Role of Cardiothoracic Surgeon in Severe Multiple Trauma

H. M. Cho

Department of Trauma & Surgical Critical Care,
Konyang University Hospital, Daejeon, Korea

Trauma *CENTER* : hospital that meets certain requirements for the excellent care of trauma patients.

Trauma *SYSTEM* : regional system of care that includes all providers - prehospital, hospital and rehabilitation.

Trauma systems

Ideal Trauma System

- Leadership
- System development
- Pre-hospital care
- Definitive hospital care
- Data collection
- Trauma system evaluation
- Public information
- Education and prevention
- Human resources
- Legislation and finances

Trauma: The Genesis of a System

- 1970s – Lessons from Viet Nam – Early transfer to surgery = improved outcomes
- Translated to civilian environment
- Bypass Smaller Facilities With All Trauma – Exclusive Model

Evolution of Civilian Trauma Systems

- 1966

  NAS: Accidental Death and Disability - The Neglected Disease of Modern Society

  National Highway Safety Act
- 1969

  MIEMSS
- 1971

  Illinois Trauma Program

Evolution of Civilian Trauma Systems

- Exclusive System
  - Acts to centralize all injuries, regardless of type or severity, at tertiary centers
  - Excludes acute care facilities with unknown or variable capabilities
  - Favors over-triage to avoid any under-triage

Evolution of Civilian Trauma Systems

- Problems with Exclusive System
  - Delayed transport → Delayed Care
  - Triage based on likelihood of admission rather than tiered resource utilization
  - Perpetuates non-participation of non-categorized facilities and places them outside the PI process.
  - Lack of experience during MCI

Evolution of Civilian Trauma Systems

- 1973 Emergency Medical Services Act
- 1976: Optimal Hospital Resources for Care of the Injured Patient (ACS)
- 1979 Orange County Study
- 1992: The Model Trauma Care System Plan (HRSA, 2006))
  - Introduced “Inclusive System”

Evolution of Civilian Trauma Systems

- Inclusive System
  - Assumes all acute care facilities are part of a larger integrated system
  - Tiered approach built on known quantity of available & invariable resources

Trauma System

Inclusive vs. Exclusive

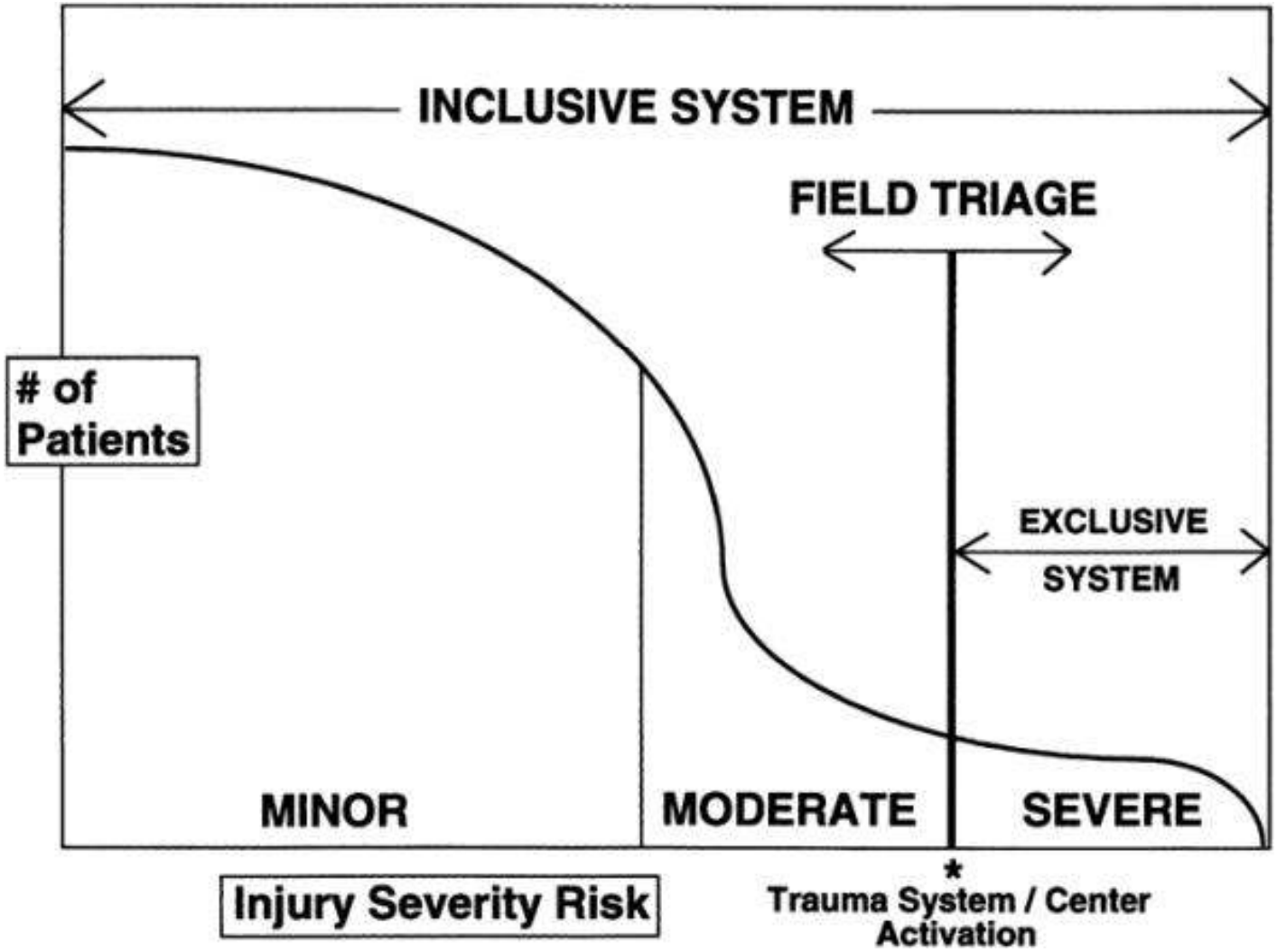
Exclusive Model

- Improved Trauma Outcomes – Penetrating Trauma
- Over-Triage and Selective Triage
- Patient Dumping
- Loss of Smaller Facility Utilization
- Unachievable in Rural Area

Inclusive Model

- Developed in Washington and Oregon in 1990s
- Recognition That Most Injuries Don’t Need Level I Trauma Care
- Increased Organizational Response at Smaller Facilities
- Less Over Triage and Selective Triage
- Role for All Facilities

Innovative concept: Inclusive Trauma Care System



Inclusive system	Exclusive system
• All compassing approach, from **pre-hospital care** through **acute care** and **rehabilitation** • Provide optimal care & available resources for **all injured patients** • less expensive • more recent type	• Focuses only on the **major trauma patient** in the major trauma center cared for by the trauma team • **expensive** • traditional trauma system

Trauma System

Inclusive > Exclusive

Inclusive Trauma System

- To match each trauma care facility's (or provider's) resources to the needs of injured patients

  → every patient receives optimal care from the initial recognition of the injury through return to the community.
- To care for the most severely injured patients & for the majority of less severely injured.

Level I Trauma Center

- Lead Hospital
- Designated as a **regional resource leader** within a service area
- Generally serves large numbers of injured patients with a certain severity level of injury
- Must be able to manage large numbers of injured patients with a certain severity level of injury
- Expected to conduct **trauma research**
- Be a leader in **education**, **prevention** and **out reach activity**

Trauma Care Facilities

Level II

- Provides comprehensive trauma care in two environments
- population-dense area where this facility supplements the clinical activity and expertise of a Level I center
- A less population-dense area where the facility serves as the lead trauma facility for a geographic area when a Level I institution is not geographically close : Must have an outreach program that involves smaller institutions in its service area

Trauma Care Facilities

Level III

- Must have continuous general surgical coverage
- Must be capable of managing the initial care of the majority of injured
- Must have transfer agreements with other trauma hospitals for patients that exceed its patient care resources

Level IV

- Located in a rural area
- Usually supplements care within a larger trauma system
- Provide initial evaluation and assessment of injured patients, but most require transfer to higher level trauma centers

Trauma Center Type ?

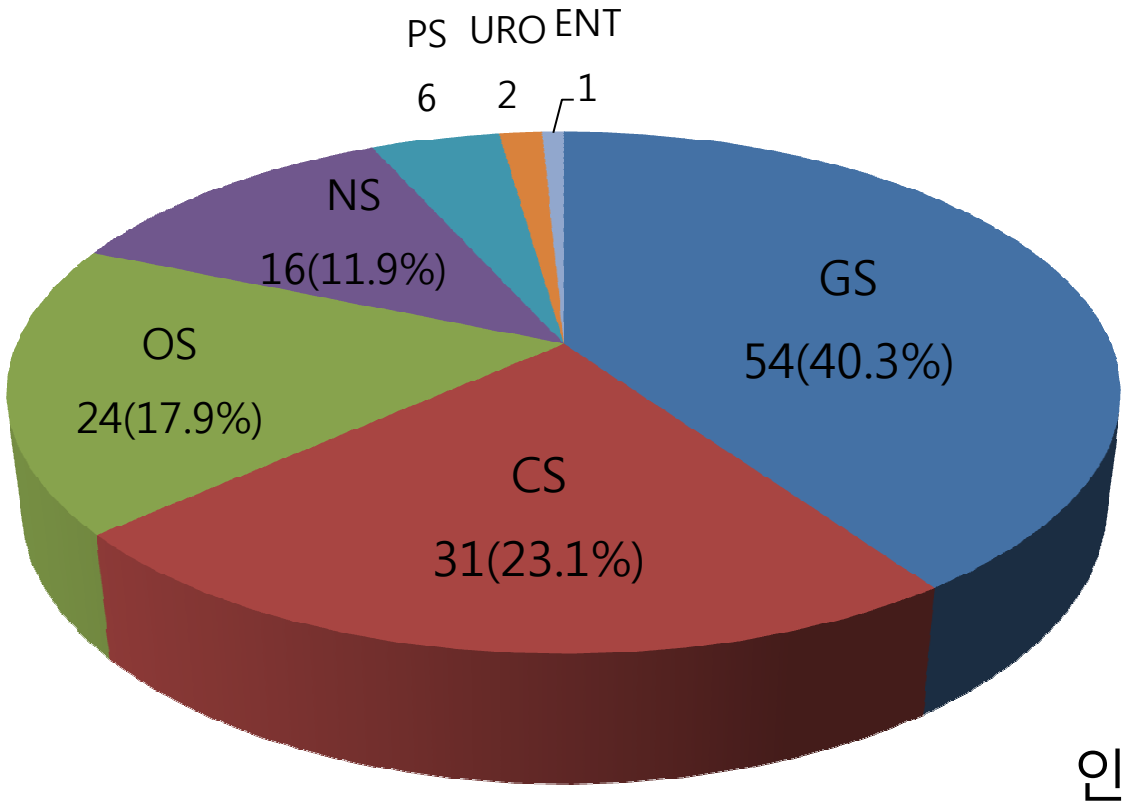
< Exclusive


772
2010.03.26


2010.11.23


2011.01.21

외상외과 세부전문의(2012, N=134)



인원수(%)

2013년 외상외과 세부전문의(N=11)

김선희 (부산대학교병원)-흉부외과
김영환 (아주대병원)-외과
심홍진 (신촌세브란스병원)-외과
윤정석 (단국대학교병원)-외과
이경학 (서울대학교병원)-정형외과
이승택 (목포중앙병원)-외과
정경원 (아주대학교병원)-외과
정규환 (분당서울대학교병원)-외과
최석진 (전북대학교병원)-외과
최석호 (서울대학교병원)-외과
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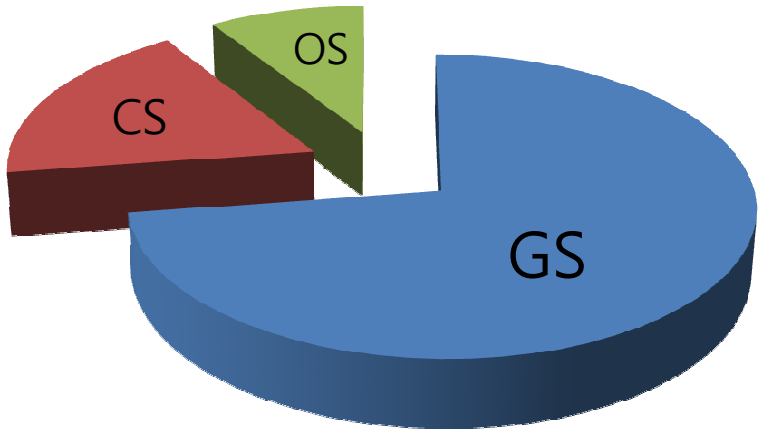


Lethal Injuries & Time to Death

Table 4. Cause of Death and Mechanism of Injury for Deaths Occurring Within the First Hour and 24 Hours After Arrival at the Hospital

Lethal injuries	All	Blunt	Penetrating
Central nervous system	165	92	73
Multiple*	63	56	7
Thoracic vascular	32	18	14
Abdominal vascular	18	0	18
Liver	6	4	2
Other	6	6	0
Total	290	176	114

*Multiple injuries are cause of death.

