대한수혈학회 부회장
대한민국의학한림원 정회원
Asian Australasian Congress of Anesthesiologists (AACA) 2022 조직위원회 부위원장
대한마취통증의학회 서울경인지회 지회장
World Federations of Societies of Anesthesiologists (WFSA) Asia Australasia Regional Section 이사
대한외래마취학회 기획이사

▌관심 및 연구분야:

perioperative echocardiography, patient blood management, perioperative fluid management, blood coagulation and viscosity, patient safety

Bleeding & Coagulation Management

Tae-Yop Kim, M.D., Ph.D.

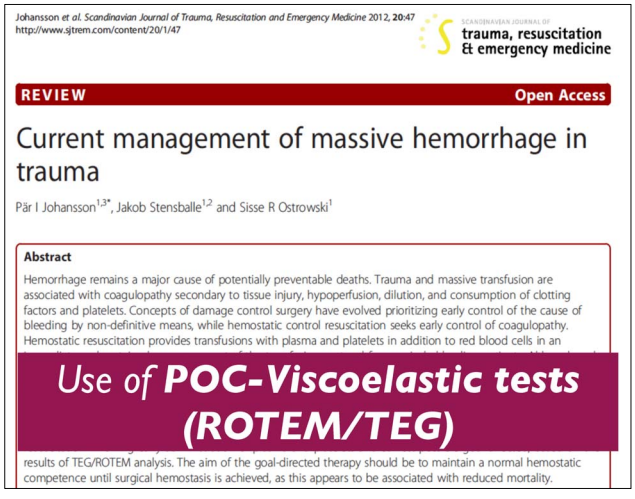
Department of Anesthesiology, Konkuk University School of Medicine, Seoul Korea

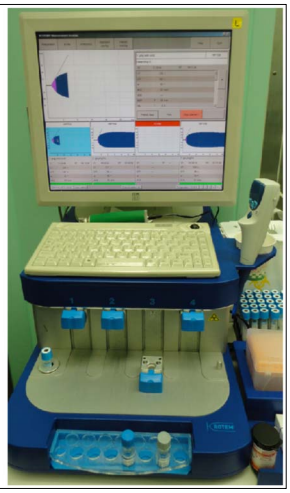
Disclosure

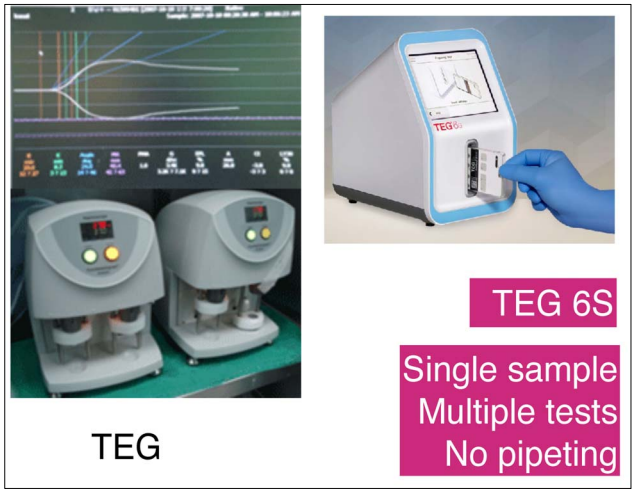
- *None for this presentation*
- *Honoraria in past 5 years*
  - *–JW Pharma, MSD, **Werfen**, 3M, Medtronic, Fresenius-Kabi, Siemens (Acuson), Edward Lifesciences, in several conferences & seminars*
- *Consultation*
  - *–3M, Medtronic, Edward Lifescience*
- *Consultant*
  - *–Medtronic (Asia Anesthesia Forum)*

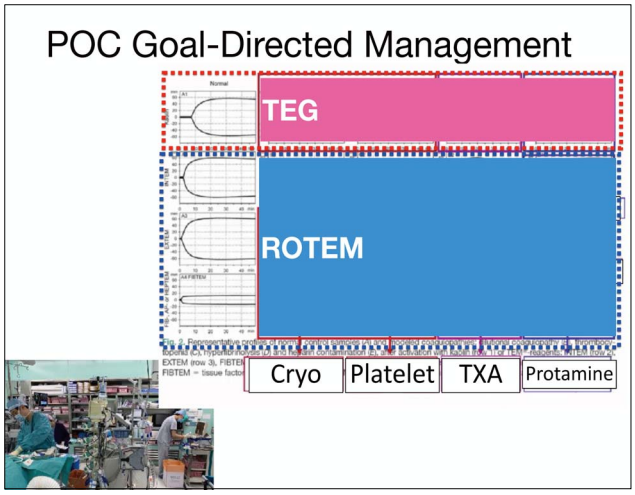
Contnets

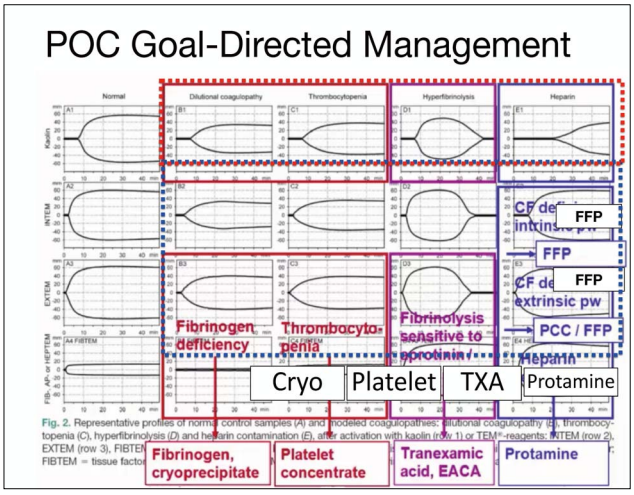
- *Point-of-care viscoelastic test (ROTEM/TEG)*
  Goal-directed application & Limitation
- *Prothrombin complex concentrate*
- *Fibrinogen concentrate*
- *Implementing of PCC & FC-based strategy*
  on POC-viscoelastic test-based management
- *ROTEM-based trauma management algorithm(Korean Journal of Anesthesiology)*
- *Tranexamic acid*

