늑골 골절의 진단: 단순 가슴촬영과 CT

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늑골 골절은 흉부 손상 중 가장 흔하게 관찰되며 전체 흉부외상의 약 50% 정도로 보고되고 있지만 단순 흉부방사선 촬영 등의 검사에서 모든 늑골 골절을 발견할 수 없기 때문에 발생 빈도는 더 높을 것으로 생각된다. 대부분 직접적인 흉부 외상 때문에 발생하지만 심한 운동이나 무거운 물건을 들고나서, 기침 그리고 기억하지 못하는 가벼운 외상 때문에 발생하는 일도 있다. 이런 환자에서 늑골 골절이 의심될 경우 단순 흉부방사선 촬영과 늑골방사선 촬영을 시행하여 늑골 골절을 진단을 하지만, 늑골은 12쌍이 전체적으로 사선을 형성하며 겹쳐져 있고, 전측은 흉골과 연결된 연골로 이루어져 있고, 상부는 견갑골에 의해 겹쳐지므로 단순 흉부방사선 촬영(전후 촬영)과 늑골방사선 촬영(좌우 사선 촬영)에서 전위가 없는 초기 골절을 진단하기란 매우 어렵다. 문헌에 따르면 흉부 통증 환자에서 단순 흉부방사선 촬영상 늑골 골절을 발견하는 것은 12~50%정도로 보고되고 있다. 가장 많이 골절되는 부위는 제 4-9번째 늑골이지만 제 1-2번째 늑골 골절의 경우 대혈관 손상 등이 흔히 동반되기 때문에 심한 손상을 의미하며 하부 골절인 제 9-12번째 늑골 골절은 비장, 간, 콩팥의 열상을 동반할 수 있다. 따라서, 환자의 통증과 문진으로 늑골 골절이 의심되나 단순 흉부방사선 촬영에서 늑골 골절이 발견되지 못하는 경우이거나, 심한 골절과 더불어 발생된 동반된 내부 장기의 합병증이 의심이 될 경우에는 좀 더 정밀한 검사인 흉부CT 등을 실시하여 더 정확히 상태를 평가하여야 한다.

흉부 CT는 단순히 늑골 골절의 진단보다는 동요흉(flail chest) 등의 심한 흉부 외상이 있거나 다른 장기의 손상이 동반된 경우 혈관 및 내부 장기의 손상여부를 쉽고 빠르게 진단할 수 있는 장점이 있어 다발성 외상 환자나 중증 외상 환자에서 사용을 하고 있다. 중증 흉부 외상 환자의 상태는 호흡조절이 어렵고 여러 가지 모니터 장치를 부탁하고 있어 어려움이 많은데, CT는 이러한 어려움을 극복할 수 있는 영상 획득 시간이 매우 짧아 병변의 위치 및 자세에 대한 제한이 적고, 진단에도 매우 유용하며 최근에는 다중검출기 CT(MDCT)가 많이 시행되어 3차원 재구성 영상(3D reconstructed view) 등으로 입체적인 병변의 진단이 가능해 골절 진단에 많은 도움을 받고 있다. 이런 다중검출기 CT는 보다 넓은 범위를 얇은 절편으로 단시간에 촬영할 수 있는 장점이 있으며, 동적 인공물이 적은 고해상도 영상과 양질의 다 평면 재구성 영상(Coronal view, Sagittal view, Axial view with maximum intensity projection[MIP] for rib) 및 3차원 재구성 영상을 적용함으로써 외상 환자의 빠른 치료와 낮은 사망률을 보이게 되었다. 중증 흉부 외상 환자에 있어 빠른 진단과 정확한 판단은 무엇보다 중요한데 Alkadhi 등은 늑골 골절 환자를 CT축상 영상(Axial view)과

3차원 재구성 영상을 연구한 결과 3차원 재구성 영상과 축상 영상의 정확도에는 큰 차이가 없으며, 시간적 효율 면에서 3차원 재구성 영상이 축상 영상보다 뛰어나 진단의 시간이 단축되고, 환자의 상태를 설명할 때 보다 효과적이다. 단, 몇 가지 취약점이 발견 되었는데 환자 검사 시 호흡정지가 제대로 이루어지지 못해서 운동 성 인공 산물(motion artifact)이 발생하여 거짓 골절의 형태가 보일 수 있으며, 재구성 시 견갑골 등이 골절을 가릴 수 있으므로 주의가 필요하다.

늑골 골절의 정확한 진단은 처음부터 쉽지가 않지만, 단순 늑골 골절부터 동요흉 등의 심한 합병증을 동반할 수 있는 다발성 늑골 골절환자에서 흉부방사선 촬영과 흉부 CT에서 보이는 늑골 골절의 다양한 양상을 인지하고 정확한 진단과 치료 방침을 세우는 것이 환자의 이환율과 사망률을 낮출 수 있을 것으로 생각된다.

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늑골 골절의 진단 : 초음파와 WBBS

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1. 흉부 둔상 환자의 임상적 특징 및 통상적인 치료

흉부 둔상환자 주된 호소증상은 손상부위의 운동 혹은 휴식시의 통증으로, 환자의 주소(Chief complaints)에 따라 초진의사는 문진 및 이학적 검사를 하며, 먼저 단순 방사선 촬영을 통해 진단을 한다. 단순 방사선 촬영의 경우 늑골 골절, 혈흉, 기흉 등이 저명할(definite) 경우에는 확진이 가능하다. 이후 환자는 초진 진단에 의해 진통제, 근 이완제등을 주사하거나 경구투약, 심한 통증의 경우 늑간 신경차단술 등의 적극적인 통증 조절법등 보존적인 치료를 시행하게 된다. 이러한 보존적 치료로 2-3일 후에는 통증이 상당 부분 호전되며, 이후 경구 진통제를 2-3주간 복용하면서 외래 추적관찰 하는 것이 상례이다. 그리고 늑골 골절의 전위(displacement)가 심할 경우 (동요 분절-flail segment 포함), 지속적인 통증, 그리고 흉곽의 변형이 있는 경우 등에 늑골 고정술을 고려해 볼 수 있다

2. 흉부 둔상의 합병증과 지연 진단의 문제점 그리고 정확한 진단이 필요한 이유

보존적인 치료를 통해서도 통증이 지속되거나 악화되는 경우, 그리고 초진 당시 보이지 않았던 증상이나 징후 등을 확인하게 되면 임상의사는 초기 진단에 대해 미발견 진단이 있는 것은 아닌가 하는 생각을 갖게 되며, 이 경우에는 다시 단순 방사선 촬영을 해보거나 추가적인 진단 방법들으로 고려하게 된다. 간혹 재촬영한 단순 방사선 촬영에서 처음 촬영 시 발견되지 못한 늑골 골절의 소견이 발견되는 경우도 있는데 이런 경우는 수상 당시의 통증으로 인한 흉곽 근육의 긴장이 시간이 경과함에 따라 이완되어 늑골 골절이 저명해 지는 경우도 있을 것으로 사료된다. 그런데 발견되지 않은 늑골 골절에 의한 무기폐에 의한 폐 합병증, 지연성 혈흉(혹은 기흉), 심근 좌상, 심장 판막 손상 등이 진행된 것으로 진단 될 경우 응급 수술이 필요하게 되거나 심하면 환자의 생명이 위태롭게 된다. 또한 법적, 보험문제로 진단을 명확하게 해야 할 경우 추가적인 진단법이 필요하다.