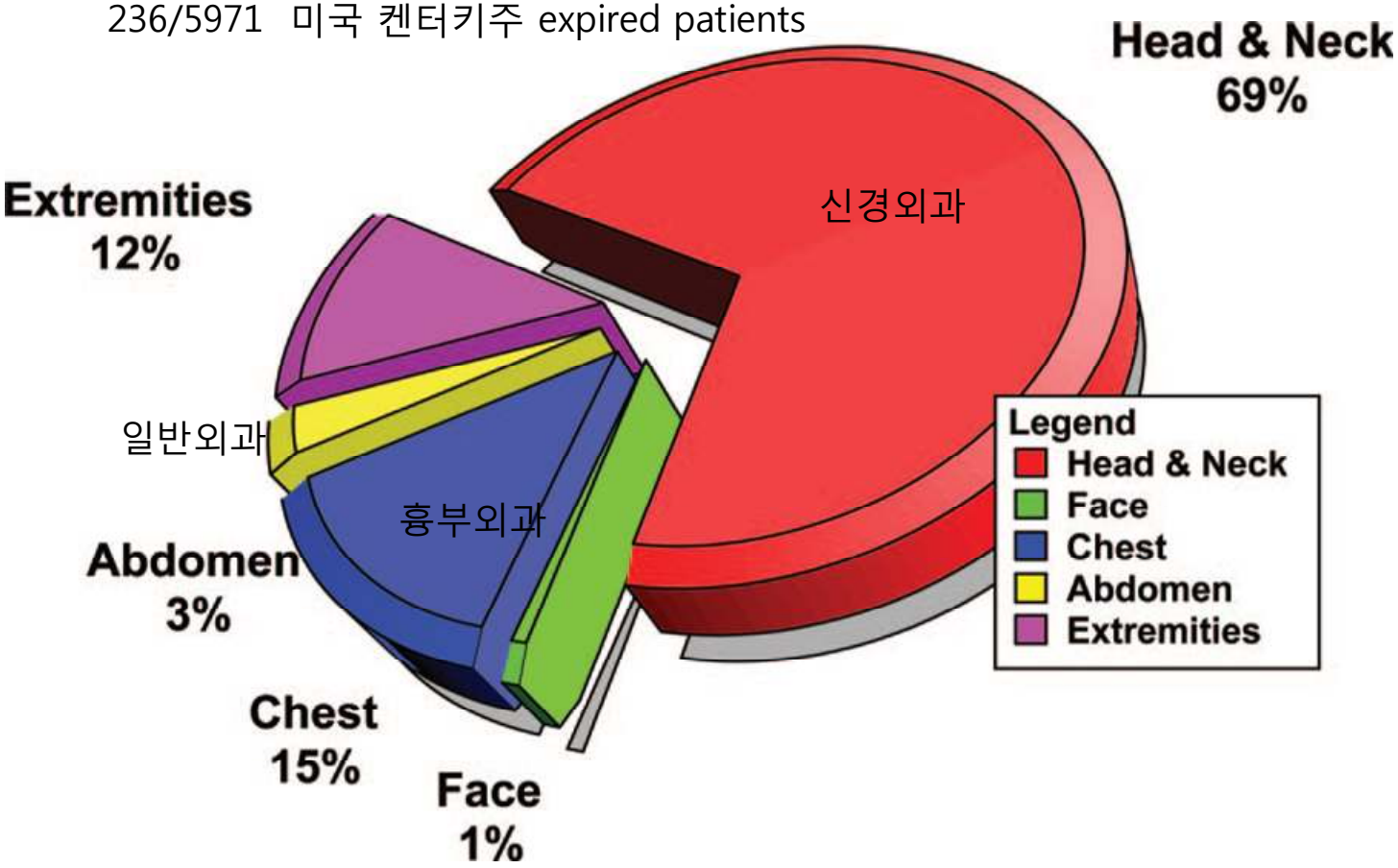
Lethal Injuries & Time to Death

Table 5. Cause of Death and Mechanism of Injury for Deaths Occurring After the First 24 Hours and Before 72 Hours After Arrival at the Hospital

Lethal injuries	All	Blunt	Penetrating
Central nervous system	77	59	18
Acute inflammatory process	7	6	1
Thoracic vascular	5	1	4
Multiple*	4	4	0
Abdominal vascular	1	0	1
Other	5	5	0
Total	99	75	24

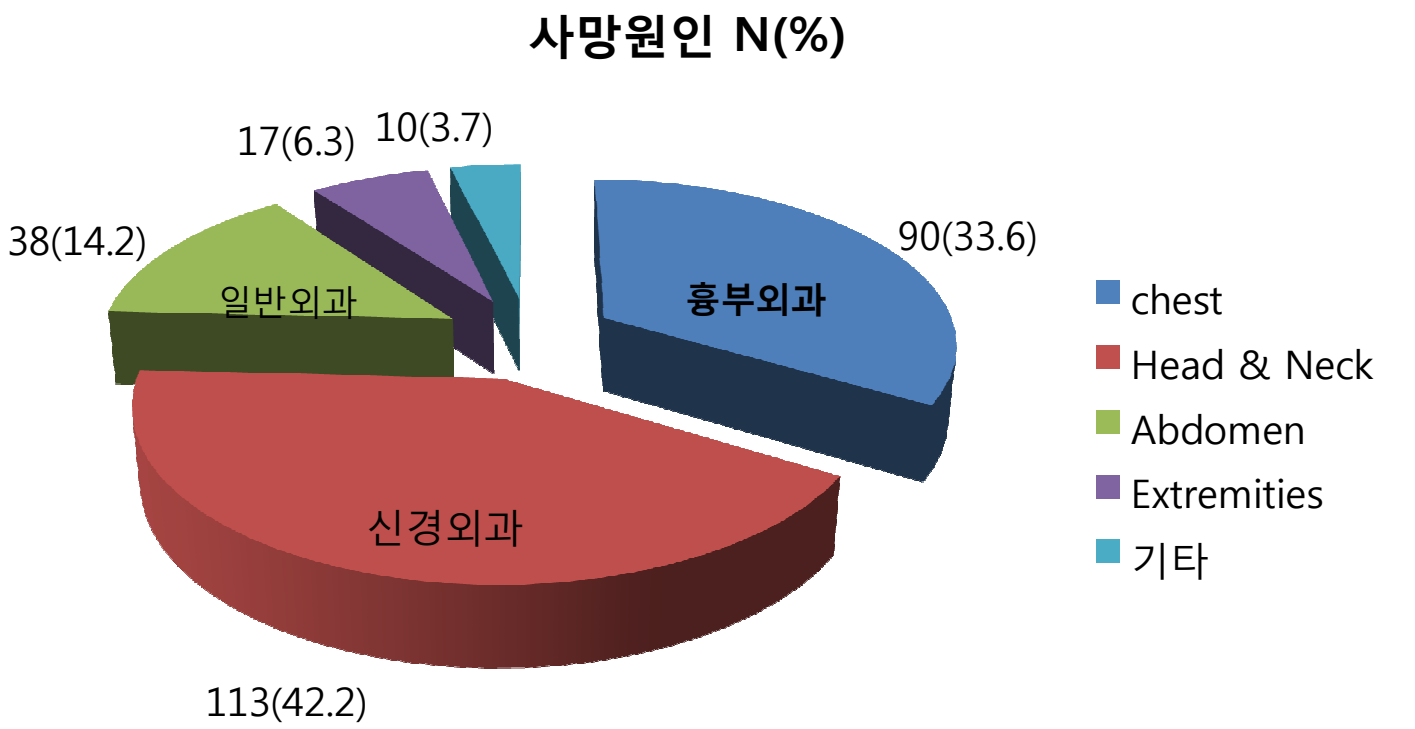
*Multiple injuries are cause of death.

236/5971 미국 켄터키주 expired patients



Ferraris et al. The Journal of ***TRAUMA® Injury, Infection, and Critical Care • Volume XX, Number XX, XXX 2010***

국내사망환자 원인 분석(N=268/17001)



Predominant injury in trauma patients who expired

2010 대한흉부심장혈관외과학회

Lethal Injuries & Time to Death

Table 2. Cause of Death and Mechanism of Injury for Deaths Occurring Within the First 15 Minutes After Arrival at the Hospital

Lethal injuries	All	Blunt	Penetrating
Thoracic vascular	103	33	73
Central nervous system	65	33	32
Multiple*	28	24	4
Pelvic fracture	1	1	0
Liver	3	2	1
Abdominal vascular	15	6	9
Other	4	4	0
Total	219	103	119

*Multiple injuries are cause of death.

Lethal Injuries & Time to Death

Table 3. Cause of Death and Mechanism of Injury for Deaths Occurring Within the First 16–60 Minutes After Arrival at the Hospital

Lethal injuries	All	Blunt	Penetrating
Thoracic vascular	49	6	43
Central nervous system	25	16	9
Multiple*	26	21	5
Liver	4	4	0
Abdominal vascular	11	1	10
Other	4	2	2
Total	119	50	69

*Multiple injuries are cause of death.

TABLE 4. Mechanism of Injury (N = 434)

Mechanism	n	Percent
MVC	187	43.0
Fall	61	14.0
Firearms	49	11.0
Motorcycle crash	20	5.0
Pedestrian struck	18	4.0
Hangings	17	4.0
ATV—bicycle	16	4.0
Industrial	14	3.0
Stab wounds	8	2.0
Horses	7	2.0
Aircraft	5	1.0
Other	32	7.0
Total	434	100

ATV, all-terrain vehicle.

TABLE 5. Preventability Rates

	n	Percent
Preventability for all cases (N = 434)		
FP	3	0.7
PP	26	6.0
NP deaths	405	93.3
Preventability for cases surviving to care (N = 261)		
FP	3	1.0
PP	26	10.0
NP deaths	232	89.0

TABLE 6. Opportunities for Improvement of Care—by Phase of Care

Phase of Care (Patient Contacts)	Inappropriate Care Related to	Number of Occurrences*	Patient Contacts (%)
Prehospital (n = 254)	Airway management	58	45
	C-spine	10	8
	Documentation	13	10
	Fluid resuscitation	31	24
	Medication	18	14
Total prehospital		130	
ED (n = 248)	Airway management	28	17
	Documentation	24	15
	Fluid resuscitation	18	11
	Evaluation of abdomen or chest	14	8
	Inappropriate imaging/ diagnostics	16	10
	Management of chest injury	17	10
	Other	39	24
	Recognition of injury severity	9	5
Total ED		165	
Post-ED (n = 141)	Documentation	4	7
	Fluid resuscitation	2	4
	Inappropriate operation	17	30
	Management or monitoring of head injury	4	7
	Other	21	38
	Treatment of rebleeding	4	7
	Ventilator care	4	7
Total post-ED		56	
Total all phases		351	

* Some patients were noted to have multiple errors in a single phase of care.

Trauma surgery

- surgical specialty involved in the invasive treatment of physical injuries, typically in an emergency setting
- most injuries to the neck, chest, abdomen & extremities
- initial resuscitation & stabilization of the patient, as well as ongoing evaluation & management (surgical critical care)
- leads the trauma team

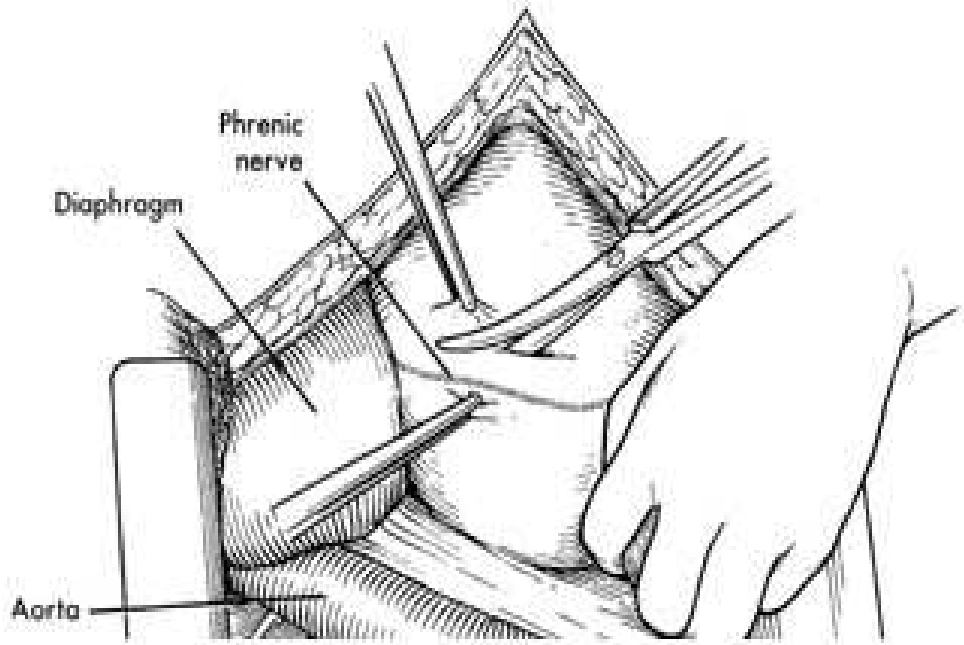
ER thoracotomy

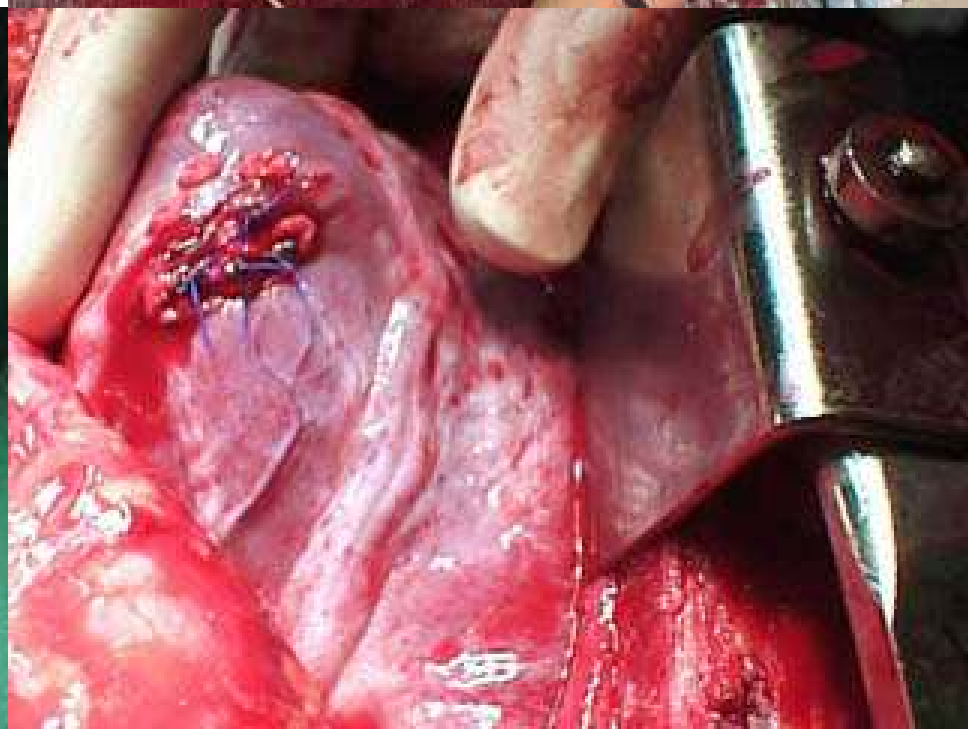
Accepted Indications ; selected patients

- **Penetrating thoracic injury**
  - Traumatic arrest with previously witnessed cardiac activity
  - Unresponsive hypotension (BP < 70 mmHg)
- **Blunt thoracic injury**
  - Unresponsive hypotension (BP < 70 mmHg)
  - Rapid exsanguination from chest tube (> 1500 ml)

Contraindications ; unnecessary thoracotomy

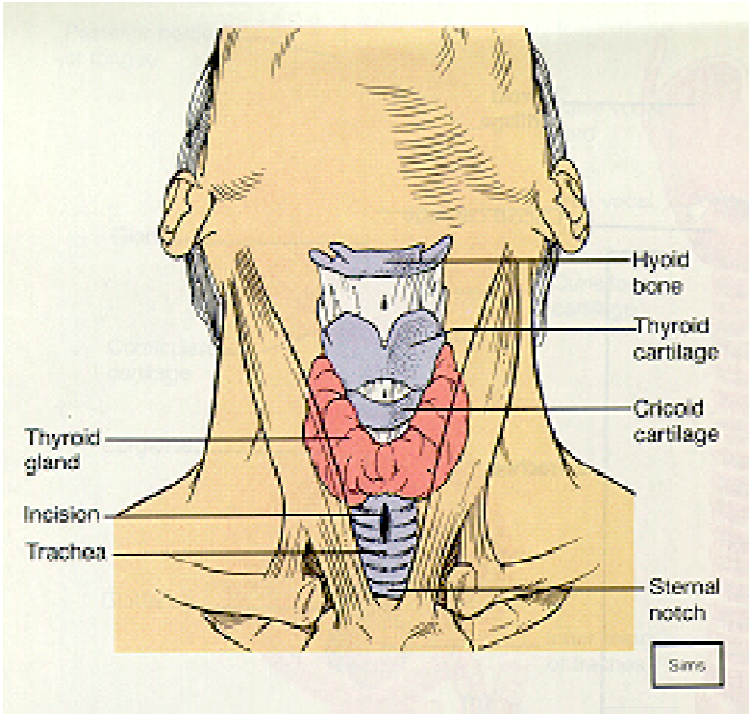
- Blunt injuries
  - Blunt thoracic injuries with no witnessed cardiac activity
  - Multiple blunt trauma
  - Severe head injury