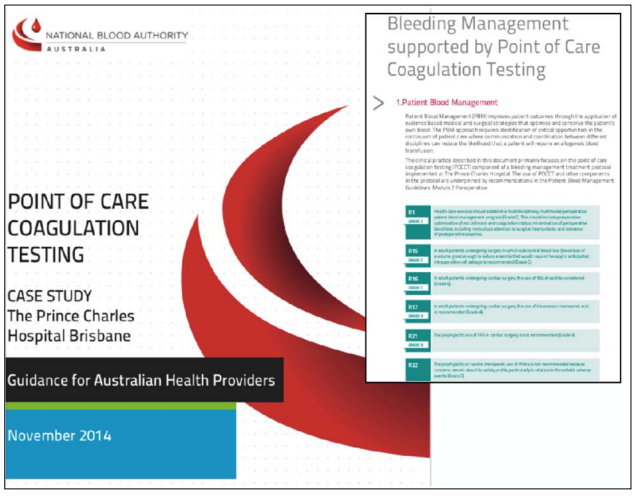


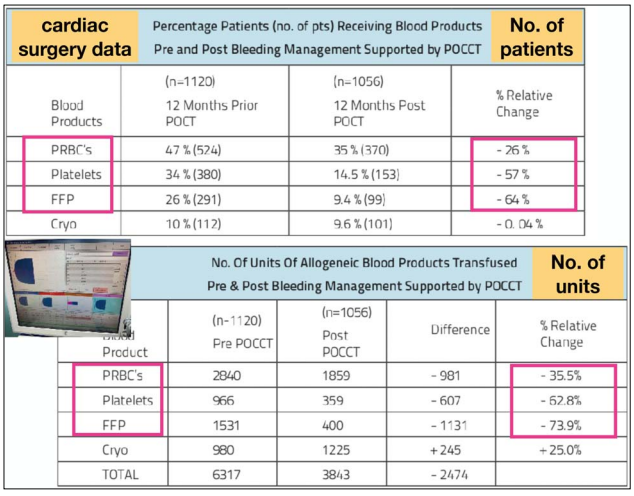








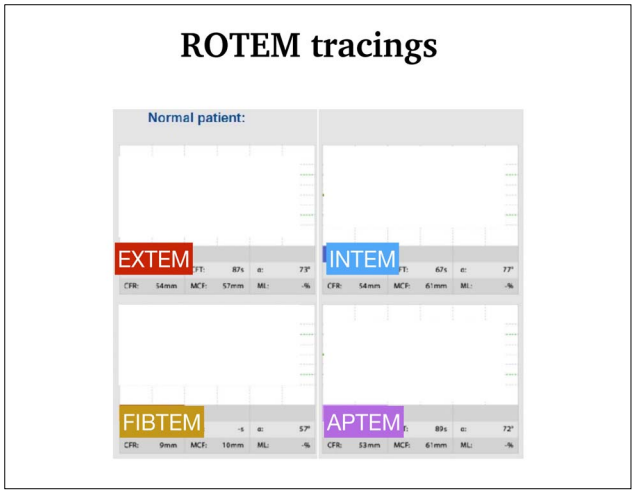


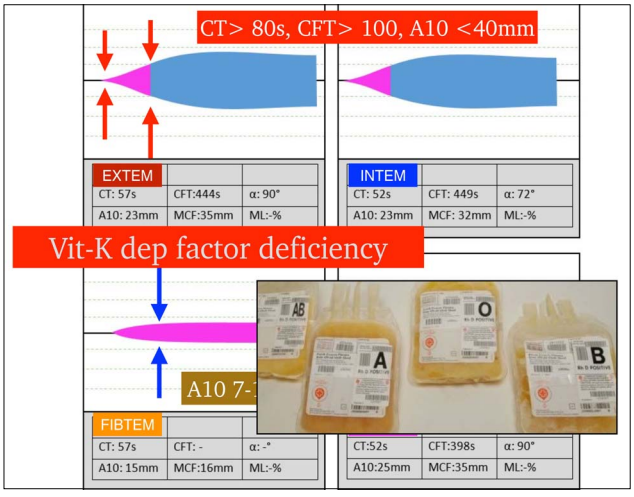


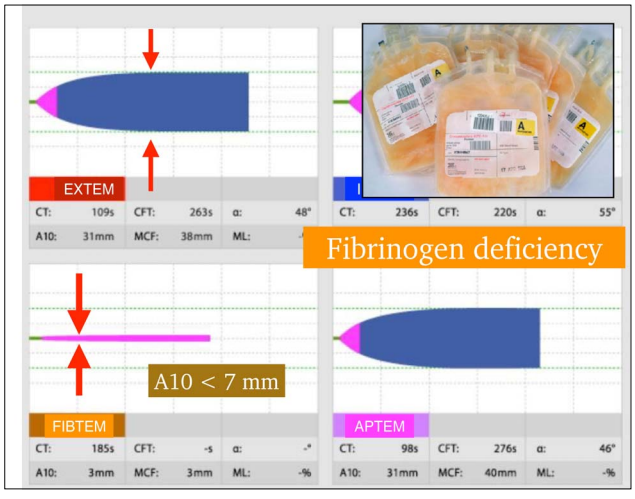
cardiac surgery data	Percentage Patients (no. of pts) Receiving Blood Products Pre and Post Bleeding Management Supported by POCCT		No. of patients
Blood Products	(n=1120) 12 Months Prior POCT	(n=1056) 12 Months Post POCT	% Relative Change
PRBC's	47 % (524)	35 % (370)	- 26 %
Platelets	34 % (380)	14.5 % (153)	- 57 %
FFP	26 % (291)	9.4 % (99)	- 64 %
Cryo	10 % (112)	9.6 % (101)	- 0. 04 %