3. 단순 방사선 촬영의 단점

단순 방사선 촬영에 의한 진단에는 여러 가지 단점이 존재한다. 늑골의 골성 부분은 골절의 전위 정도가 저명(definite)하지 않은 경우, 연골의 경우 calcification이 있지 않으면 단순 방사선 촬영 상보이지 않으므로 늑-연골 접합부의 분리나 연골의 골절은 단순 방사선 촬영으로 진단하기 어렵다. 또한 환자의 비만정도나 기존 폐질환이 있는 경우 같은 방사선의 조사량이라 하더라도 영상이 달라지므로 판독에 의한 진단이 곤란해지기도 한다. 그 이외에도 하부 늑골의 골절이 의심 될 경우 복부와 겹쳐져 늑골 촬영의 결과가 불분명해지기도 한다. 또한 외상에 의한 혈흉이 존재할 경우 일정 정도 이상의 혈흉이 존재하여야만 fluid

shifting이 나타난다.

4. 다른 진단 기법 -초음파 검사법

비 침습적 (Non-invasive)이면서 시행이 간편한 초음파 검사법은 환자의 통증 호소 부위를 중심으로 초음파를 이용하여 흉벽의 근, 골격을 촬영하게 되는데, 단순 방사선 촬영상에 발견하지 못한 흉골 피질의 결손, 늑연골 접합부의 분리(disruption), 미세한 늑골피질의 결손(defect), 혈흉, 기흉, 심근 좌상, 심장 판막 손상등이 발견되는 경우가 50-88%에 이른다. 특히 늑-연골의 골절의 경우 단순 방사선 촬영으로는 연골의 석회화가 심한 경우가 아니면 발견되지 않고 환자는 지속적인 통증을 호소하여 임상의로 하여금 Malingering을 의심하는 등 혼란을 가져오게 된다. 이때 초음파촬영이 연골 골절에는 단순 방사선 촬영보다 더욱 예민한 검사라는 것이 알려져 있다. 또한 혈흉의 진단에서도 단순 방사선 촬영의 경우 150ml 정도는 되어야 진단이 가능한 반면 초음파 검사로는 40ml의 혈흉 이라도 진단이 가능하여 매우 민감도가 높은 검사법이다.

기존의 연구에 의하면 Kara 등은 단순 방사선 촬영 상 늑골 골절이 보이지 않은 37례를 대상으로 흉벽 초음파를 시행하여 미 발견 늑골 골절이 초음파 검사 상 발견될 수 있는 선행인자(Predictor)를 알아보고자 하였는데 이 연구의 결과 미 발견 늑골 골절을 의심할 수 있는 선행인자는 알아 볼 수 없었으나, 골성 늑골 골절의 경우에서 연골 골절보다 통증의 지속기간이 긴 것으로 알려졌다. Hendrich 등은 흉골 골절에서 초음파 검사를 시행하는 적응증을 제시하였는데, 1) 초음파 검사는 흉골 골절의 유무를 확인하는 정도이며, 흉골 골절의 정도는 단순 방사선 촬영이 우수하다, 2) 기존의 old fracture 와 newly developed fracture인지 감별하는 것, 3) 흉골 골절이 단순 방사선 촬영 상 저명하지 않은 경우 추가적인 방사선 노출 없이 보다 많은 정보를 얻을 수 있다고 제시하였다. 그러나 이 연구에 포함된 환자 군이 모두 45례였으며 단순 방사선 촬영 상 발견되지 못한 흉골 골절이 초음파 검사로 발견된 것이 1 례로서 초음파 검사의 정확도를 결정짓기는 곤란하다고 하였다.

초음파 검사가 좀 더 유효한 검사라는 연구 결과로서 Turk 등은 증상이 있으면서 단순 방사선 촬영에서 골절이 발견되지 않은 환자군에서는 초음파 검사가 효과적이라고 하였으며, Lee 등은 단순 방사선 촬영과 CT 에서도 골절이 발견되지 않은 환자군에서 늑연골 (Costal cartilage) 골절을 진단하는데 효과적이라고 하였다.

그리고 저자의 연구에 의하면 초음파 검사를 통한 늑골 골절의 진단에 있어서도 기존의 연구와 같이 단순 방사선 촬영에서 골절이 발견되지 않은 환자군에서는 초음파 검사가 발견하지 못한 늑골 골절의 진단에 효과적이었다. 그리고 초음파 검사는 늑골 고정술을 시행하기에 앞서 골절된 늑골의 위치를 정확하게 파악하고 절개 부위를 정할 수 있어 불필요한 절개선의 연장등을 피할 수 있는 장점이 있다.

그러나 Hurley등은 단순 방사선 촬영과 초음파 검사의 효용성을 비교한 전향적 연구에서 단순 방사선 촬영에서 전위(displace)가 저명할 경우 초음파검사와 결과가 일치하므로 초음파가 단순 방사선 촬영보다 우위를 나타내지 않고 또한 초음파 검사가 환자에게 통증을

유발 할 수 있고, 검사하는데 있어 시간이 소비 되며, 골절의 위치에 따라 초음파 검사가 제한적이라고 하였다.

5. 다른 진단 기법 - 전신 골 주사 (Whole body bone scan)

WBBS는 통상 수상 후 48시간 이후부터 (고령이 경우 시간이 좀 더 길어지기도 함) 의미 있는 검사로서 99m-technetium-diphosphate를 검사 2-3시간 전에 정맥 주사 한 뒤 검사를 시행 하게 된다. 정주된 technetium의 uptake는 골내의 blood flow, 특히 osteoblast의 activity와 직접적인 연관을 갖고 있으며, laminar osteoid (actively bone-forming mineralizing layer)에 선택적으로 축적된다.

Lee등은 외상 환자에서 통상적인 검사로서 발견되지 않은 골절을 WBBS으로 진단 할 수 있으며, 특히 법적, 보험문제로 진단을 명확하게 해야 할 경우 추가적인 진단법을 고려해야 한다고 하면서 무의식 환자, ISS (Injury Severity Score)가 높을수록 WBBS이 screening test로 의미를 갖는다고 하였으며, rib, sternum이 가장 흔하게 미 발견 골절이 WBBS으로 진단된다고 하였다.

6. 결론

늑골 골절은 기본적으로 단순 방사선 촬영으로 진단이 가능하나 여러 가지 요소에 의해 진단이 불명확하거나 통상적인 치료 후에도 임상 양상이 호전되지 않을 경우, 그리고 법적, 보험문제로 진단을 명확하게 해야 할 경우 추가적인 진단법을 고려해야 한다.

초음파 검사는 단순 방사선 촬영에서 골절이 발견되지 않은 환자군에서 유효한 검사법이라고 생각되며, 특히 늑연골 골절(혹은 접합부 분리), 흉골 골절 등에서 효과적이며, 늑골 고정술의 절개선을 결정할 때 효과적이라고 할 수 있겠다.