Phrenic
nerve
Diaphragm
Aorta



Airway Management

Tracheostomy



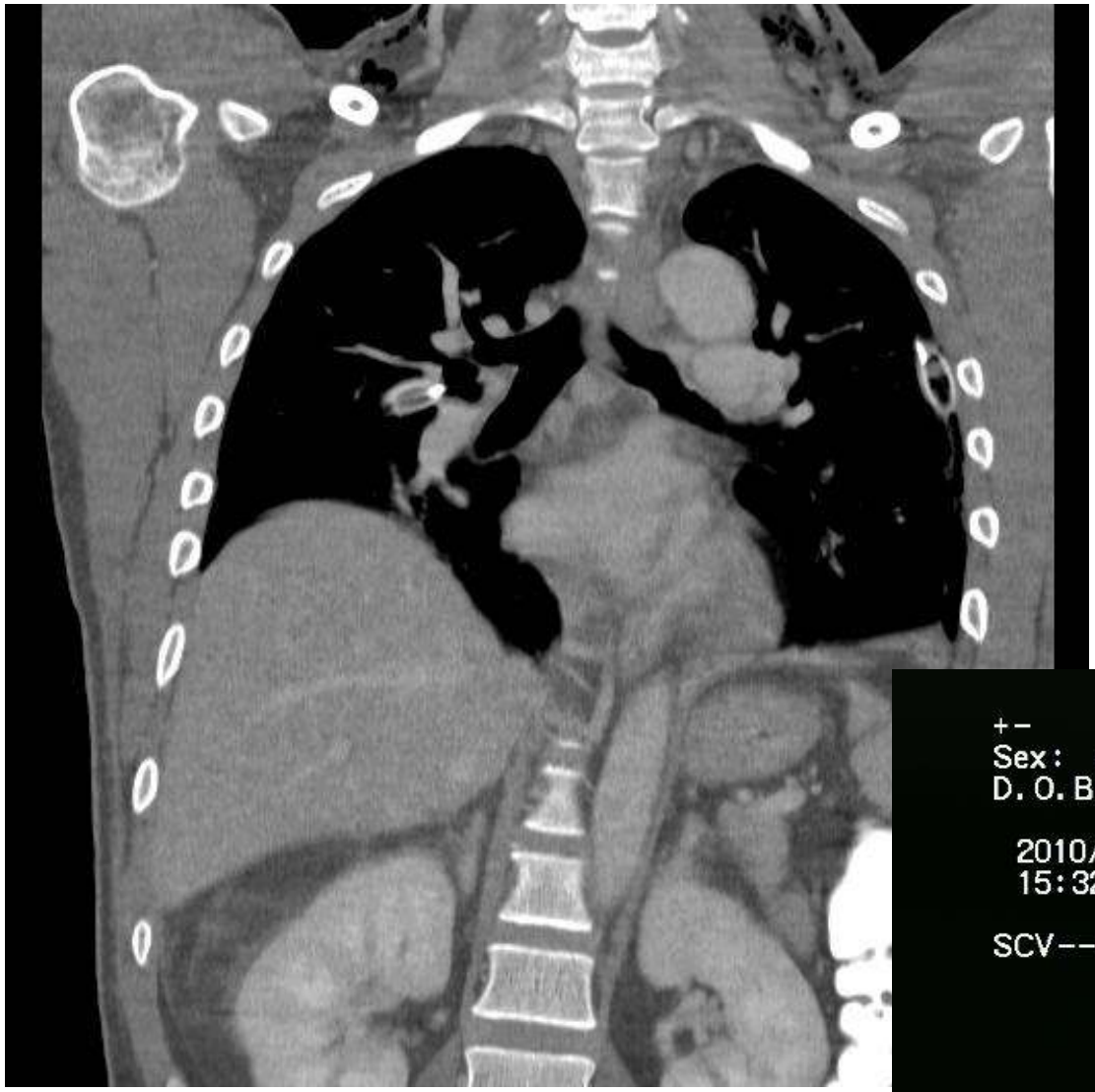
PDT

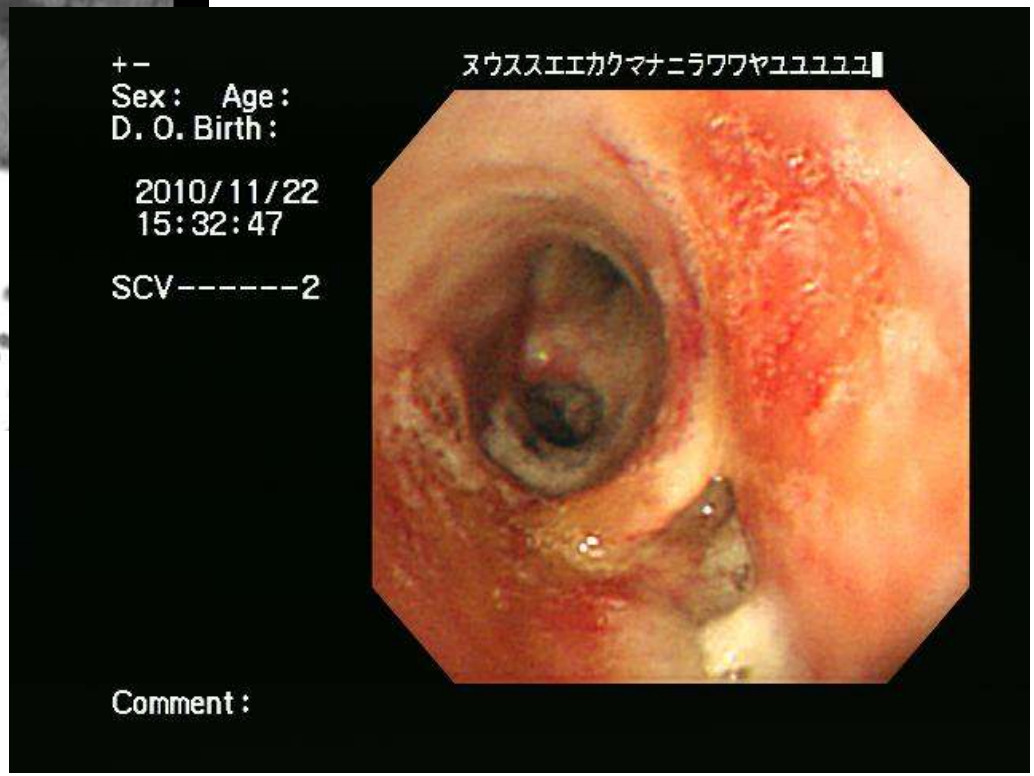
FIGURE 2. Percutaneous dilational tracheostomy (Ciaglia technique). From deBoisblanc BP. Percutaneous dilational tracheostomy techniques. Clin Chest Med. 2003;24:399-407, with permission from Elsevier.

The Role of Surgeon

(airway management)

- ↑Tracheostomy outside OR(ICU)
- PDT > ST
- 7% of elective PDT : conversion to ST
- Contraindications of PDT
  - morbid obesity
  - repeated tracheostomy
  - high PEEP
  - severe coagulopathy
  - unusual neck anatomy
- Optimal technique & Timing

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Sex : Age :
D. O. Birth :
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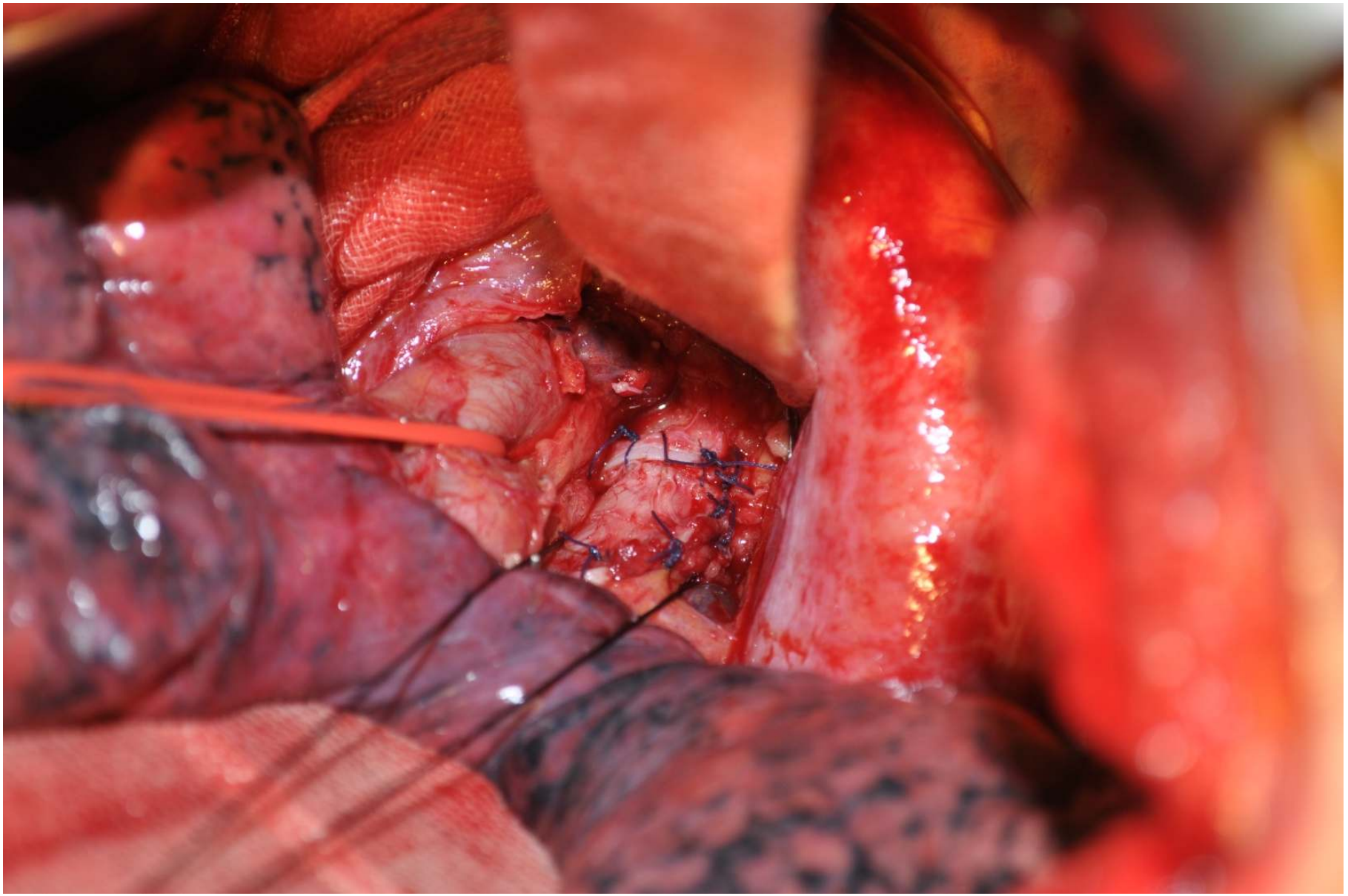

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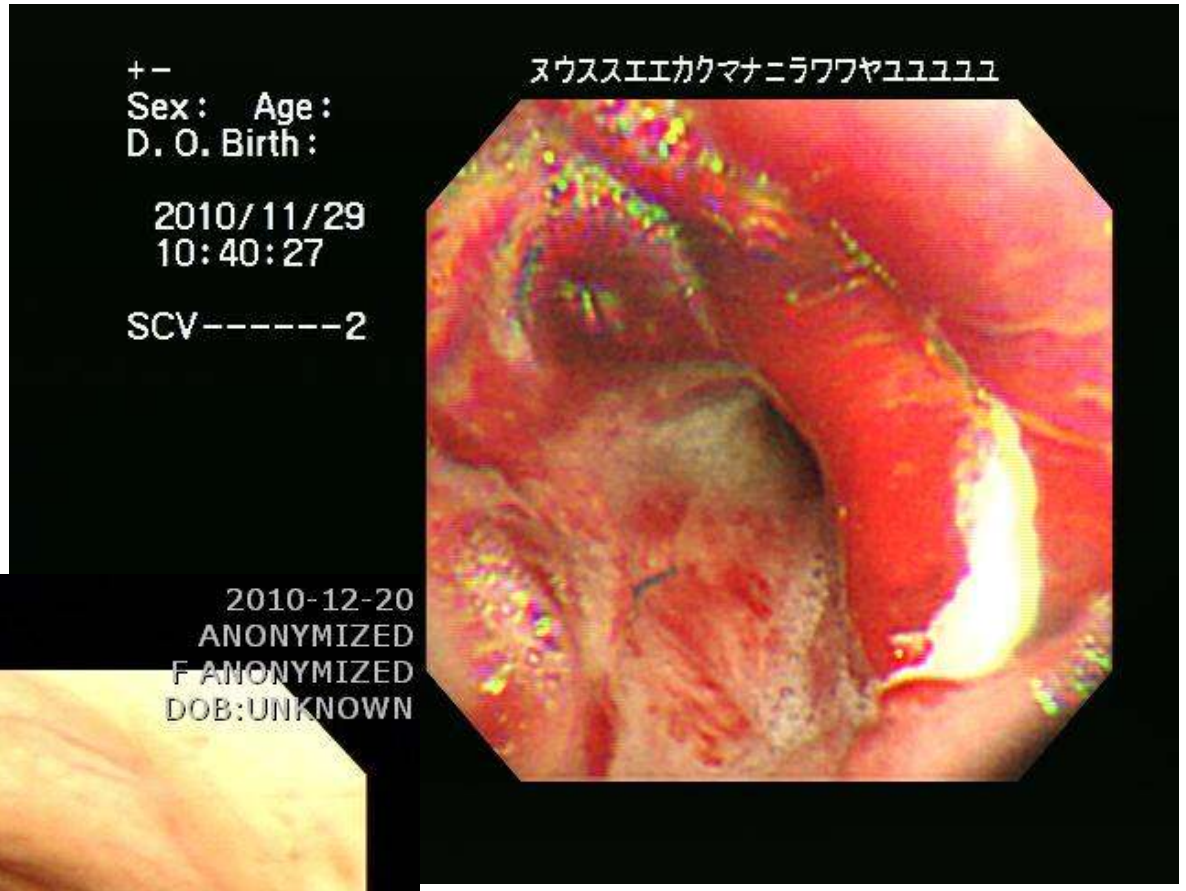
POD #5 ⟶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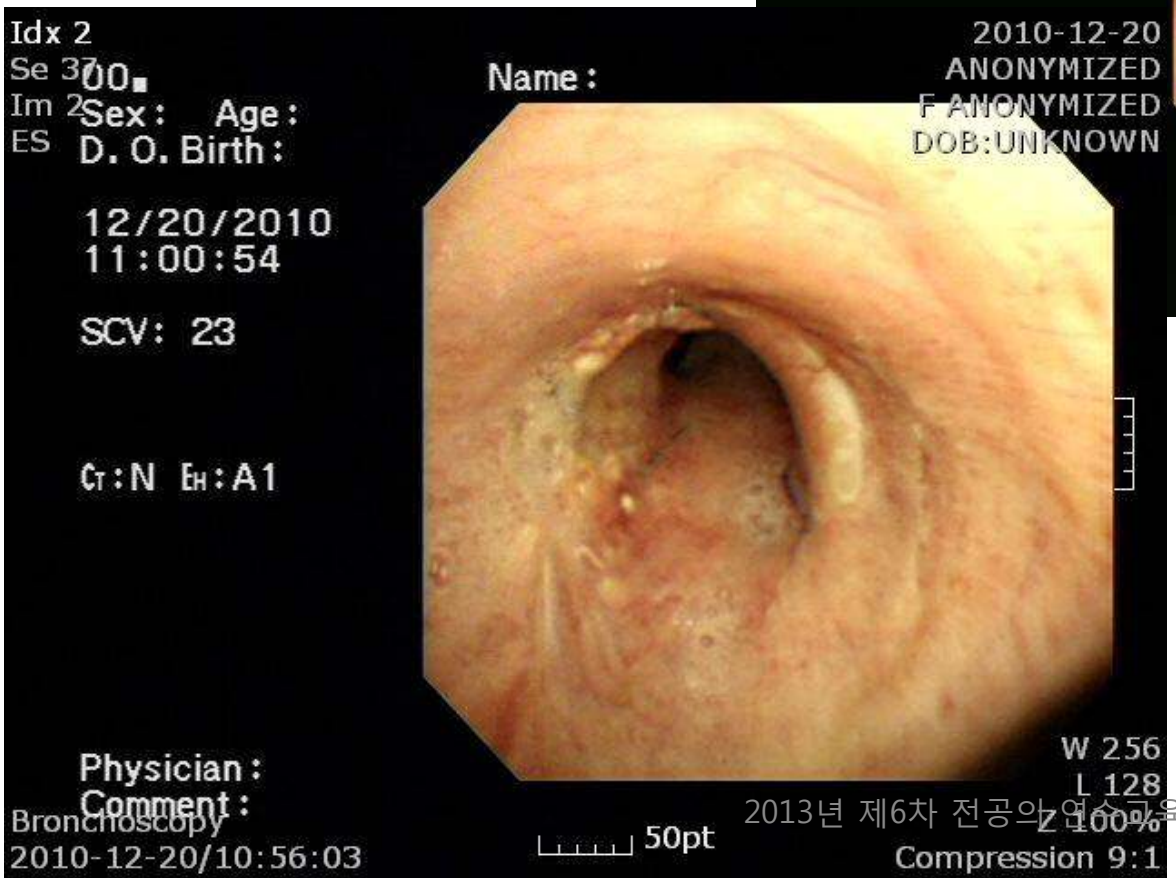
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ES
Name :
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F ANONYMIZED
DOB:UNKNOWN
Sex : Age :
D. O. Birth :
12/20/2010
11:00:54
SCV: 23
CT:N EH:A1
Physician :
Comment :
Bronchoscopy
2010-12-20/10:56:03
50pt
W 256
L 128
Z 100%
Compression 9:1