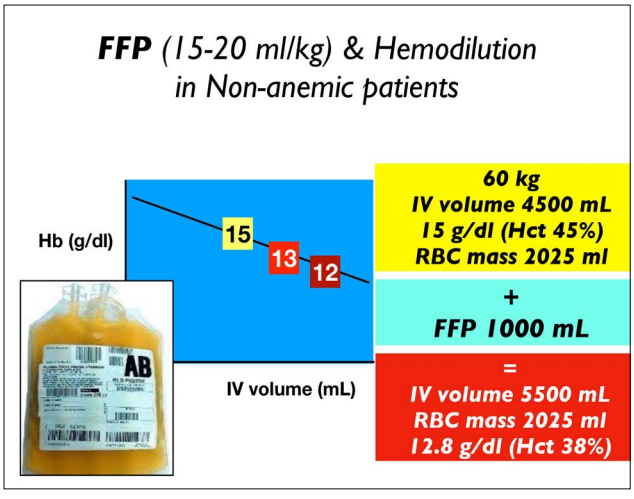
	No. Of Units Of Allogeneic Blood Products Transfused Pre & Post Bleeding Management Supported by POCCT			No. of units
Product	(n=1120) Pre POCCT	(n=1056) Post POCCT	Difference	% Relative Change
PRBC's	2840	1859	- 981	- 35.5%
Platelets	966	359	- 607	- 62.8%
FFP	1531	400	- 1131	- 73.9%
Cryo	980	1225	+ 245	+ 25.0%
TOTAL	6317	3843	- 2474	


Alcohols


ROTEM tracings
Normal patient:
EXTEM
INTEM
FIBTEM
APTEM


CT> 80s, CFT> 100, A10 <40mm
EXTEM
CT: 57s
CFT:444s
α: 90°
A10: 23mm
MCF:35mm
ML:-%
INTEM
CT: 52s
CFT: 449s
α: 72°
A10: 23mm
MCF: 32mm
ML:-%
Vit-K dep factor deficiency
FIBTEM
CT: 57s
CFT: -
α: -°
A10: 15mm
MCF:16mm
ML:-%
CT:52s
CFT:398s
α: 90°
A10:25mm
MCF:35mm
ML:-%


EXTEM
CT: 109s
CFT: 263s
α: 48°
A10: 31mm
MCF: 38mm
ML:
CT: 236s
CFT: 220s
α: 55°
Fibrinogen deficiency
A10 < 7 mm
FIBTEM
CT: 185s
CFT: -s
α: -°
A10: 3mm
MCF: 3mm
ML: -%
APTEM
CT: 98s
CFT: 276s
α: 46°
A10: 31mm
MCF: 40mm
ML: -%


FFP (15-20 ml/kg) & Hemodilution
in Non-anemic patients
Hb (g/dl)
15
13
12
IV volume (mL)
60 kg
IV volume 4500 mL
15 g/dl (Hct 45%)
RBC mass 2025 ml
+
FFP 1000 mL
=
IV volume 5500 mL
RBC mass 2025 ml
12.8 g/dl (Hct 38%)

...ia in Bleeding Patients

Hb (g/dl)

9

7

IV volume (mL)

60 kg
IV volume 4000 mL
9 g/dl (Hct 27%)
RBC mass 1080 ml

+
FFP 1000 mL

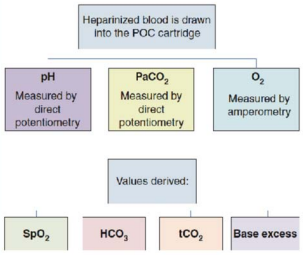
=
IV volume 5000 mL
RBC mass 1080 ml
7 g/dl (Hct 21%)

Point-of-Care ABG Analyzer

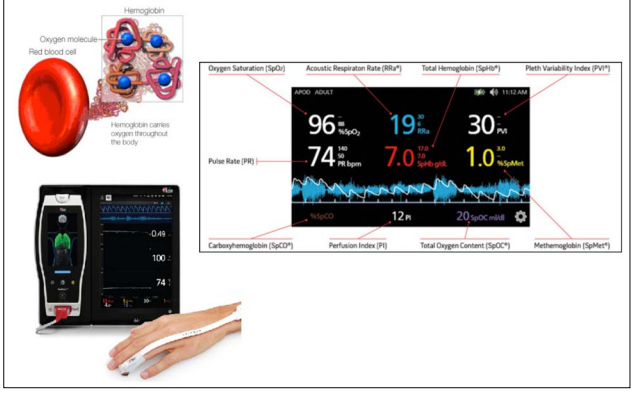
Hct/Hb,
as a trigger for RBC transfusion

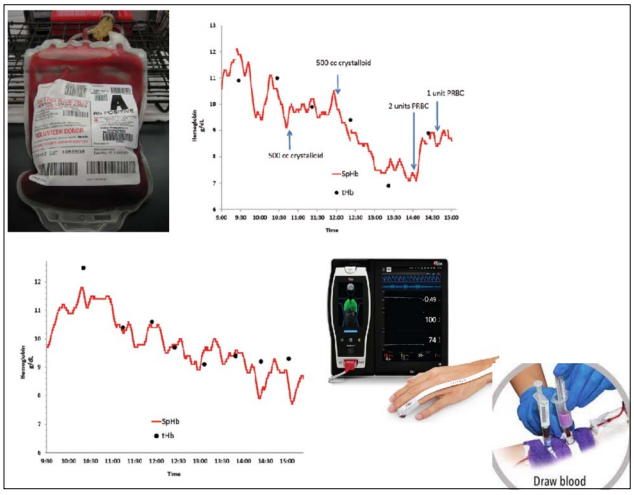
Transfusion Requirements in Cardiac Surgery III - TRICS III