WBBS은 매우 민감도가 높은 검사로서 무의식 환자, 중증도가 높은 환자군에서 screening test로 의미를 갖을 수 있다. 하지만 위에서 살펴본 연구들이 대부분 후향적인 연구이며, 대상 환자군이 소규모였으므로 그 유효성을 단정하긴 어렵다. 따라서 초음파와 WBBS의 늑골 골절 진단에 대한 유효성을 검증하기 위해 large volume, randomize controlled study가 필요할 것으로 생각된다.

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Pain control for Rib fracture

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Definition of Pain

Pain is defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage. According to literatures, Pain is not homogeneous sensory. Several nomenclatures is described a various aspects of pain. Acute pain arises from obvious tissue injury, and usually fades with healing. On the other hand, Chronic pain is presented without apparent biological value that has persisted beyond the normal tissue healing time. it is persisted usually three month or more.

According to physiological mechanisms of pain and its pathways, Pain can be devided two categories; Nociceptive pain and neuropathic pain.

A nociceptor is a nerve fiber preferentially sensitive to a noxious stimulus or to a stimulus that would become noxious if prolonged. Nociceptive pain is the perception of nociceptive input, usually due to tissue damage. Nociceptive pain is further subdivided into somatic and visceral pain.

Neuropathic pain arises from abnormal neural activity secondary to disease, injury, or dysfunction of the nervous system. It commonly persists without ongoing disease.

Pain transmission mechanism

Pain sensation begins in the periphery of the nervous system. Pain stimuli are sensed by specialized nociceptors that are the nerve terminals of the primary afferent fibers. The pain signal is then transmitted to the dorsal horn of the spinal column and transmitted through the central nervous system (CNS) where it is processed and interpreted in the somatosensory cerebral cortex

Peripheral sensitization — Tissue inflammation may result in changes in the chemical environment of the peripheral terminal of nociceptors. Damaged cells may release intracellular contents and synthesize substances including cytokines.

Central sensitization — Central sensitization amplifies the synaptic transfer from the nociceptor terminal to dorsal horn neurons. Later transcriptional changes in the molecular machinery of the dorsal cell sustain the sensitization beyond the initiating stimulus.

- **Pain in Rib fractures**

Rib fractures are the commonest of all chest injuries and are identified in 10% of patients after trauma. Pain in chest trauma and rib fractures would limit respiratory activities involving cough and deteriorate function of respiratory. Results of this process, it is complications of respiratory including atelectasis, pneumonia, ARDS and mortality in acute phase. In late phase, chronic pain and long term disability would be presented, if pain control had not enough.

- **Agents of Pain relief**

Specific agents

Morphine : the prototype opiate and remains widely used in the intensive care unit. The onset of analgesia is rapid, with the peak effect occurring in one to two hours with an elimination half-life of three to five hours. After hepatic conjugation to glucuronide metabolites, renal elimination usually occurs within 24 hours.

Fentanyl — Fentanyl is a synthetic derivative of morphine and is approximately 100 times more potent. It is also more lipid-soluble than morphine, and therefore has improved penetration of the blood-brain barrier which leads to a more rapid onset of action and a shorter half-life (two to three hours) than morphine.

Hydromorphone — Hydromorphone is a semisynthetic opiate agonist that, like fentanyl, has a more rapid onset of analgesia (within 30 minutes) and a shorter half-life (2.4 hours) than morphine.

Fentanyl derivatives — Remifentanil, sufentanil, and alfentanil

Non-opioid analgesics

Ketamine -an N-methyl-D-aspartate (NMDA) receptor antagonist

Acetaminophen — Parenteral acetaminophen (paracetamol) is an effective analgesic and antipyretic agent that can be used for the short-term treatment of moderate pain and fever

NSAIDs — Nonsteroidal anti-inflammatory drugs (NSAIDs)

ketorolac, ibuprofen, and indomethacin

Gabapentinoids -The gamma aminobutyric acid (GABA) analogues, gabapentin and pregabalin

Carbamazepine-oral tricyclic antiepileptic

Modalities of Pain control for Rib fractures

- **Regional Thoracic analgesia**

  Epidural Narcotics / Anesthetics:

  Most effective method for pain control but limitations for Multiple Trauma and uncooperations [Surgery 2004;136:426-30]
  But, Hypotension, risk of dural puncture and spinal cord injury, delayed respiratory depression.

  Intrapleural Anesthesia

  No CNS depression, single placement for multiple injections

  But, Significant amount of anesthetic may be lost with tube, Migration of catheter

  Relative limitation of Trauma, especially presence of hemothorax,

  Limitation of position

  Thoracic Paravertebral Block

  Technically simple, safer and easier

  But, Risk of pneumothorax, dermatomal spread not as predictable as epidural anesthesia, high blood LA levels with potential for LA toxicity

  Intercostal Nerve Block:

  Highly effective for 8–24 h with each injection, no CNS depression

  But, Risk of pneumothorax and not suitable for posterior rib fractures

- **Transdermal opioid :**

  TTS is a safe, non-invasive and effective method in the treatment of pain secondary to multiple rib fractures. [Balkan Med J 2013; 30: 277-81]

- **Lidocaine 5% Patch :**

no evidence that the lidocaine patch 5% improves pain control in traumatic rib fractures. [J Am Coll Surg 2010;210:205–209.]

- **Intravenous narcotics :**

  Simplicity, no need for positioning, utility as a supplement

  But, CNS and respiratory depression, nausea, cough suppression

- **Surgical management.**

  Limited experience and published data

Conclusion

There are no absolute method of treatment for pain derived from chest trauma and rib fractures.

Be selected according to each situation, however, underestimation for pain causes a poor prognosis of trauma patients.

Pain Control in Rib fractures

Dae Sung Ma, M.D.

Trauma Center, Gachon University Gil Medical Center.

Contents

1. Definition of Pain
    1) Definition
    2) Mechanism of Pain
2. Why need Pain control?
3. What can be used for pain control?
4. Conclusion

Definition of Pain

- **Definition of Pain**

" An unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage"

[Price DD. IASP Press, Seattle 1999. Vol 15.]

Type of pain

- According to duration

Acute

"Arises from obvious tissue injury, and usually fades with healing"

Chronic

" Pain without apparent biologic value that has persisted beyond the normal tissue healing time (usually taken to be three months)"

The International Association for the Study of Pain (IASP)