⟵ POD #26

Variables	<48hrs(n=17)	>48hrs(n=13)	p-value
Age	34.7	46.3	0.413
Gender(M:F)	14:3	9:4	
Op date	1.38	8.17	0.00
ISS	18.1	27.0	0.011
RTS	7.18	6.86	0.062
CT진단	12/14(87.5%)	5/11(45.5%)	0.011
Cause			
blunt	11	13	
penetrating	6	0	
Operation			
repair	12	6	
end-to end	1	2	
lung resection	0	4(pneu:1,lob:3)	
observation	4	1	
Symptoms			
subcutaneous emphysema	17	12	
pneumothorax	5	5	
bleeding	4	0	
intubation	2	6	
Diagnosis			
bronchoscopy	14	11	
no bronchoscopy	3	2	
Mortality	1(shock)	1(ARDS)	

Flail chest & Pulmonary contusion

- **V/Q mismatch**
  - PEEP/CPAP, extubation as early as possible
- **Pulmonary toilet**
  - Physiotherapy, NT suctioning
  - Timely tracheostomy
- **Fluid resuscitation**
  - Colloids? / Hypertonic saline?
- **Pain management** : epidural PCA / TPVB
- ***Surgical fixation*** *: selected patients*

Prospective Trial from Japan

- 37 flail chest patients

  Randomization after

  5 days on ventilation

  -18 rib fixation

  -19 internal pneumatic

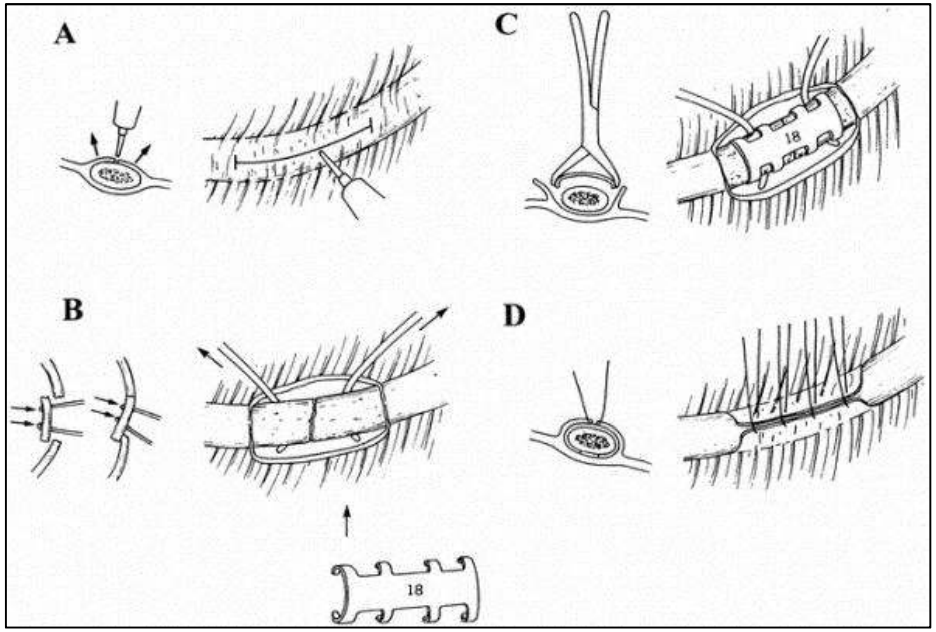


Table 1 Group Demographics of Internal Pneumatic Stabilization Group and Surgical Stabilization Group*

Group	Sex (M/F)	Age (yr)	ISS	No. of Fractures	Site of Flail Segment			Pao_2/Fio_2 at Admission	Tube Thoracotomy
					AL	PL	Stove-In Chest		
Surgical (n = 18)	12/6	43 ± 12	33 ± 11	8.2 ± 3.3	11	4	3	223 ± 68	18/18
Internal (n = 19)	14/5	46 ± 9	30 ± 8	8.2 ± 2.6	14	3	3	256 ± 34	19/19
p Value	NS	NS	NS	NS	NS	NS	NS	NS	NS

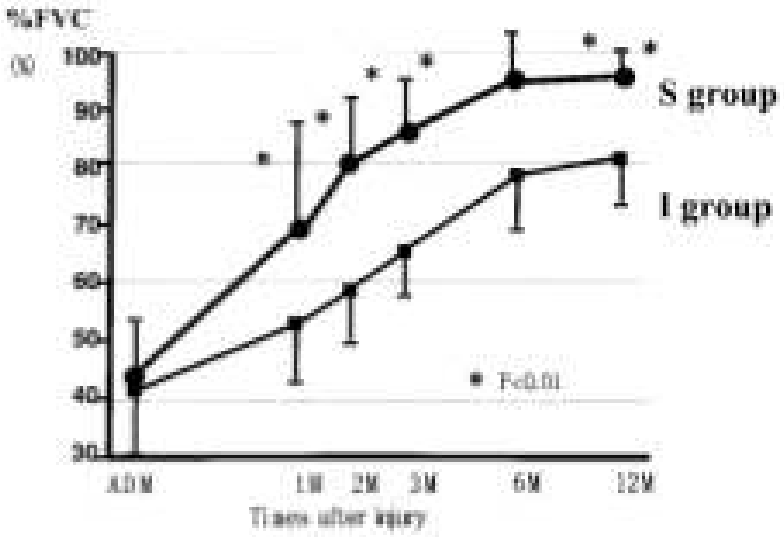
AL, anterolateral; PL, posterolateral; NS, not statistically significant.

* The group demographics were all similar in the two groups; $p < 0.05$ between the two groups. Mean ± SD.

Immediate Results

	Surgical (n=18)	"internal" (n=19)	
Pneumonia, day 7	5%	16%	NS
Pneumonia, day 21	22%	90%	**<.05**
Ventilator days, total (post-op)	10.8 (2.5)	18.3	**<.05**
Tracheostomy, day 7	0	5/19	NS
Tracheostomy, day 21	3/18	15/19	**<.05**
Total ICU stay (post-op)	16.5 (9.2)	26.8	**<.05**
Medical expense	$13,455	$23,423	**<0.5**

Long-term Results

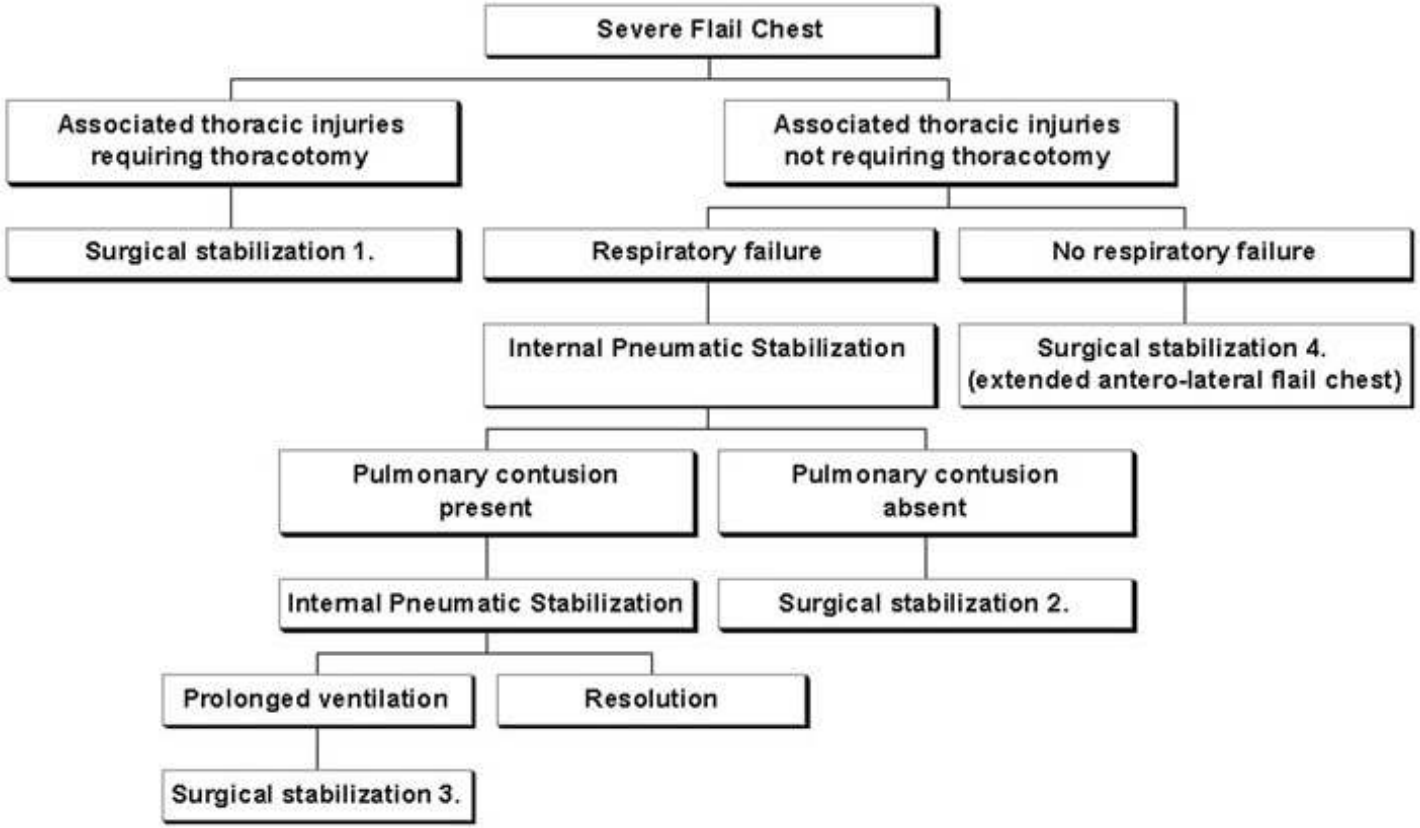


Forced expiratory functional capacity, 0-12 months

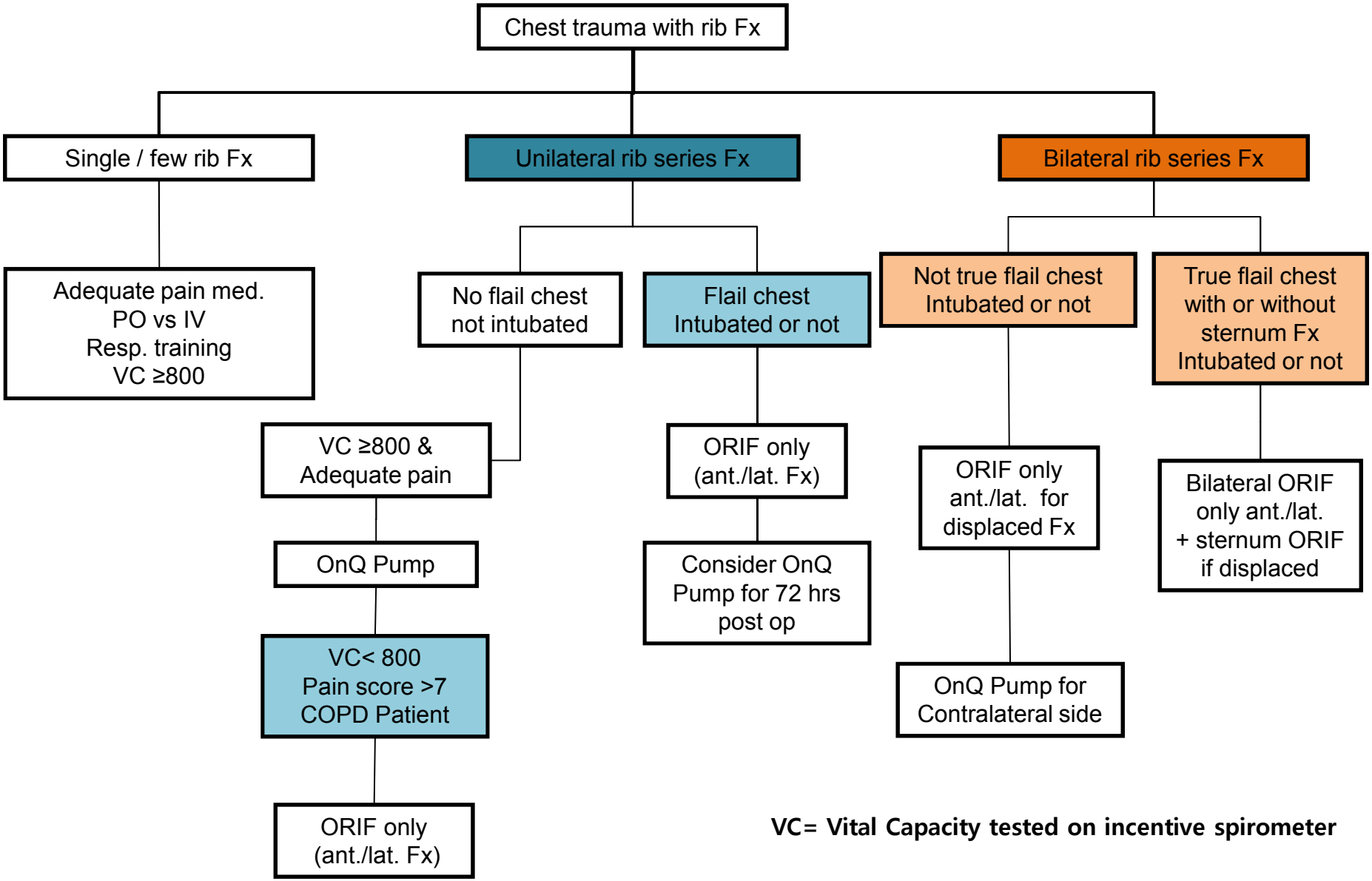
Questionnaire at 12 months after injury

	I group	S group	p value
Chest tightness	16/19(84%)	6/18(33%)	<0.05
Thoracic cage pain	17/19(89%)	7/18(39%)	<0.05
Dyspnea on effort	12/19(63%)	5/18(28%)	<0.05