Transfusion requirements in critical care TRICC II



Continuous Noninvasive Hb



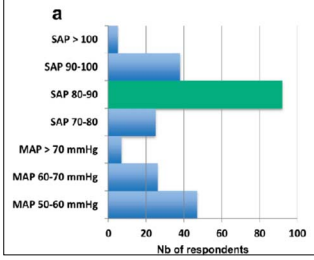


RESEARCH Open Access

European trauma guideline compliance assessment: the ETRAUSS study

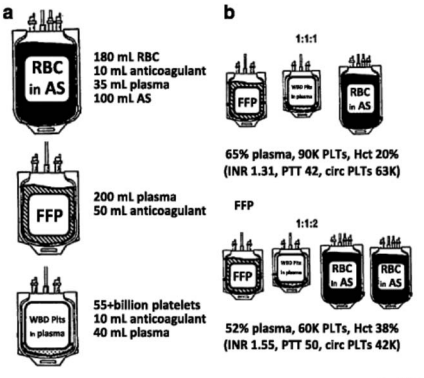
Sophie Rym Hamada[1*], Tobias Gauss[2], Jakob Pann[3], Martin Dünser[3], Marc Leone[4] and Jacques Duranteau[1]

SAP 80–90 *mmHg without brain injury. (Grade 1C)*
In severe TBI (GCS ≤8), ***MAP ≥80*** *mmHg(Grade 1C)*

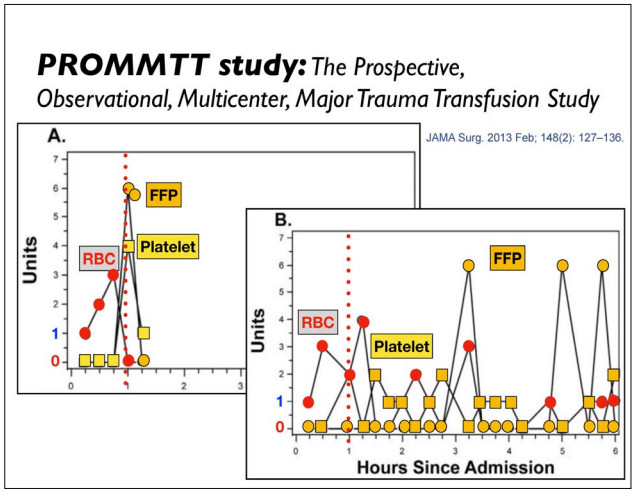


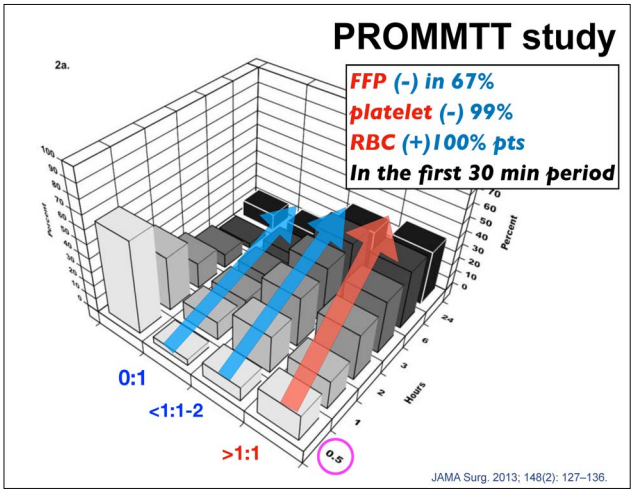
Hamada et al. Critical Care (2015) 19:423
Rossaint et al Crit Care 2016; 20: 100

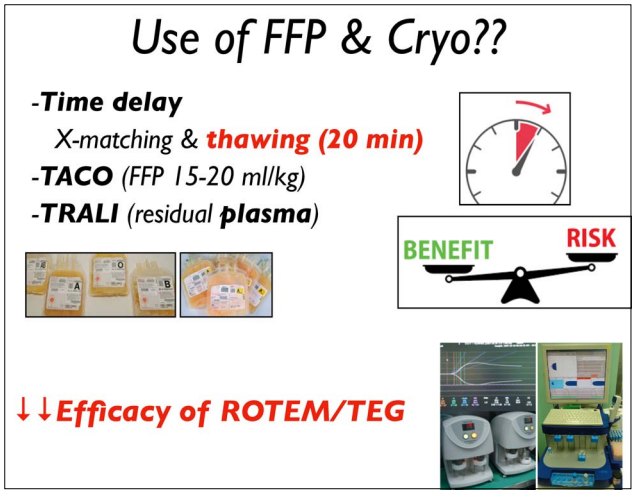
1:1:1 vs 1:1:2 ratio in Trauma

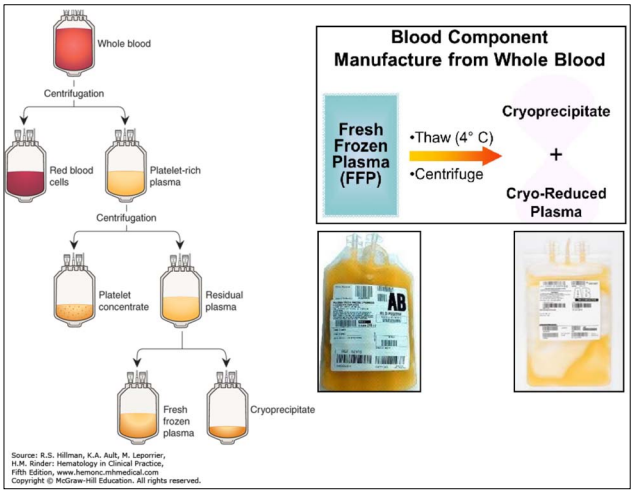


Journal of Intensive Care2017;5:2


PROMMTT study: The Prospective, Observational, Multicenter, Major Trauma Transfusion Study
JAMA Surg. 2013 Feb; 148(2): 127–136.
A.
B.
Units
FFP
RBC
Platelet
Hours Since Admission


PROMMTT study
2a.
FFP (-) in 67%
platelet (-) 99%
RBC (+)100% pts
In the first 30 min period
0:1
<1:1-2
>1:1
Hours
Percent
JAMA Surg. 2013; 148(2): 127–136.