Type of pain

- According to patho-physiological process

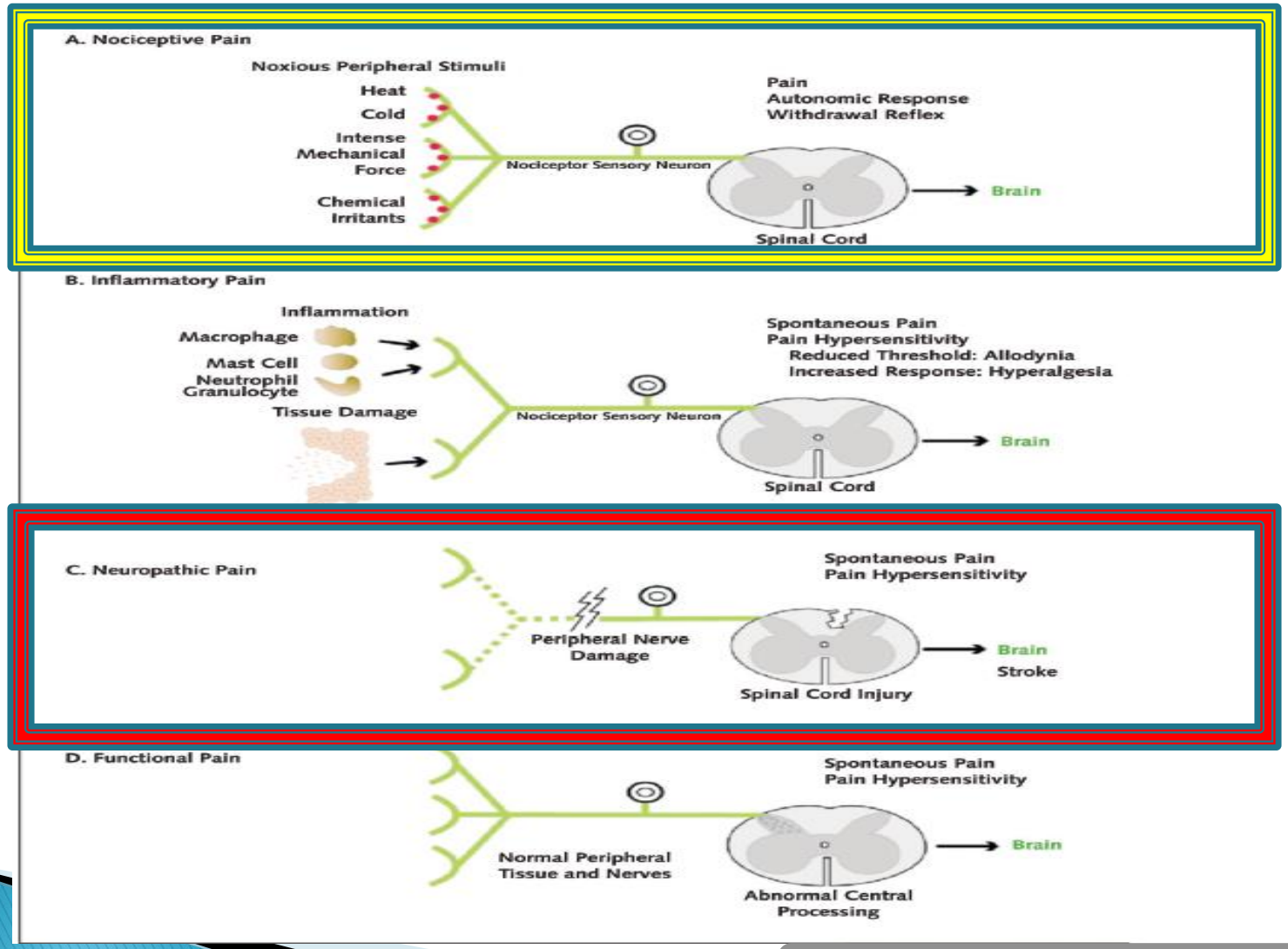
Nociceptive

The perception of nociceptive input, usually due to tissue damage

Neuropathic

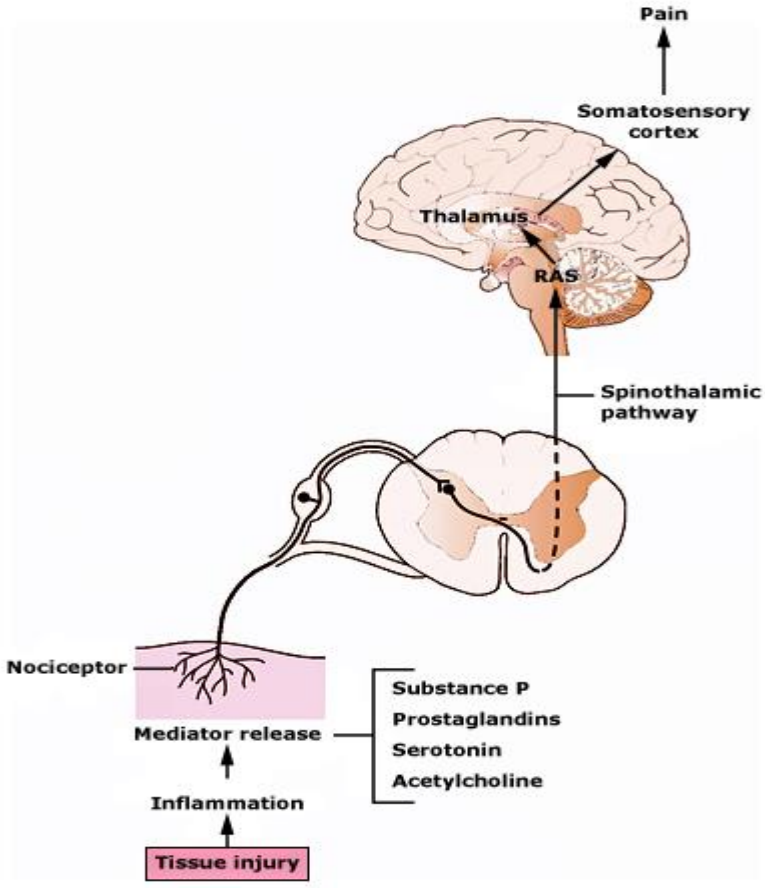
Abnormal neural activity secondary to disease, injury, or dysfunction of the nervous system

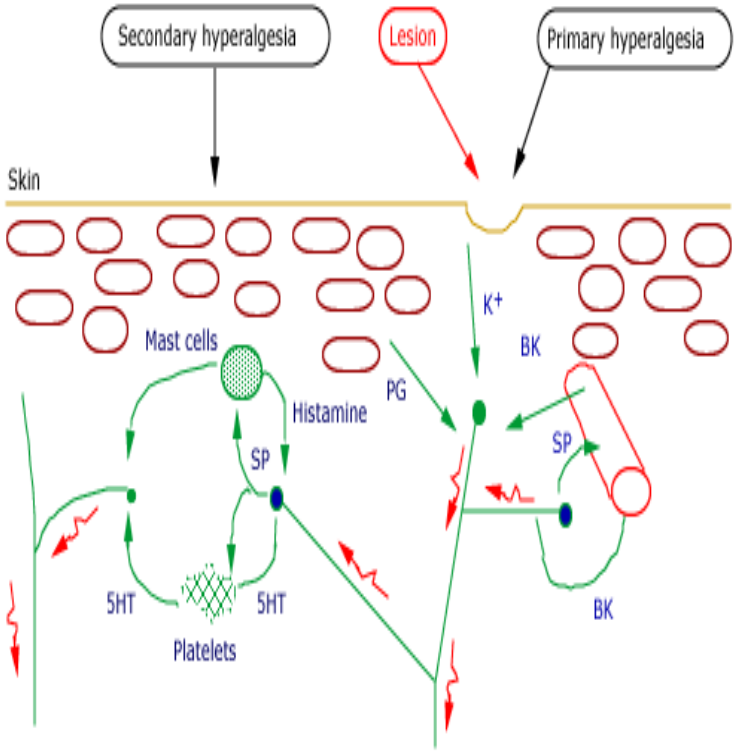
Type of pain



Ann Intern Med. 2004;140:441-451.