“Italian” Algorithm



1. Patient who require a thoracotomy for associated thoracic injuries
2. Intubated patients without pulmonary contusion with deteriorating pulmonary function
3. Intubated patients without severe pulmonary contusion and cerebral injuries who fail to wean from the ventilator
4. Patients with extended antero-lateral flail chest and progressive dislocation of the fractured ribs



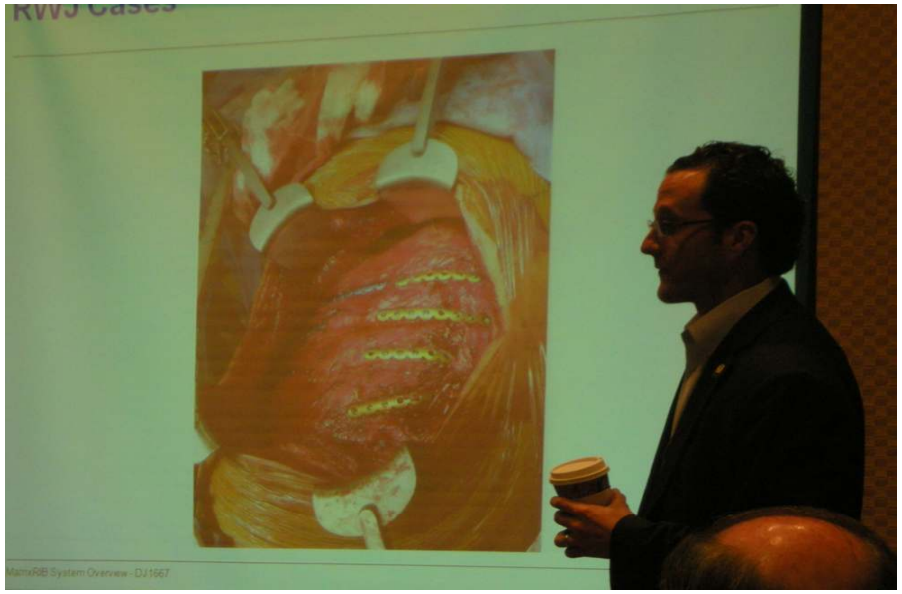
VC= Vital Capacity tested on incentive spirometer

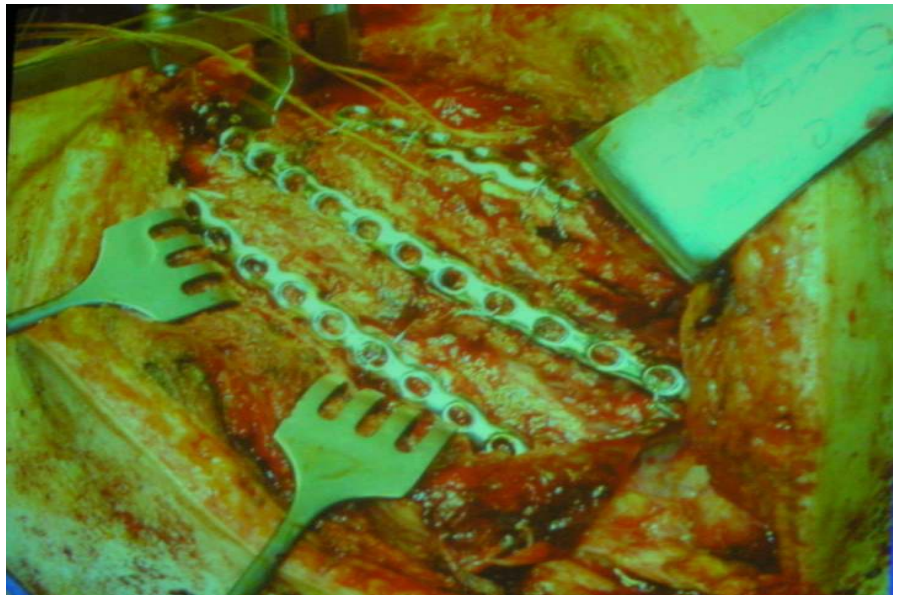
Guidelines of severe MRF(KYUH)

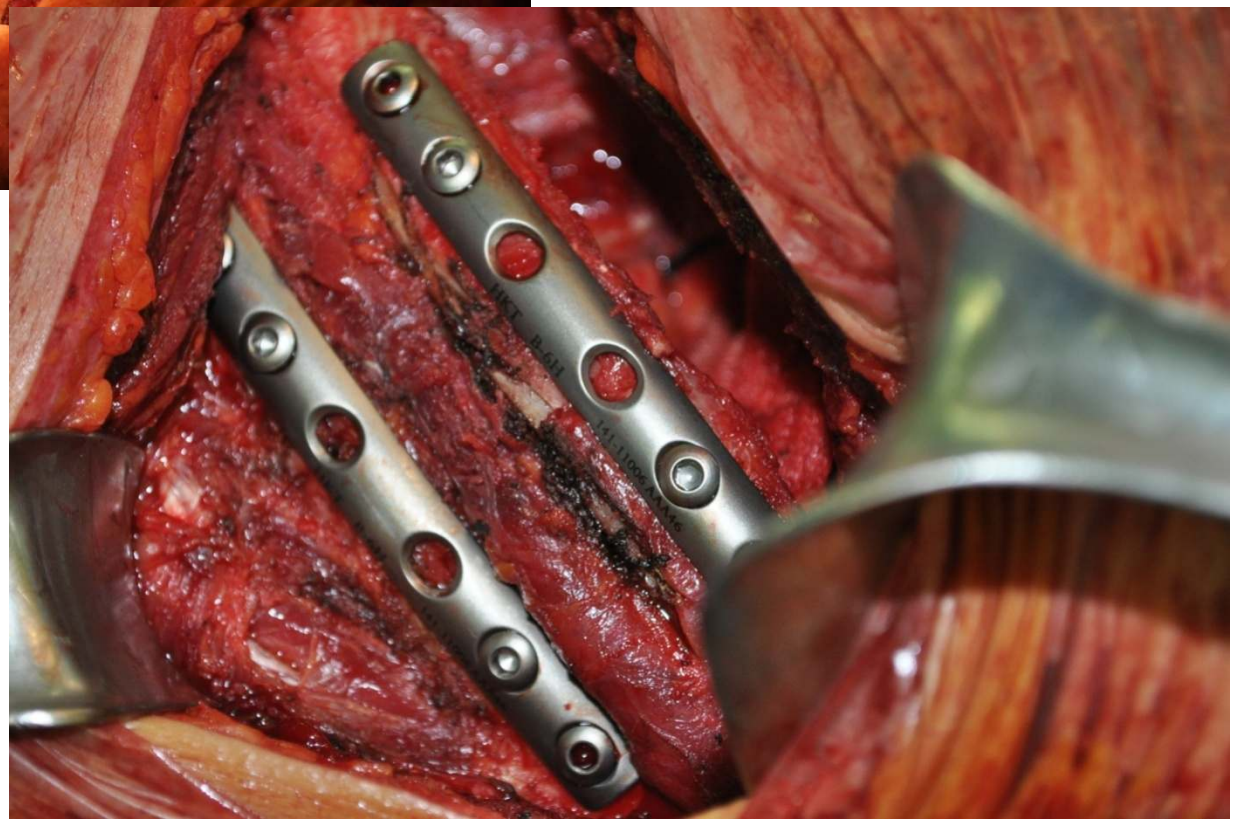
- ***Early Surgical Stabilization***
  - Combined thoracic injury
    emergency thoracotomy
  - Flail chest with respiratory distress
    lung contusion / lung parenchymal injury
  - Anterolateral severe dislocation

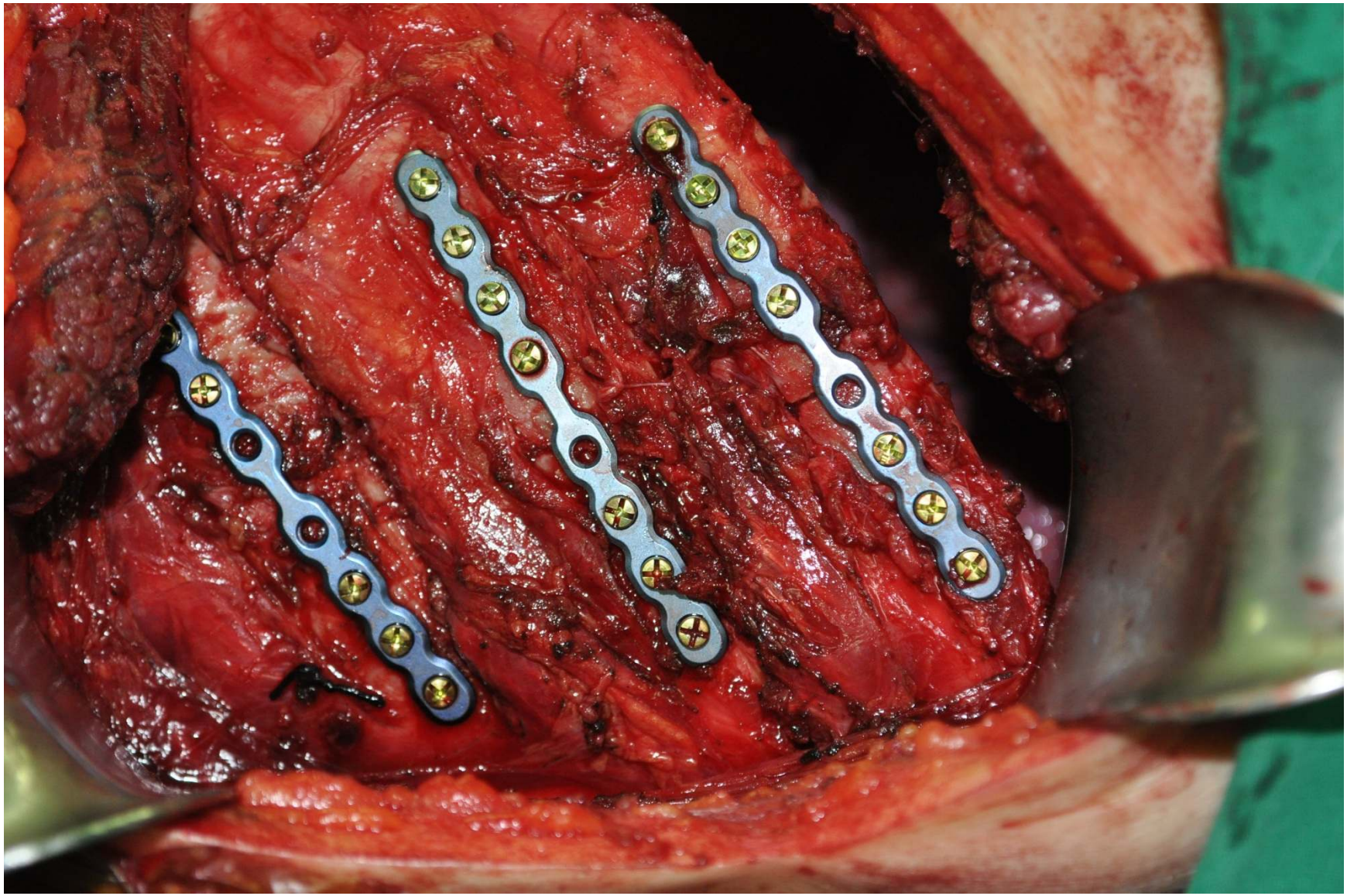
- ***Late Surgical Stabilization***
  - Associated injuries : head/abdomen
  - Malalignment : nonunion/malunion
  - Chronic pain : intercostal neuralgia

EAST, 2012, Orlando, FL, U.S.A









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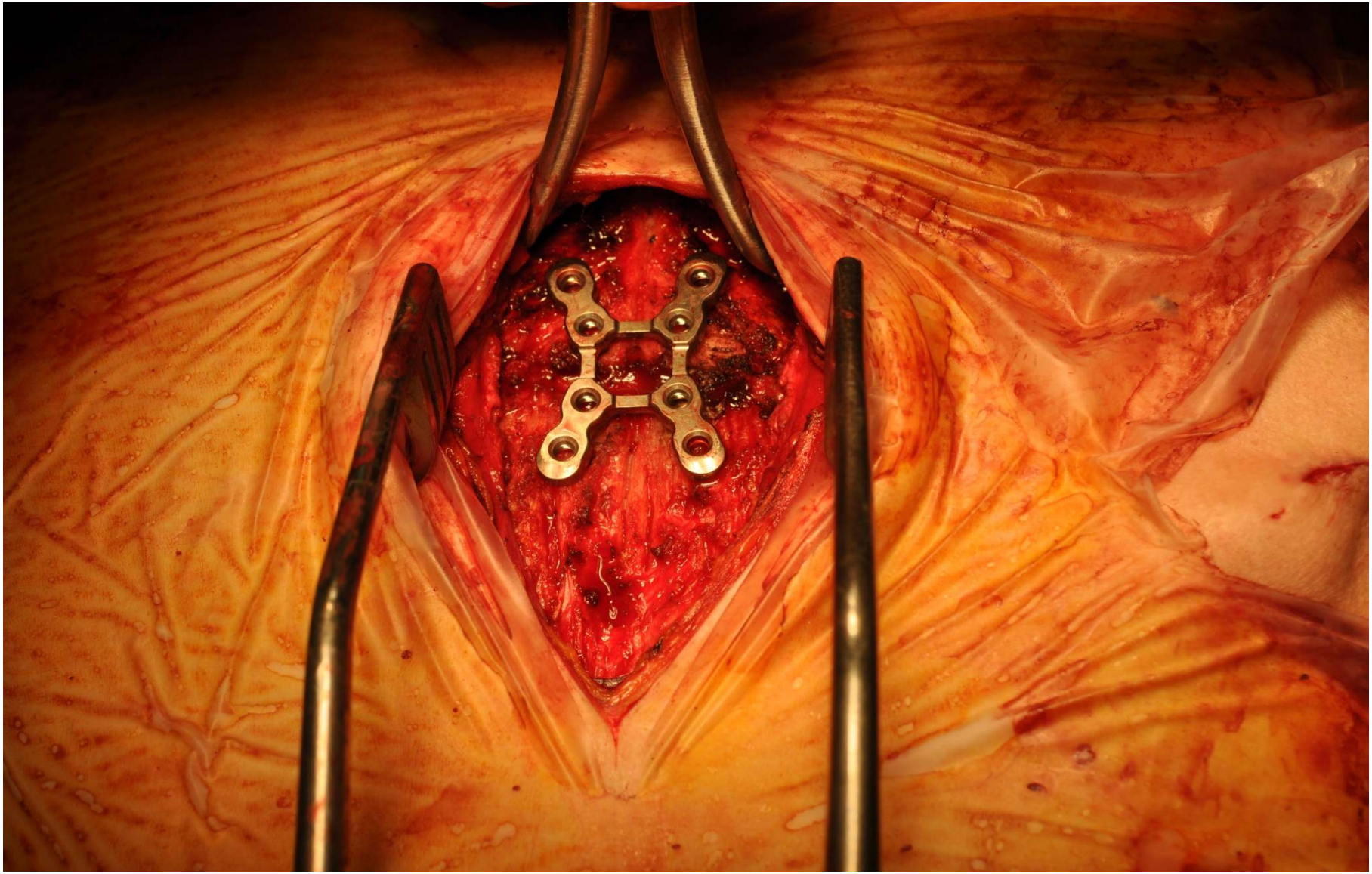