Use of FFP & Cryo??
-Time delay
X-matching & thawing (20 min)
-TACO (FFP 15-20 ml/kg)
-TRALI (residual plasma)
BENEFIT
RISK
↓↓Efficacy of ROTEM/TEG


Whole blood
Centrifugation
Red blood cells
Platelet-rich plasma
Centrifugation
Platelet concentrate
Residual plasma
Fresh frozen plasma
Cryoprecipitate
Blood Component Manufacture from Whole Blood
Fresh Frozen Plasma (FFP)
•Thaw (4° C)
•Centrifuge
Cryoprecipitate
+
Cryo-Reduced Plasma
Source: R.S. Hillman, K.A. Ault, M. Leporrier, H.M. Rinder: Hematology in Clinical Practice, Fifth Edition, www.hemonc.mhmedical.com
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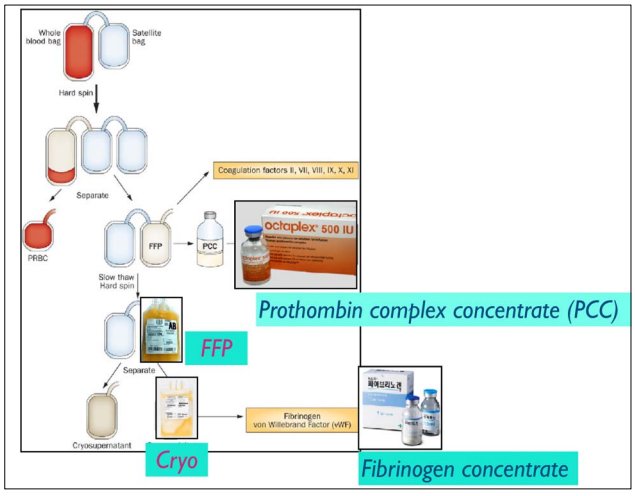
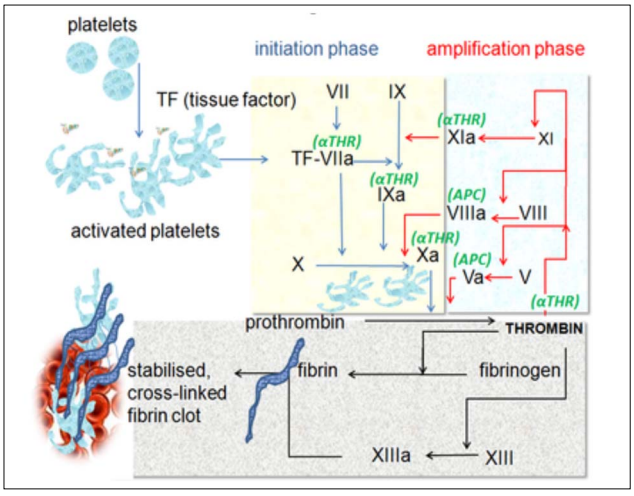
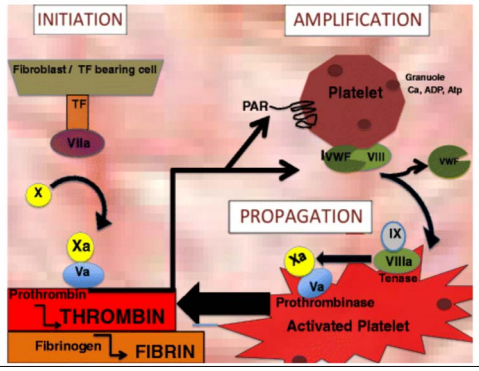
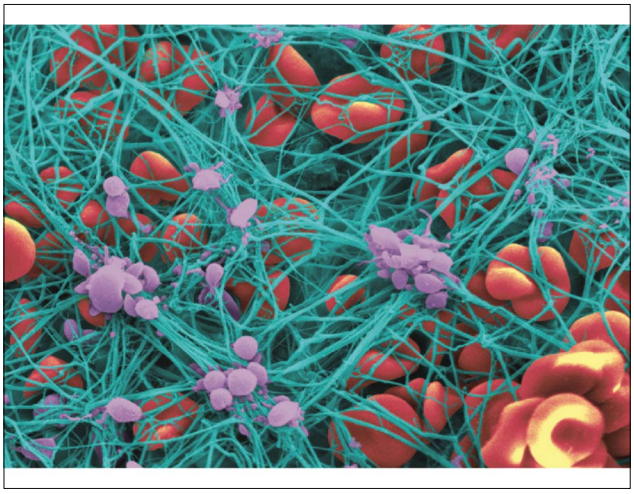

Whole blood bag
Satellite bag
Hard spin
Separate
PRBC
FFP
PCC
Coagulation factors II, VII, VIII, IX, X, XI
octaplex 500 IU
Slow thaw
Hard spin
Separate
Cryosupernatant
Fibrinogen von Willebrand Factor (vWF)
Prothombin complex concentrate (PCC)
FFP
Cryo
Fibrinogen concentrate


platelets
initiation phase
amplification phase
TF (tissue factor)
VII
IX
(αTHR)
TF-VIIa
IXa
XIa
XI
(APC)
VIIIa
VIII
activated platelets
X
Xa
Va
V
prothrombin
THROMBIN
stabilised, cross-linked fibrin clot
fibrin
fibrinogen
XIIIa
XIII

Clot formation & amplification





PCC, Initial Treatment Measure

for

Rapid restoration of coagulation factors

Rapid reversal of elevated INR (warfarin)

Prothrombin complex concentrate (PCC)

Vit-K factors	rFVIIa	FFP	3-factor PCC	4-factor PCC
X		✓	✓	✓
IX			✓	✓
VII	✓	✓		✓
II		✓	✓	✓

Protein C, Protein S, antithrombin, & heparin

PCC (vs. FFP)

Faster preparation/administration
*(vs. FFP **X-matching** & **thawing**)*
TACO (-)
(vs. FFP 15-20 ml/kg for sufficient clotting)
TRALI (-)
*(vs. residual **plasma** in FFP)*
More factors-II VII IX X (vs. II VII X in FFP)
Anti-thrombotic ingredient
Protein C, Protein S, Antithrombin, heparin