Pathogensis of Pain





Anesth Clin North Am 1992; 10:211.

Mechanism of Persistent Pain

Figure 2. Contributions of primary sensory neurons to pain.

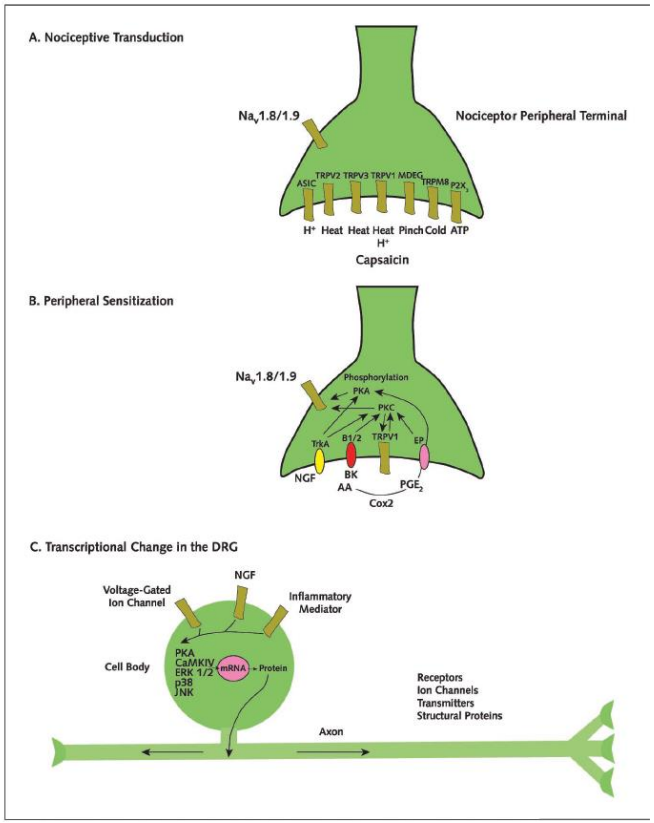
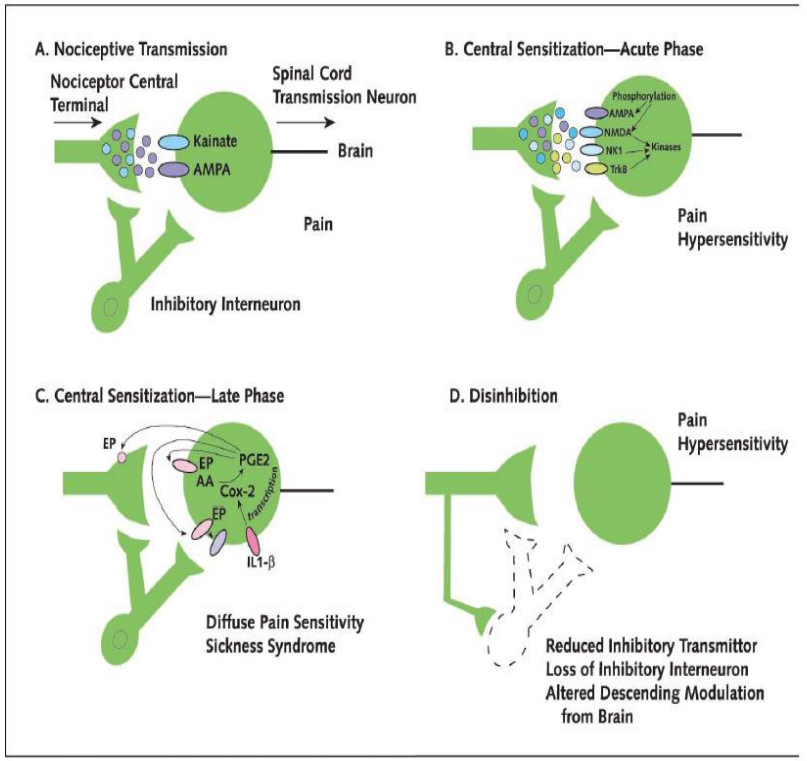


Figure 3. Contributions of spinal cord dorsal horn neurons to pain.



Peripheral sensitization

Central sensitization

Ann Intern Med. 2004;140:441–451.

Why need Pain control? Pain in Rib fractures

- Acute phase

Respiratory deterioration – inability cough and breath deeply

Pneumonia – Incidence 6% ~11% <65 year old < 34%

Respiratory failure

Mortality

" Pneumonia was associated with mortality only in patients with isolated thoracic trauma."

Crit Care Med. 2006;34(6):1642.

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European Journal of Cardio-thoracic Surgery 24 (2003) 133–138

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

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A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management

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Received 9 January 2003; received in revised form 16 March 2003; accepted 2 April 2003

Abstract

Objective: A rib fracture secondary to blunt thoracic trauma is an important indicator of the severity of the trauma. In the present study we explored the morbidity and mortality rates and the management following rib fractures. **Methods**: Between May 1999 and May 2001, 1417 cases who presented to our clinic for thoracic trauma were reviewed retrospectively. Five hundred and forty-eight (38.7%) of the cases had rib fracture. There were 331 males and 217 females, with an overall mean age of 43 years (range: 5–78 years). These patients were allocated into groups according to their ages, the number of fractured ribs and status, i.e. whether they were stable or unstable (flail chest). **Results**: The etiology of the trauma included road traffic accidents in 330 cases, falls in 122, assault in 54, and industrial accidents in 42 cases. Pulmonary complications such as pneumothorax (37.2%), hemothorax (26.8%), hemo-pneumothorax (15.3%), pulmonary contusion (17.2%), flail chest (5.8%) and isolated subcutaneous emphysema (2.2%) were noted. 40.1% of the cases with rib fracture were treated in intensive care units. The mean duration of their stay in the intensive care unit was 11.8 ± 6.2 days. 42.8% of the cases were treated in the wards whereby their mean duration of hospital stay was 4.5 ± 3.4 days, while 17.1% of the cases were followed up in the outpatient clinic. Twenty-seven patients required surgery. Mortality rate was calculated as 5.7% ($n = 31$). **Conclusions**: Rib fractures can be interpreted as signs of significant trauma. The greater the number of fractured ribs, the higher the mortality and morbidity rates. Patients with isolated rib fractures should be hospitalized if the number of fractured ribs is three or more. We also advocate that elderly patients with six or more fractured ribs should be treated in intensive care units due to high morbidity and mortality.

Keywords: Thoracic trauma; Rib fracture; Pneumothorax; Hemothorax

1. Introduction

Thoracic traumas comprise 10–15% of all traumas and are the causes of death in 25% of all fatalities due to trauma [1]. Seventy percent of the thoracic traumas are blunt and the remaining are penetrating injuries. Most commonly 4–9th ribs are fractured. On the other hand, fractures of the upper ribs (1st and 2nd ribs) usually signify a severe trauma whereby concomitant great vessel injuries are commonplace. Fracture of the lower ribs (9–12th) may result in laceration of the spleen, liver or the kidneys [2–4].