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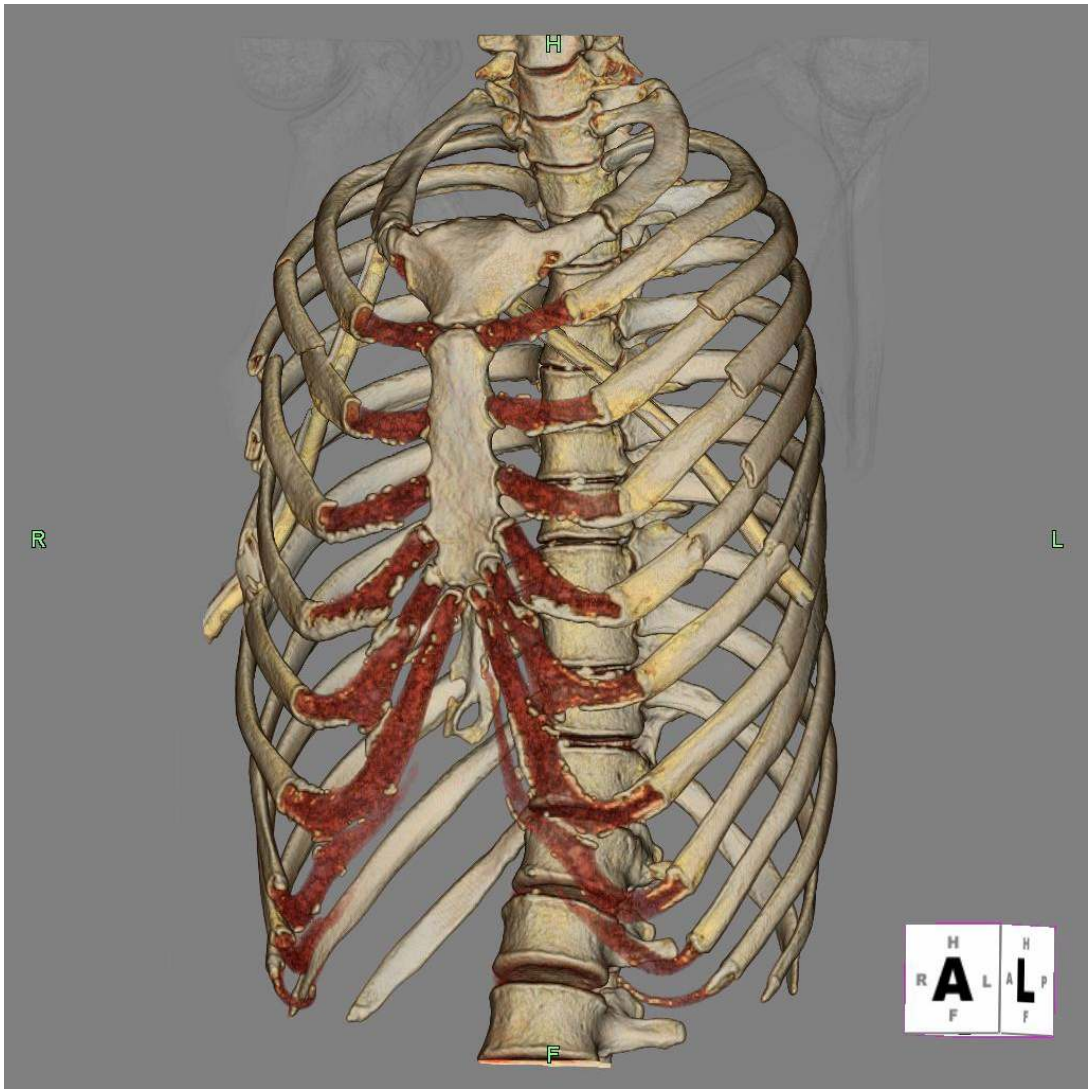
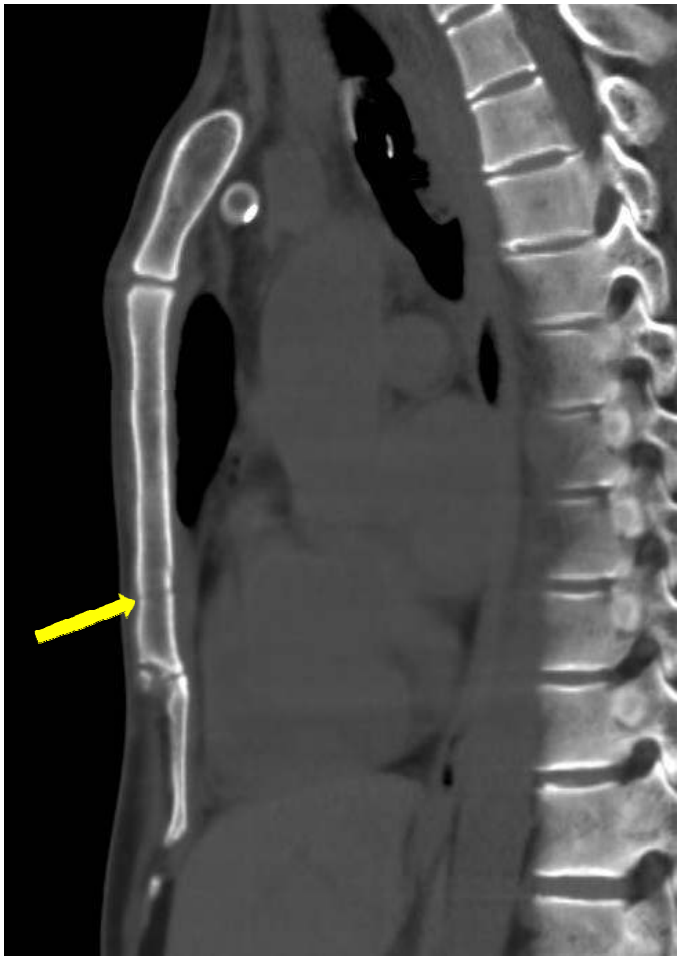
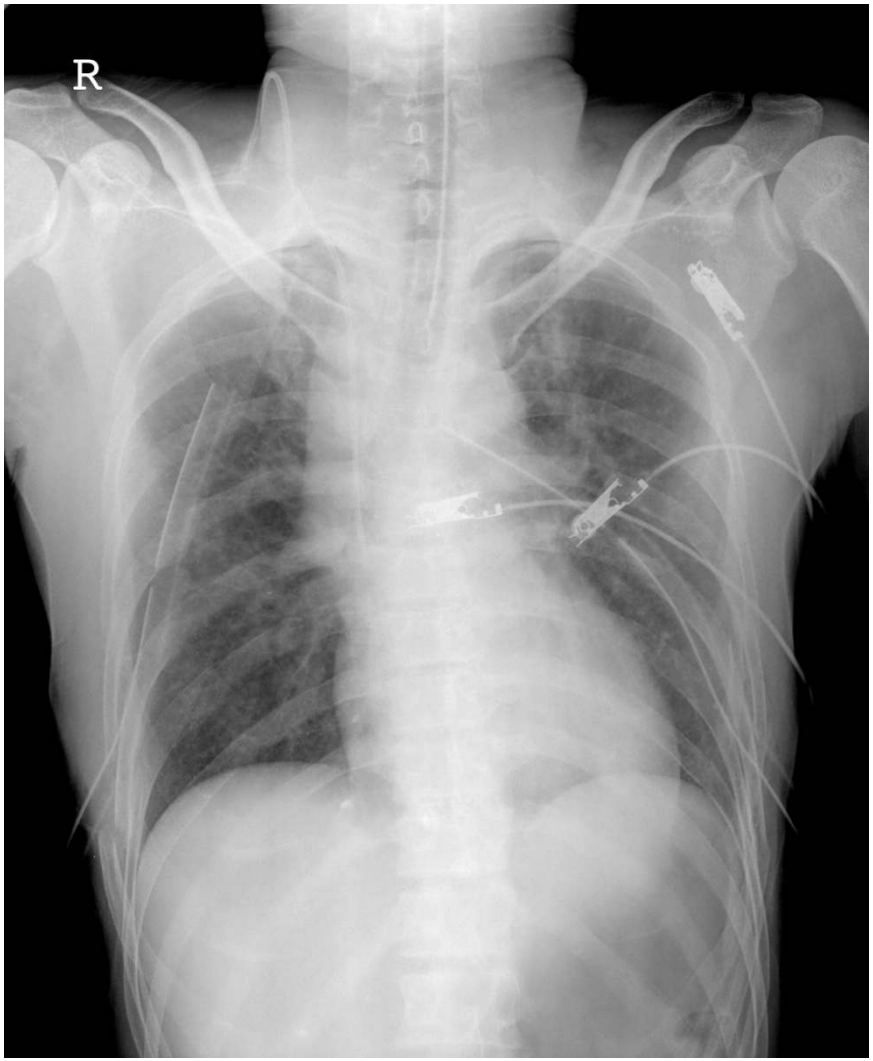
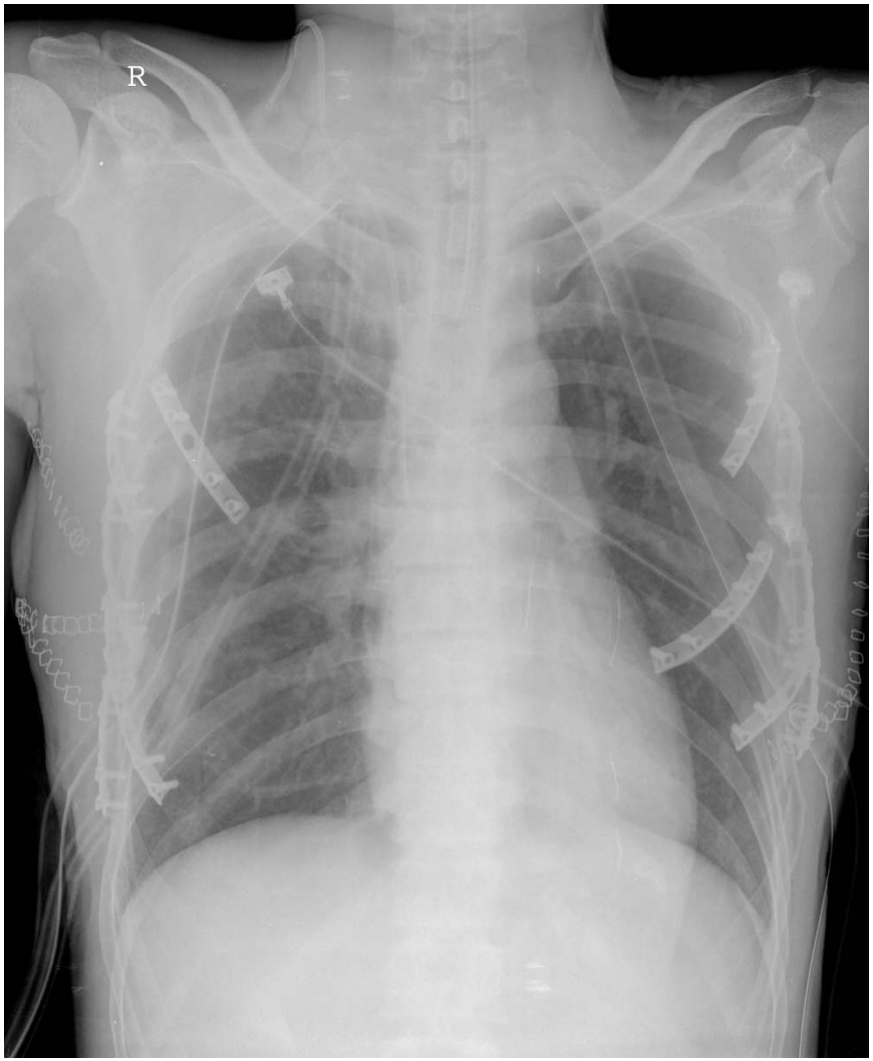
Flail chest : M/40, direct hit