Fibrinogen concentrate (vs. Cryo)

Faster preparation/administration
(vs. X-matching thawing in Cryo)
Higher purity:TRALI (-)
*(vs. residual **plasma** in Cryo)*
Accurate dosing:
standardized content
Improved safety
-pathogen reduction technology

Fibrinogen concentrate (vs. Cryo)

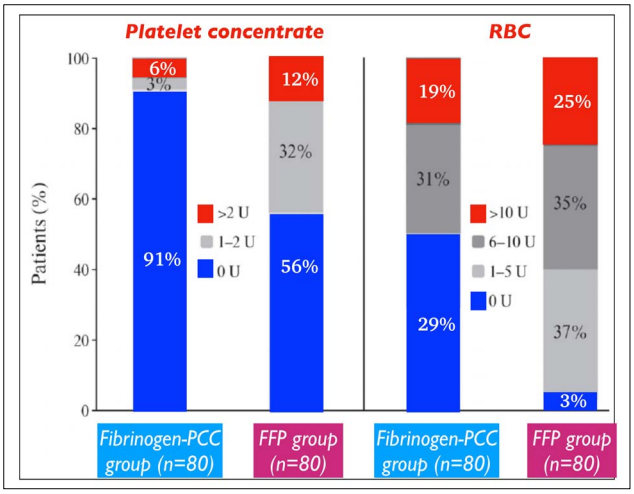
Schöchl et al. Critical Care 2011, 15:R83
http://ccforum.com/content/15/2/R83

CRITICAL CARE

RESEARCH Open Access

Transfusion in trauma: thromboelastometry-guided coagulation factor concentrate-based therapy versus standard fresh frozen plasma-based therapy

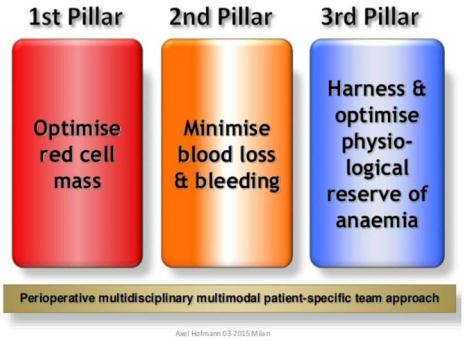
Herbert Schöchl[1,2], Ulrike Nienaber[3], Marc Maegele[4], Gerald Hochleitner[5], Florian Primavesi[2], Beatrice Steitz[6], Christian Arndt[7], Alexander Hanke[8], Wolfgang Voelckel[2] and Cristina Solomon[6*]



CURRENT OPINION

Applying 'Patient Blood Management' in the trauma center

Oliver M. Theusinger, Philipp Stein, and Donat R. Spahn

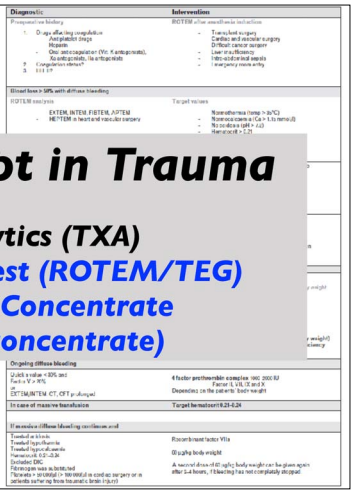


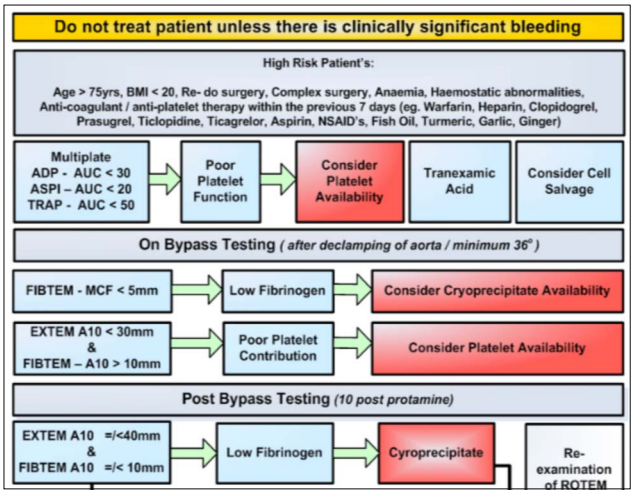
Axel Hofmann 03-2015 Milan

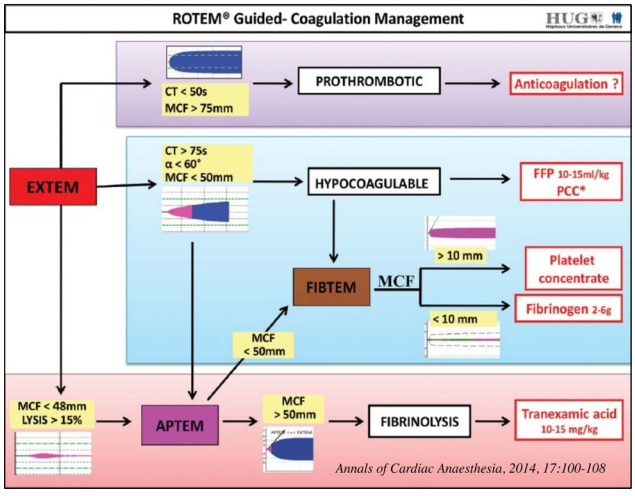
PBM concept in Trauma

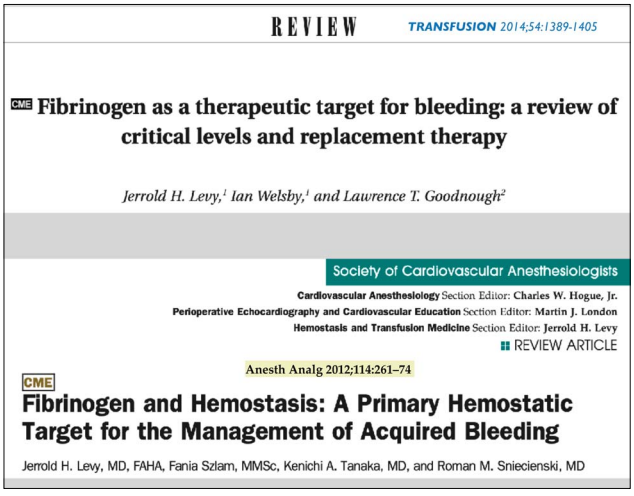
Early anti-fibrinolytics (TXA)
POC-viscoelastic test (ROTEM/TEG)
Lyophilized Factor Concentrate (PCC, fibrinogen concentrate)