In the present study we have attempted to shed light on the clinical course, treatment strategies and the risk factors that have an impact on the morbidity and mortality rates of rib fractures, which are the most frequent clinical scenarios in thoracic traumas.

2. Materials and methods

A total of 1417 cases who were admitted to our clinic due to thoracic trauma between May 1999 and May 2001 were reviewed retrospectively. Rib fracture was identified in 548 (38.7%) of the cases. Cases were allocated into subgroups according to the number of fractured ribs (1–2 fractures, 3–5 fractures and more than 6 fractures), age (children = younger than 12 years of age; adolescents = aged between 13 and 17; adult = aged between 18 and 59; elderly = older than 60 years of age) and status (those with or without a flail chest). Patients were also analyzed according to gender,

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pulmonary complications of the cases

-pneumothorax	Lung contusion	Flail chest	Isolated subcutaneous emphysema
	15	–	9
	32	12	3
	47	20	–
	94	32	12

M. Sırmalı et al.
European Journal of Cardio-thoracic Surgery 24 (2003) 133–138

Why need Pain control?

Pain in Rib fractures

- Late phase

Chronic pain

Long term disability

"One hundred ten (59%) patients had prolonged chest wall pain and 142 (76%) had prolonged disability"

Am J Surg. 2013 May;205(5):511-5

Injury, Int. J. Care Injured 46 (2015) 61–65

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Quality of life after major trauma with multiple rib fractures

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Flail chest

ABSTRACT

Introduction: Rib fractures are a common injury presenting to major trauma centres and community hospitals. Aside from the acute impact of rib fracture injury, longer-term morbidity of pain, disability and deformity have been described. Despite this, the mainstay of management for the vast majority of rib fracture injuries remains supportive only with analgesia and where required respiratory support. This study aimed to document the long-term quality of life in a cohort of major trauma patients with rib fracture injury over 24 months.

Methods: Retrospective review (July 2006–July 2011) of 397 major trauma patients admitted to The Alfred Hospital with rib fractures and not treated with operative rib fixation.

The main outcome measures were quality of life over 24 months post injury assessed using the Glasgow Outcome Scale Extended and SF12 health assessment forms and a pain questionnaire.

Results: Assessment over 24 months of major trauma patients with multiple rib fractures demonstrated significantly lower quality of life compared with published Australian norms at all time points measured. Return to work rates were poor with only 71% of those who were working prior to their accident, returning to any work.

Conclusions: This study demonstrates a significant reduction in quality of life for rib fracture patients requiring admission to hospital, which does not return to the level of Australian norms for at least two years.

Background

Rib fractures are a common injury presenting to both major trauma centres and community hospitals. Rib fracture injuries extend across a broad spectrum of severity from a single fractured rib which may be sustained in a fall or sporting injury, to multiple fractured ribs resulting in a flail chest with paradoxical chest wall movement and respiratory failure. Fractured ribs are present in approximately 21% of patients admitted to trauma centres with blunt chest trauma [1]. Mortality rates of up to 33% have been reported for flail chest injury reflecting the high impact nature of the injury as well as associated life threatening injuries such as splenic or liver lacerations [2]. Aside from the acute impact of rib fracture injury, longer-term morbidity of pain, disability and deformity have been described [3,4]. Despite this, the mainstay of management for the vast majority of rib fracture injuries remains supportive only with analgesia and where required respiratory support. However, in many patients this acute management does not address the potential longer-term morbidity of such injuries.

The aim of this study was to examine the long-term morbidity and quality of life outcomes in a single centre cohort of rib fracture patients over 24 months post injury.

Methods

Morbidity and quality of life data were collected from a consecutive cohort of patients from The Alfred Hospital, Australia. The Alfred Hospital is one of two adult major trauma services in the state of Victoria, Australia. Approximately 1200 major trauma patients are treated at The Alfred each year with an overall mortality of 8%. Approximately 600 major chest trauma patients

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http://dx.doi.org/10.1016/j.injury.2014.06.014
0020–1383/

·216)	Multi-trauma group (n = 181)	p value
	26 (14%)	0.02
	14 (8–26)	<0.001
	39 (22%)	<0.001
	106 (59%)	<0.001
	10 (6%)	0.02
	2 (0–5)	0.35
	2 (0–5)	0.09
	0 (0–5)	0.50
	37.3 (12.3)	0.14
	39.4 (13.8)	0.26
	39.2 (14.0)	0.11
	48.3 (14.4)	0.61
	49.2 (12.8)	0.99
	47.9 (12.5)	0.32
	38/131 (22.5%)	<0.001
	45/117 (27.8%)	0.06
	43/101 (29.8%)	<0.001

The American Journal of Surgery (2014) 207, 659-663

The American Journal of Surgery

North Pacific Surgical Association

The contribution of rib fractures to chronic pain and disability

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KEYWORDS:
Rib fractures;
Flail chest;
Chronic pain;
Disability

Abstract

BACKGROUND: The contribution of rib fractures to chronic pain and disability is not well described.

METHODS: Two hundred three patients with rib fractures were followed for 6 months. Chronic pain was assessed using the McGill Pain Questionnaire Pain Rating Index and Present Pain Intensity (PPI) scales. Disability was defined as a decrease in work or functional status.

RESULTS: The prevalence of chronic pain was 22% and disability was 53%. Acute PPI predicted chronic pain. Associated injuries, bilateral rib fractures, injury severity score, and number of rib fractures were not predictive of chronic pain. No acute injury characteristics were predictive of disability. Among 89 patients with isolated rib fractures, the prevalence of chronic pain was 28% and of disability was 40%. No injury characteristics predicted chronic pain. Bilateral rib fractures and acute PPI predicted disability.

CONCLUSION: The contribution of rib fractures to chronic pain and disability is significant but unpredictable with conventional injury descriptors.

Chronic pain and disability are significant contributors to diminished quality of life following injury.[1-4] It is estimated that about a third of the population of the United States and Canada suffer from chronic pain.[5,6] Although cause-specific data are lacking, it is estimated that up to one quarter of the 1 billion disabled individuals worldwide have injury-related disabilities.[7] Economic costs specific to injury-related chronic pain and disability in the United States and Canada are also lacking, but estimates range at least in the tens of billions of dollars per year.[8] Rib fractures are commonly recognized as a significant source of acute pain following injury, but little is known about their specific contribution to chronic pain and disability. Last year we reported that the traditional view that most rib fracture pain resolves within 6 to 8 weeks of injury is incorrect.[9] In this companion report we document the extent of chronic pain and disability in the same cohort of rib fracture patients.

Methods

All injured patients evaluated in the Oregon Health & Science University emergency department or inpatient units from July 2005 to January 2008 were screened for the

The authors declare no influence from private industry or study sponsor. The decision to publish and the content of the publication were not influenced by the study sponsor, the Medical Research Foundation of Oregon.