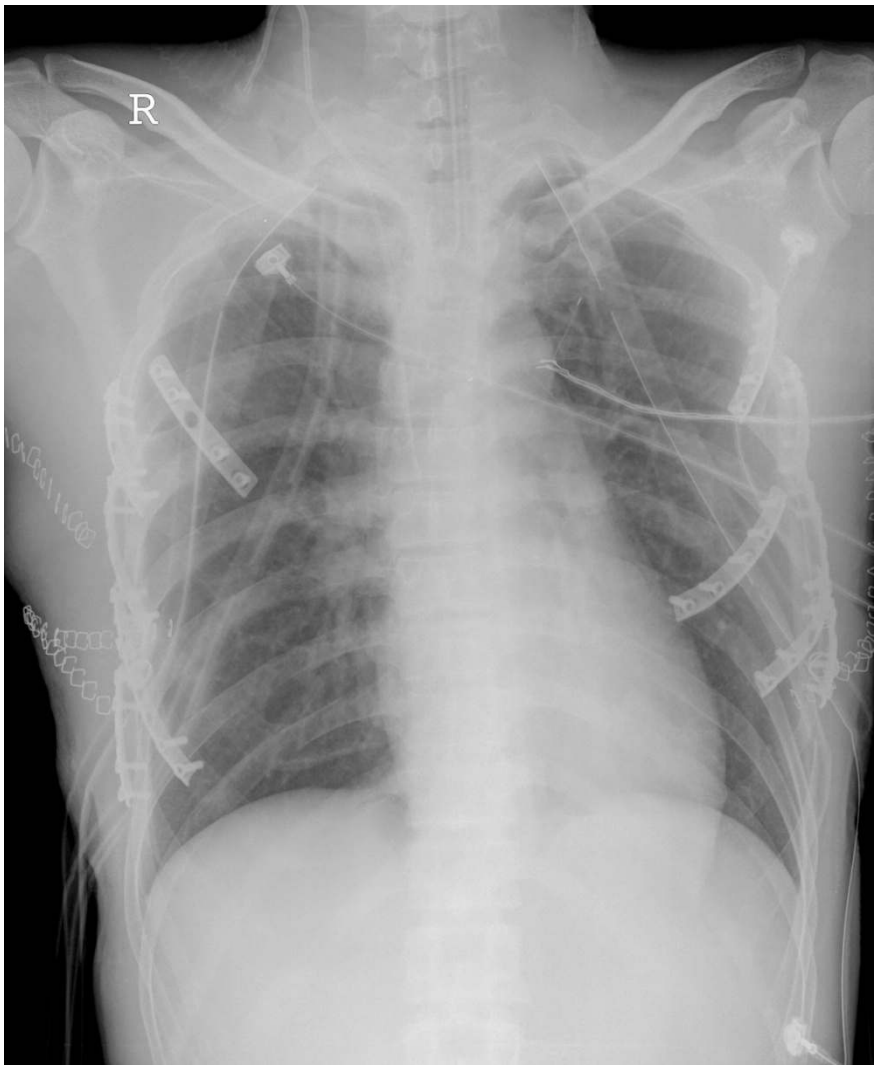
1차 수술 : 2012-06-23





2013년 제6차 전공의 연수교육

2차 수술 : 2012-06-25

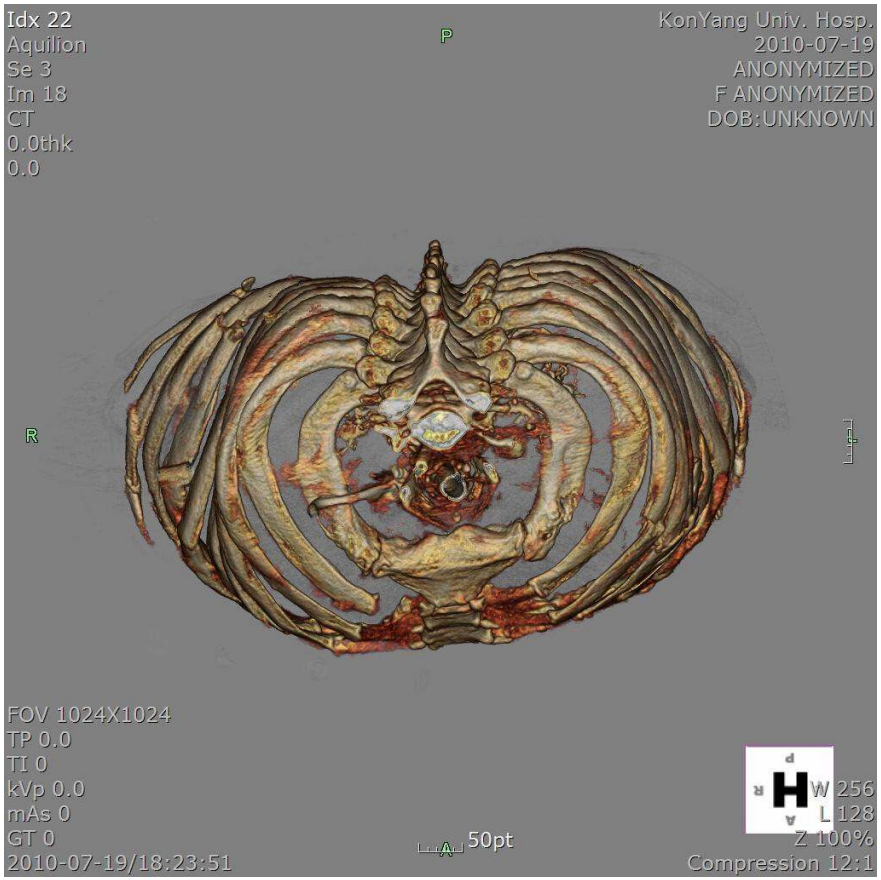


2013년 제6차 전공의 연수교육

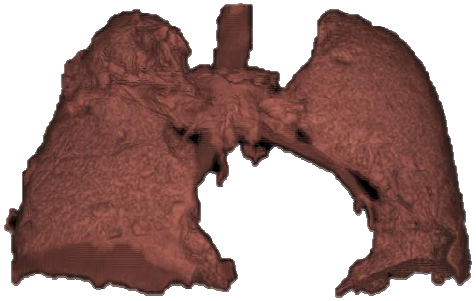
Clinical Study in KYUH

- Duration : 2008. 11 – 2010. 10
- M:F = 58:22, Age: 57.8±14.1years old
- Multiple Fx: 64(80.0%)
  hemo/pneumothorax: 59(73.8%)
  bilateral or sternal Fx: 19(23.8%)
- Rib fixation: 5.3±3.7/person
- Follow up: 7.4±2.4 months
- **Lung Volume**(3D-CT) / **PFT** / **ABGA**

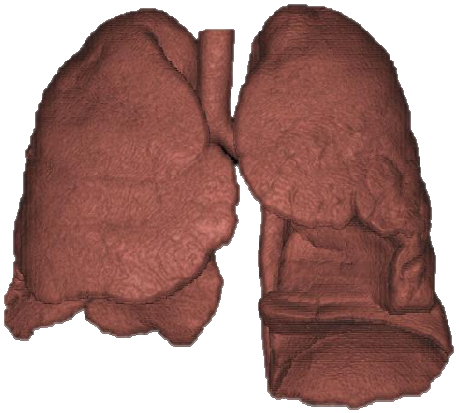
Integrity of Chest Wall



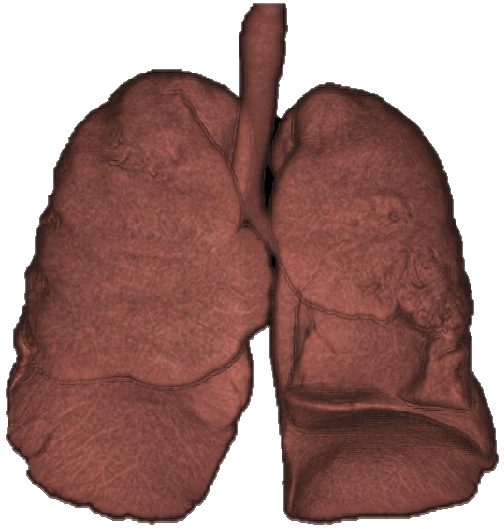
Quantitative CT : Lung Volume



2008-12-31
941.4cm^3

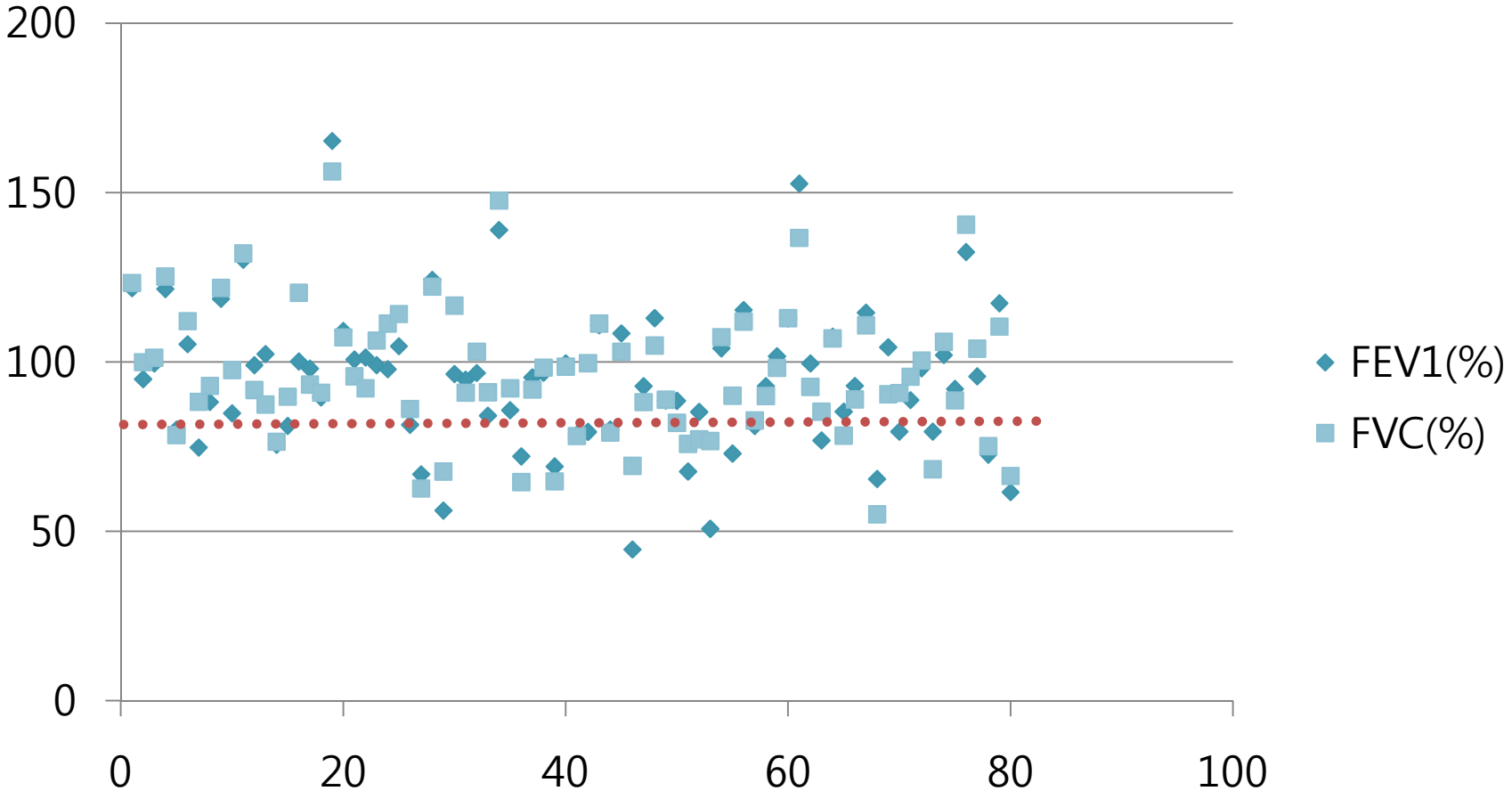


2009-01-29
3493.4cm^3

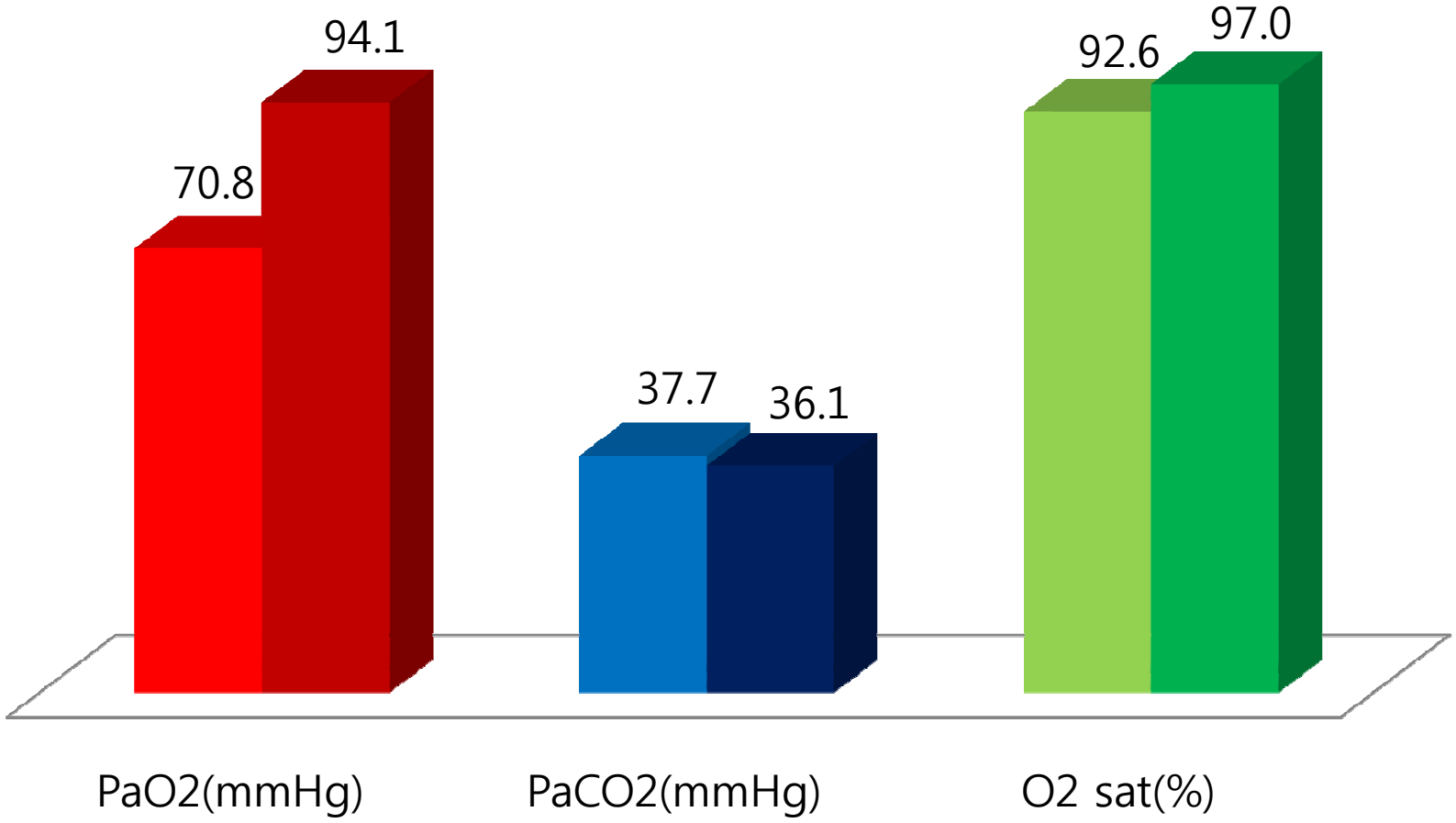


2009-07-29
4284.8cm^3

PFT(postop 6mons)



ABGA(pre & post op)



Surgical Stabilization of Flail Chest
The Impact on Postoperative Pulmonary Function

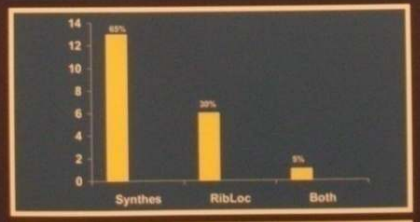
Sameh M. Said MD, Brian D. Kim MD, Naeem Goussous MD, Martin D. Zielinski MD, Henry J. Schiller MD
Division of Trauma, Critical Care and General Surgery
Mayo Clinic, Rochester, MN

Methods

Preoperative
- Bed side FVC
- Non-contrasted chest CT (3-D)

Postoperative
- FVC
  - 1 month (or pre-hosp dismissal)
  - 3 months
- Non-contrast chest CT (3-D)