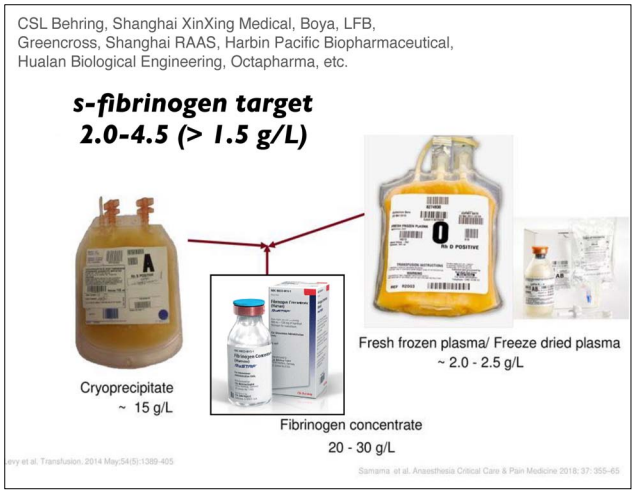
3rd ver of Transfusion Algorithm
University Hospital of Zurich 2013, Switzerland

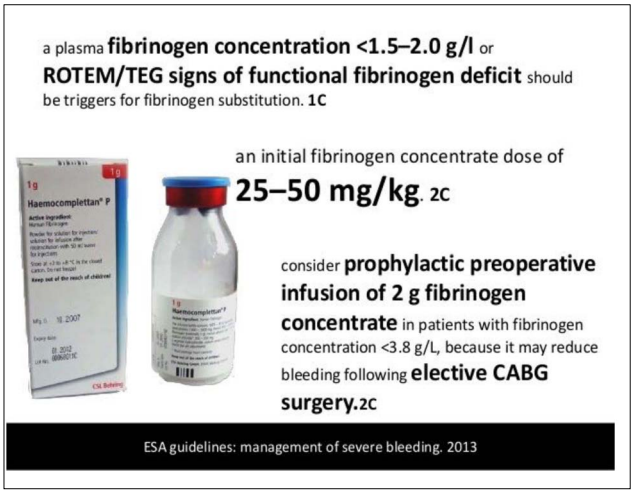


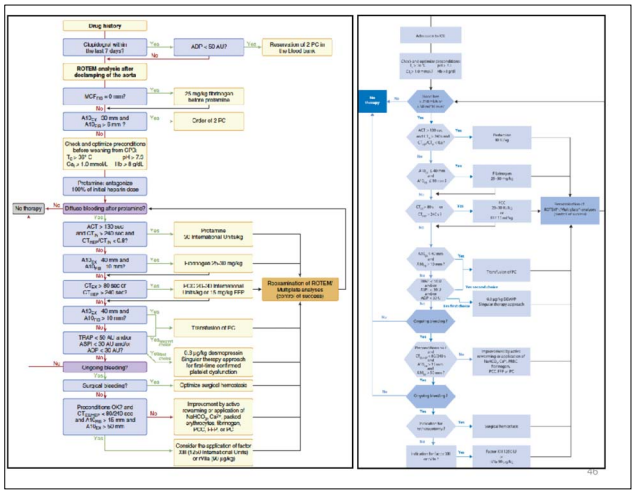


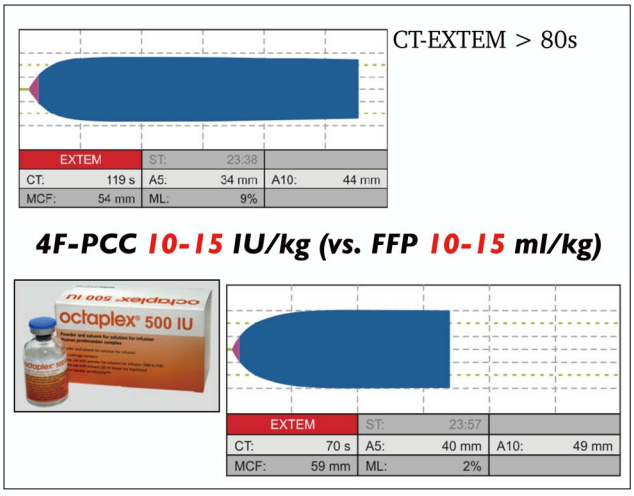

ROTEM® Guided- Coagulation Management
HUG
EXTEM
CT < 50s
MCF > 75mm
PROTHROMBOTIC
Anticoagulation ?
CT > 75s
α < 60°
MCF < 50mm
HYPOCOAGULABLE
FFP 10-15ml/kg
PCC*
FIBTEM
MCF
> 10 mm
Platelet concentrate
Fibrinogen 2-6g
< 10 mm
MCF < 50mm
MCF < 48mm
LYSIS > 15%
APTEM
MCF > 50mm
FIBRINOLYSIS
Tranexamic acid
10-15 mg/kg
Annals of Cardiac Anaesthesia, 2014, 17:100-108