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Results:

Chronic pain 22% (35/159)

Chronic disability 53% (86/161)

Isolated rib fractures

Chronic pain was 28% (25/88)

Chronic disability was 40%(36/89)

The American Journal of Surgery (2014) 207, 659-663

Academic Emergency Medicine
Official Journal of the Society for Academic Emergency Medicine

ORIGINAL RESEARCH CONTRIBUTION

Risk Factors of Significant Pain Syndrome 90 Days After Minor Thoracic Injury: Trajectory Analysis

Raoul Daoust, MD, M
Stéphanie Camden, I
Jean-Marc Chauny, I

Abstract

Objectives: T
patients with

Methods: A
2006 to Nov
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Results: In th
pain trajecto
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initial oxygen

Conclusions:
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planning spe

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Table 4
Bivariate and Multivariate Analysis of Factors Significantly Associated With Belonging to the Trajectory of Significant Pain at 90 Days*

Characteristics	Bivariate analysis,PR (95% CI)	p-value	Multivariate,PR (95%CI)†	p-value
Smoker	1.8 (1.3–2.6)	0.001	1.8 (1.3–2.6)	0.0009
[illegible]	[illegible]	[illegible]		
One or more rib fractures‡	1.5 (1.0–2.0)	0.03		
Two or more rib fractures‡	2.0 (1.4–2.9)	<0.0001	1.9 (1.3–2.7)	0.0004
Three or more rib fractures‡	2.4 (1.6–3.6)	<0.0001		
One or more fractures of rib 3 to 9‡	1.5 (1.0–2.1)	0.03		
Dyspnea at rest at the initial visit	1.9 (1.2–3.1)	0.005		
Any dyspnea at the initial visit	1.4 (1.0–2.0)	0.07		
Oxygen saturation < 95% at the initial visit	1.9 (1.2–3.0)	0.006	1.7 (1.1–2.6)	0.03
Asthma	1.6 (1.0–2.5)	0.08		

Minor thoraci
42% of emer
blunt chest
caused by falls of less than 2 meters and motor vehicle accidents.[1,2] Up to 90% of MTI patients will seek medical attention within 72 hours of trauma.[3] MTI can produce significant pain that can last for several months.[4] This thoracic pain, often severe at the time of the trauma,[5] can significantly limit the ability to work and to perform daily activities. It has been suggested that MTI-related pain also hinders the ability to cough and breathe deeply, which can lead to atelectasis, accumulastudy,[8] some patients will have clinically or radiologically confirmed rib fractures. It was shown that standardized chest radiographs can miss up to 50% of the rib fractures detected clinically, by tomography or by ultrasound.[9–13] Bergeron et al.[7] suggested that elderly patients hospitalized with rib fractures after blunt thoracic trauma are at increased risk of mortality. Another study showed that MTI in this population is also associated with a significant rate of complications (36%)

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What can be used for pain control?

Drug	Equianalgesic parenteral dose	Starting iv dose	iv:po ratio	Starting dose po /transdermal	Duration of Action
Morphine	10 mg	Bolus dose=0.05-0.1 mg q 2-4 hours Continuous infusion=0.01-0.04 mg/kg/hr	1:3	0.15-0.3 mg/kg/dose q 4 hours	3-4 hours
Hydromorphone	1.5 mg	0.015-0.02 mg/kg q 4	1:5	0.06 mg/kg q 3 to 4 hours	2-4 hours
Oxycodone	5-10 mg	N/A		0.1-0.2 mg/kg q 3 to 4	3-4 hours
Fentanyl	100mcg	1 to 2 mcg/kg/hr as continuous infusion		25 mcg patch	72 hours
Methadone	10 mg	0.1 mg/kg q 4 to 8 hours	1:2	0.2 mg/kgq 4 to 8 hours	12 to 150 hours

What can be used for pain control?

- Morphine : prototype opiate
  - Non-CYP metabolism
  - Accumulate in hepatic or renal dysfunction and prolong effects.
  - Venodilation, hypotension, and bradycardia

- Fentanyl :synthetic derivative of morphine , approximately 100 times more potent
  - more rapid onset of action and a shorter half-life
  - Chest wall rigidity may occur with higher dosing
  - Remifentanil, sufentanil, and alfentanil

What can be used for pain control?

- Hydromorphone: semisynthetic opiate agonist
  - IV administration requires small volumes
  - Potentially neurotoxic (excitatory) metabolite(s)

What can be used for pain control?

- Acetaminophen (paracetamol)

- Lacks dependence and tolerance of opiates.

- Lacks antiplatelet effect and gastrointestinal toxicity of NSAIDs

- Anticipate pain and discomfort upon abrupt cessation

- **NSAIDs** — Nonsteroidal anti-inflammatory drugs (NSAIDs)

-ketorolac, ibuprofen, and indomethacin

World Health Organization (WHO) Step Ladder Approach

Severe Pain 7-10/10

Potent opioids (e.g. morphine) +/- non-opioids

Moderate Pain 4-6/10

Weak opioids +/- non-opioids (e.g. Tylenol #3®)

Mild Pain 1-3/10

ASA, Tylenol, NSAIDS

What can be used for pain control?

Anticonvulsants

- Agents for neuropathic pain
  - gabapentin (Neurontin®)
  - pregabalin (Lyrica®)
  - clonazepam (Klonopin®)
  - Other newer agents
- Start low, go slow
- Watch for side effects
- Monitor serum levels, if available

What can be used for pain control?

Long Acting Opioids

- Oral
  - morphine:
    - MS Contin®
    - Kadian®
    - Oramorph SR
  - oxycodone
    - Oxycontin®
    - Oxycodone SR
  - oxymorphone
    - Opana SR
  - methadone
- Transdermal
  - Fentanyl Patch (Duragesic®) –
  - Dosing Q 72 hours

What can be used for pain control?

- **Regional Thoracic analgesia**
  - Epidural Nacotics/Anesthetics
  - Intrapleural Anesthesia
  - Thoracic Paravertebral Block
  - Intercostal Nerve Block
- **Transdermal opioid**
- **Lidocaine 5% Patch**
- **Intravenous narcotics**
- **Surgical management.**