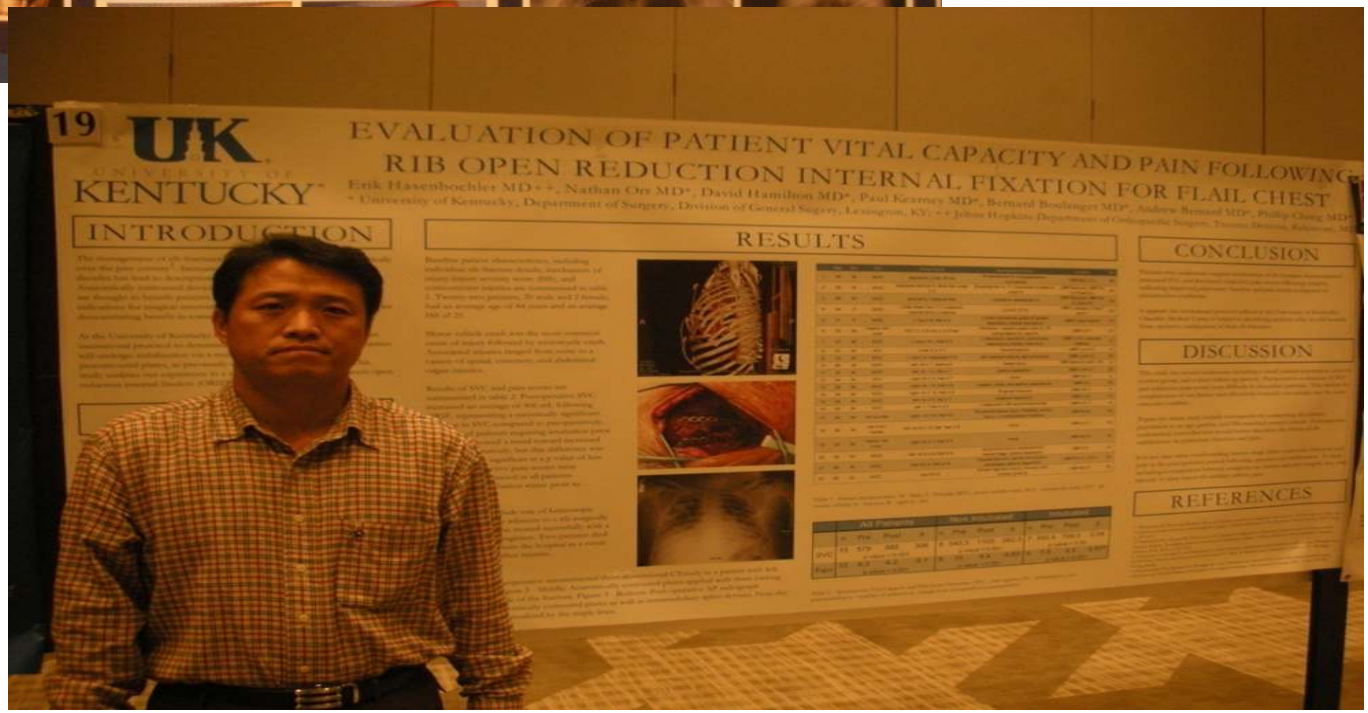
PAPVC Plating Systems



Results

- Median number of ribs in flail: 4 (2-9)
- Preoperative pneumonia: 4 pt (20%)
- Preoperative Intubation: 7 pt (35%)
  - Respiratory failure: 4 (57%)
  - Combativeness: 2 (29%)
  - Need for other surgical intervention: 1 (14%)
- Hemothorax: 17 pt (85%)

Surgical Technique



Blunt Thoracic Aorta Injury

- ***85%*** of trauma victims dies before reaching the hospital : major cause of death in severe trauma

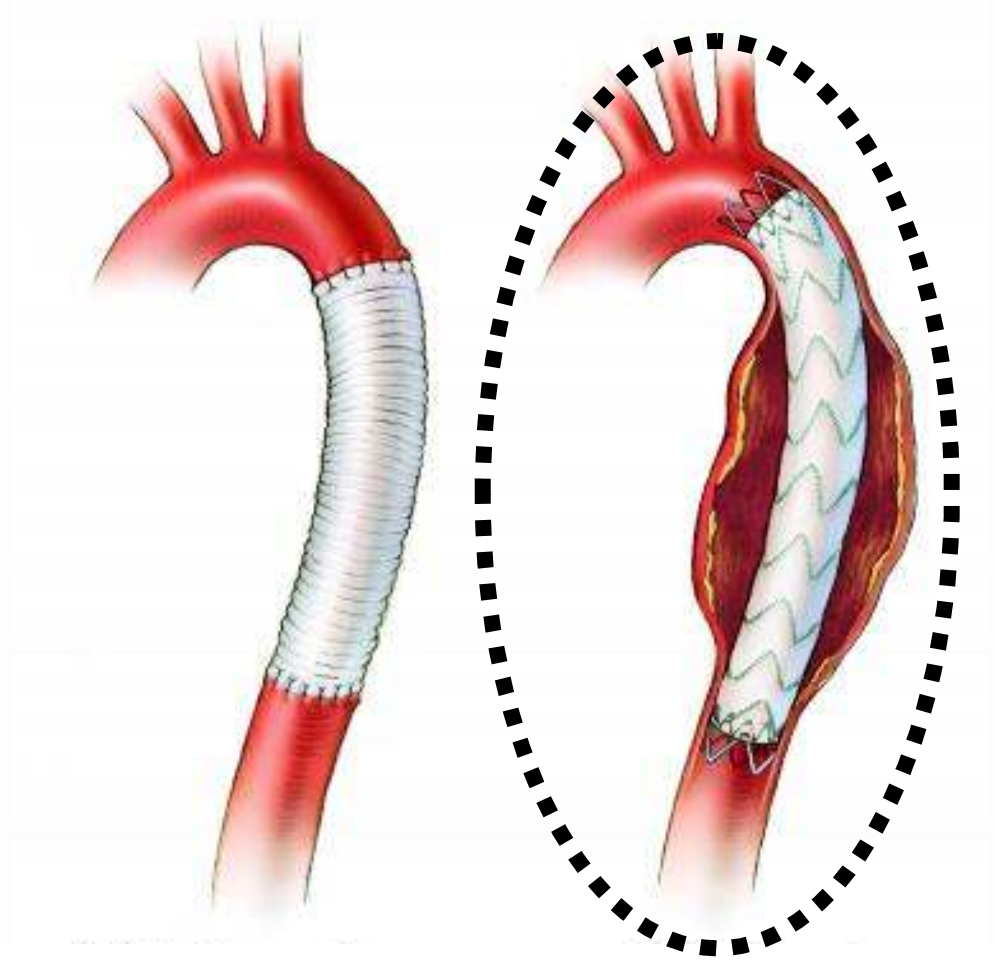
Survivors

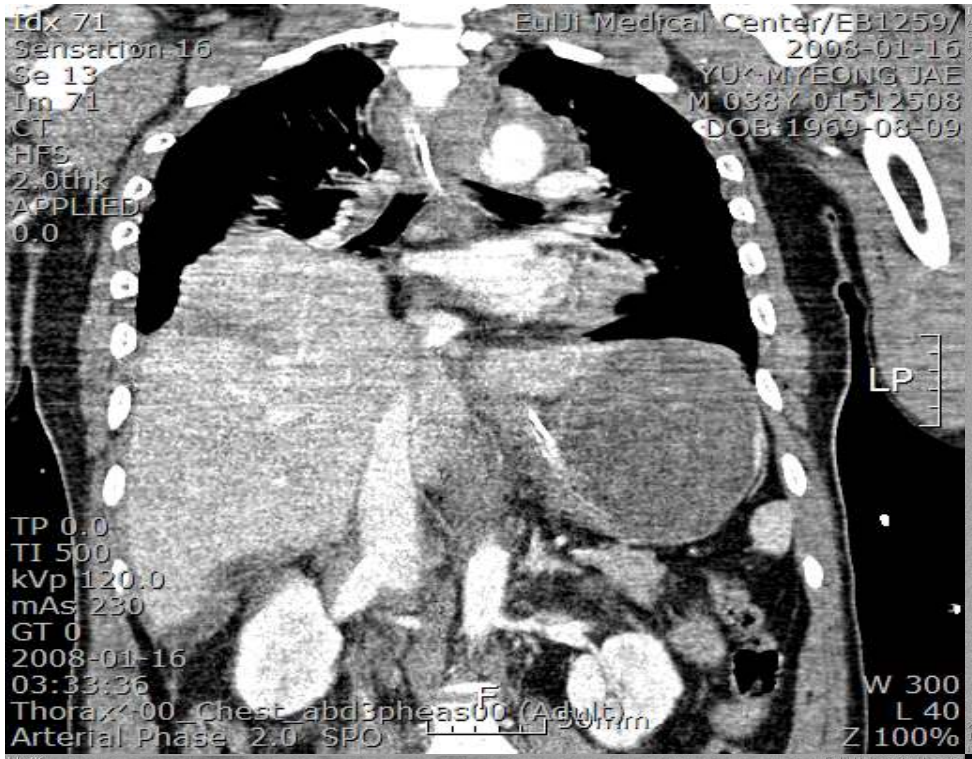
→ ***30% mortality*** within the first ***6 hours***
50% mortality within the first ***24 hours***

Am J Surg 152:660-663, 1986

→ 2~5% of patients of survive without operation
chronic false aneurysm(pseudoaneurysm)

Operation versus **Stent graft**

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Sensation 16
Se 13
Im 71
CT
HFS
2.0thk
APPLIED
0.0
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2008-01-16
YU^MYEONG JAE
M 038Y 01512508
DOB:1969-08-09
LP
TP 0.0
TI 500
kVp 120.0
mAs 230
GT 0
2008-01-16
03:33:36
Thorax^00_Chest_abd3pheas500 (Adult)
Arterial Phase 2.0 SPO
F
50mm
W 300
L 40
Z 100%

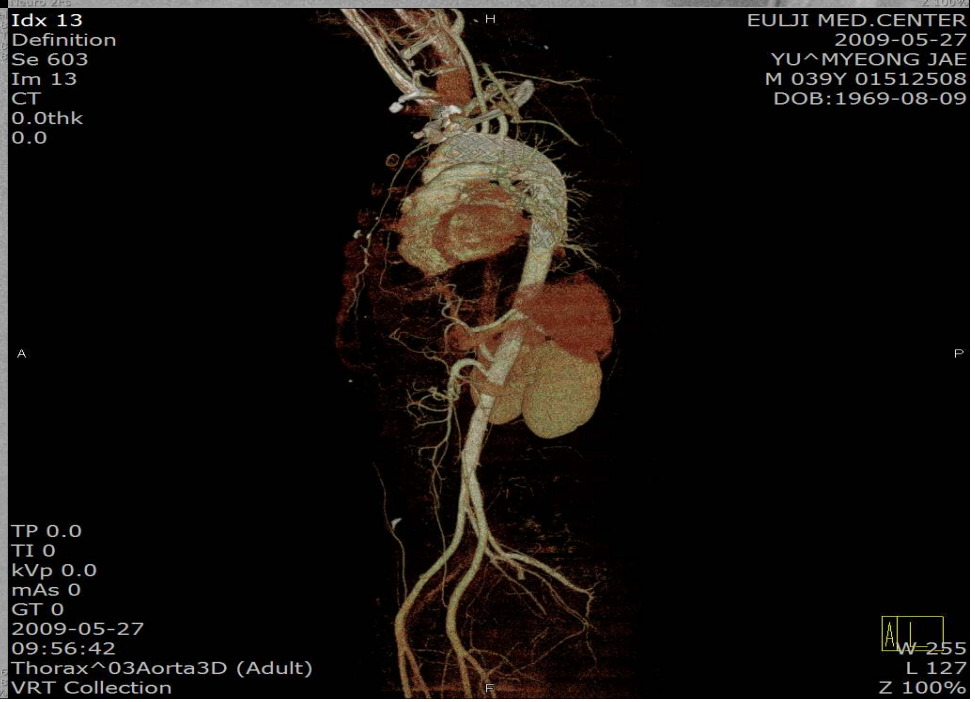
Idx 13
Definition
Se 603
Im 13
CT
0.0thk
0.0
EULJI MED.CENTER
2009-05-27
YU^MYEONG JAE
M 039Y 01512508
DOB:1969-08-09
H
A
P
TP 0.0
TI 0
kVp 0.0
mAs 0
GT 0
2009-05-27
09:56:42
Thorax^03Aorta3D (Adult)
VRT Collection
F
W 255
L 127
Z 100%

Table 4 Potential Advantages and Disadvantages of Thoracic Endovascular Grafting

Potential Advantages
Less invasive
Hazards of anticoagulation (left heart bypass)
Avoidance of thoracotomy
No single-lung ventilation:
Respiratory failure/lung contusion
Avoidance of aortic cross-clamping:
Cerebral perfusion pressure in head-injured patients
Potential Disadvantages
No specific endograft for this clinical entity available
Requirement for endograft flexibility, conformability and alignment
Unknown long-term durability/issues of material fatigue
Definite therapy or bridging with EVAR
Effect of covering of the left subclavian artery in the long-term
Requirement of guide-wire manipulation (cerebral embolization)

EVAR, endovascular repair.

Emergency Operation(2009:KYUH)

Type of Injury	Number(%)
Blunt thoracic trauma	19(57.6)
Aortic rupture	1
LV rupture	1
Hemopericardium	2
Peripheral vascular rupture	6
Diaphragm rupture	1
Multiple rib fractures	3
Flail chest	1
Bronchus rupture	1
Esophageal rupture	1
Lung laceration	2

Emergency Operation(2009:KYUH)

Type of Injury	Number(%)
Penetrating thoracic trauma	10(30.3)
RV rupture	1
Hemopericardium	1
Peripheral vascular rupture	3
Laceration of chest wall	1
Rib fractures	3
Diaphragm rupture	1
Others	4(12.1)
Foreign body in esophagus	3
Laceration of oropharynx	1

CPB / DHCA in trauma-1

- **Overall mortality** : 44.4%

  selected series of CPB(trauma setting)
- **4/5 survivors** : early institution of CPB

  first procedure in operative management
- **3/4 deaths** : late institution of CPB
- Potential benefit in **noncardiac injuries**

  ↑outcomes in severely injured patients

CPB / DHCA in trauma-2

- **Descending aorta / Pulmonary contusion**
  Femoral artery-aorta
  oxygenation & spinal perfusion
- **Retrohepatic IVC / Liver**
  RA-aorta, circulatory arrest
  rapid repair(8-12min) in a bloodless field
- **Hypothermia**(26-28℃)
  Femoral-femoral
  rapid rewarming & resuscitation

Education & Training

- **General care** : resident program

  Fluid therapy / Nutrition / Surgical skill

- ***Cadiothoracic-specific*** : fellowship

  Thoracic trauma

  airway injury / flail chest

  Cardiovascular trauma

  TEVAR / embolization

  vascular surgery

Discussion

- **Care of trauma patients**
  more appealing & sustainable alternative
  financially sustainable / professionally attractive
- **Cardiothoracic-specific management**
  Emergency thoracotomy ; Airway management
  MRF/SF ; Flail chest ; Cardiovascular trauma
  ECMO ; IABP ; Hypothermia ; CPB / DHCA
- **Prehospital care**
  competent & good clinical result
  ↓ preventable death