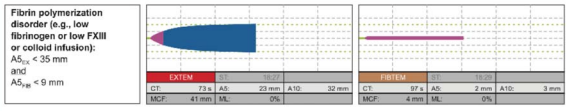

REVIEW
TRANSFUSION 2014;54:1389-1405
CME
Fibrinogen as a therapeutic target for bleeding: a review of critical levels and replacement therapy
Jerrold H. Levy,[1] Ian Welsby,[1] and Lawrence T. Goodnough[2]
Society of Cardiovascular Anesthesiologists
Cardiovascular Anesthesiology Section Editor: Charles W. Hogue, Jr.
Perioperative Echocardiography and Cardiovascular Education Section Editor: Martin J. London
Hemostasis and Transfusion Medicine Section Editor: Jerrold H. Levy
REVIEW ARTICLE
Anesth Analg 2012;114:261–74
CME
Fibrinogen and Hemostasis: A Primary Hemostatic Target for the Management of Acquired Bleeding
Jerrold H. Levy, MD, FAHA, Fania Szlam, MMSc, Kenichi A. Tanaka, MD, and Roman M. Sniecienski, MD


CSL Behring, Shanghai XinXing Medical, Boya, LFB,
Greencross, Shanghai RAAS, Harbin Pacific Biopharmaceutical,
Hualan Biological Engineering, Octapharma, etc.
s-fibrinogen target
2.0-4.5 (> 1.5 g/L)
Cryoprecipitate
~ 15 g/L
Fibrinogen concentrate
20 - 30 g/L
Fresh frozen plasma/ Freeze dried plasma
~ 2.0 - 2.5 g/L


a plasma fibrinogen concentration <1.5–2.0 g/l or ROTEM/TEG signs of functional fibrinogen deficit should be triggers for fibrinogen substitution. 1C
an initial fibrinogen concentrate dose of
25–50 mg/kg. 2C
consider prophylactic preoperative infusion of 2 g fibrinogen concentrate in patients with fibrinogen concentration <3.8 g/L, because it may reduce bleeding following elective CABG surgery.2C
ESA guidelines: management of severe bleeding. 2013




CT-EXTEM > 80s
EXTEM ST: 23:38
CT: 119 s A5: 34 mm A10: 44 mm
MCF: 54 mm ML: 9%
4F-PCC 10-15 IU/kg (vs. FFP 10-15 ml/kg)
octaplex® 500 IU
EXTEM ST: 23:57
CT: 70 s A5: 40 mm A10: 49 mm
MCF: 59 mm ML: 2%



Fibrinogen/cryoprecipitate substitution

Cut-off values* to *A5-FIBTEM (ROTEM)

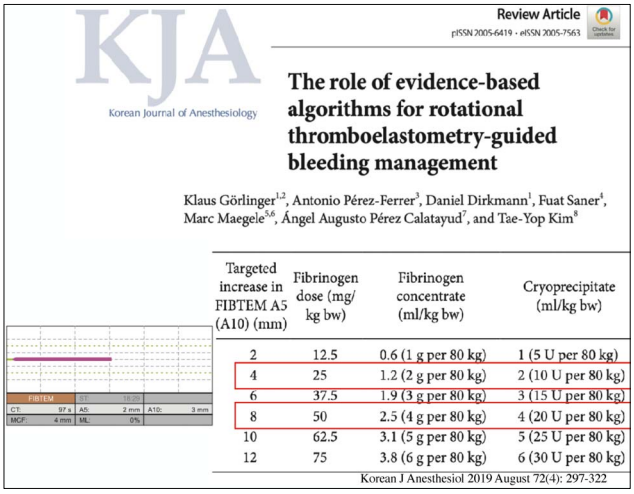
< (8-)9 mm

*In post-CPB, **trauma** & LT, orthopedic surgery*

<12 mm

In post-partum hemorrhage

Korean J Anesthesiol 2019 August 72(4): 297-322



KJA
Korean Journal of Anesthesiology

Review Article

pISSN 2005-6419 • eISSN 2005-7563

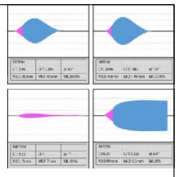
The role of evidence-based algorithms for rotational thromboelastometry-guided bleeding management

Klaus Görlinger[1,2], Antonio Pérez-Ferrer[3], Daniel Dirkmann[1], Fuat Saner[4], Marc Maegele[5,6], Ángel Augusto Pérez Calatayud[7], and Tae-Yop Kim[8]

Targeted increase in FIBTEM A5 (A10) (mm)	Fibrinogen dose (mg/kg bw)	Fibrinogen concentrate (ml/kg bw)	Cryoprecipitate (ml/kg bw)
2	12.5	0.6 (1 g per 80 kg)	1 (5 U per 80 kg)
4	25	1.2 (2 g per 80 kg)	2 (10 U per 80 kg)
6	37.5	1.9 (3 g per 80 kg)	3 (15 U per 80 kg)
8	50	2.5 (4 g per 80 kg)	4 (20 U per 80 kg)
10	62.5	3.1 (5 g per 80 kg)	5 (25 U per 80 kg)
12	75	3.8 (6 g per 80 kg)	6 (30 U per 80 kg)

Korean J Anesthesiol 2019 August 72(4): 297-322

Tranexamic Acid



***Antifibrinolytic Tx** considered in bleeding trauma*

***TXA** 10-15 mg/kg & 1-5 mg/kg/hr*

*(**CRASH II study, 1 g in 10 min & 1 g for 8 hrs**)*

***ε-aminocaproic acid** 100-150 mg/kg & 15 mg/kg/hr*

*stop **TXA** once bleeding is adequately controlled, and apply **ROTEM/TEG** if possible*

***ROTEM/TEG monitoring** in all patients and with antifibrinolytic agents*

Rossaint et al Crit Care 2010; 14: R52
Rossaint et al Crit Care 2016; 20: 100

Summary

+ *Routine POC-viscoelastic test*

↑goal-directed

↑individualized

+ *PCC/FC-based management*

↑efficacy of POC-viscoelastic test

↑prompt timing

↓ side effects

(vs. plasma/cryoprecipitate-based)

2022년
대한외상마취연구회 온라인 세미나

발 행 2022년 6월 25일

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