Regional Thoracic analgesia

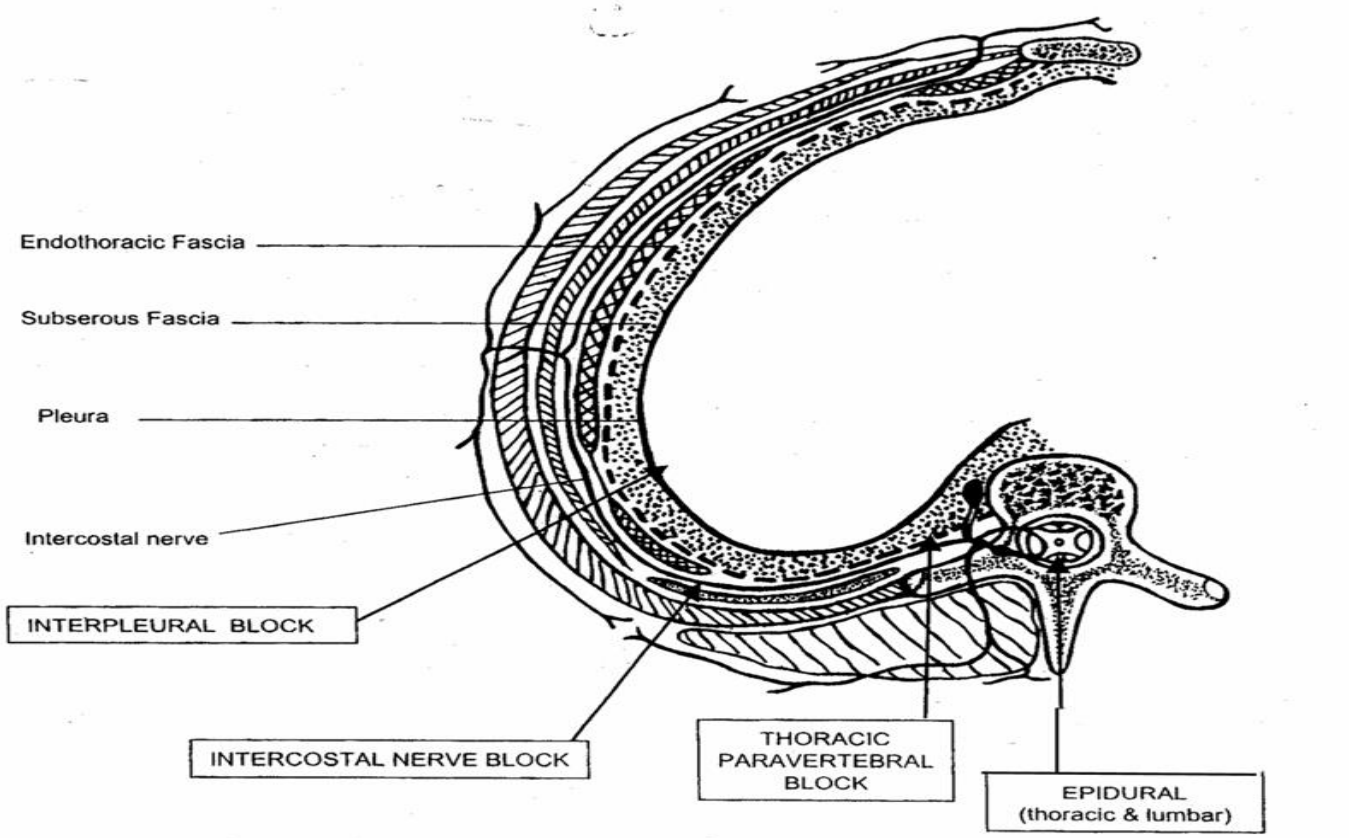
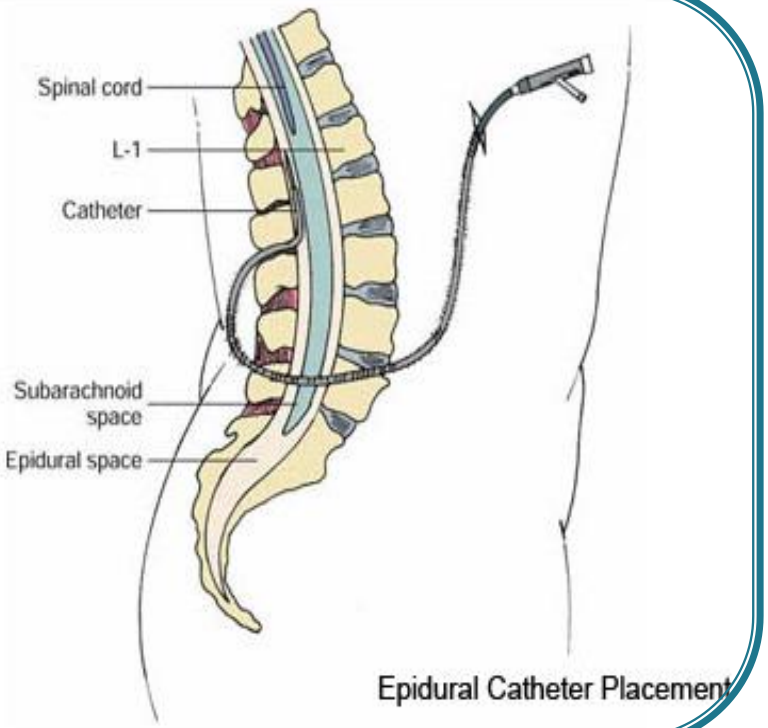


Figure 1. The anatomic location of delivery for the various modalities of regional thoracic analgesia From *Karmakar MJ, Anthony MH, Acute Pain Management of Patients with Multiple Rib Fracture[illegible] Trauma 2003; 54: 615-625*

Epidural Nacotics/Anesthetics

- Method

narcotics, anesthetic agents or combinations thereof are introduced into the spinal epidural space at the thoracic or lumbar level to provide regional analgesia



Epidural Nacotics/Anesthetics

❖ Advantage

- Effectiveness in the absence of sedation.
- Increased functional residual capacity (FRC)
- Lung compliance and vital capacity
- Decreased airway resistance and increased pO2
- Tidal volume is increased
- Chest wall paradox in flail segments in reduced

Epidural Narcotics / Anesthetics

Epidural analgesia improves outcome after multiple rib fractures

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Background. *Rib fractures are common and associated with significant pulmonary morbidity. We hypothesized that epidural analgesia would provide superior pain relief, and reduce the risk of subsequent pneumonia.*
Methods. *A prospective, randomized trial of epidural analgesia versus IV opioids for the management of chest wall pain after rib fractures was carried out. Entry criteria included patients older than 18 years with more than 3 rib fractures and no contraindications to epidural catheter placement.*
Results. *From March 2000 to December 2003, 408 patients were admitted with more than 3 rib fractures; 282 met exclusion criteria, 80 could not be consented, and 46 were enrolled (epidural n = 22, opioids n = 24). The groups were comparable for mean age, injury severity score, gender, chest Abbreviated Injury Scale, and mean number of rib fractures. The epidural group tended to have more flail segments (38% vs 21%, P = .20) and pulmonary contusions (59% vs 38%, P = .14), and required more chest tubes (95% vs 71%, P = .03) Despite the greater direct pulmonary injury in the epidural group, their rate of pneumonia was 18% versus 38% for the intravenous opioid group. When adjusted for direct pulmonary injury, there was a greater risk of pneumonia in the opioid group: OR, 6.0; 95% CI, 1.0-35; P = .05. When stratified for the presence of pulmonary contusion there was a 2.0-fold increase in the number of ventilator days for the opioid group: incident rate ratio, 2.0; 95% CI, 1.6-2.6; P < .001.*
Conclusions. *The use of epidural analgesia is limited in the trauma population due to numerous exclusion criteria. However, when feasible, epidural analgesia is associated with a decrease in the rate of nosocomial pneumonia and a shorter duration of mechanical ventilation after rib fractures. (Surgery 2004;136:426-30.)*

From the Departments of Surgery and Anesthesiology, Harborview Medical Center, University of Washington, Seattle, Wash

RIB FRACTURES ARE A COMMON INJURY in the blunt trauma population with a reported incidence of 10% among patients admitted to a regional trauma center.[1] The presence of 3 or more rib fractures has been associated with increased mortality and duration of care in intensive care units and hospitals.[2] Among the elderly, rib fractures have been associated with a 31% rate of nosocomial pneumonia.[3] The pain associated with rib fractures impairs ventilatory function and increases pulmonary morbidity. Management of these patients is therefore focused on achieving adequate analgesia and clearance of pulmonary secretions. Previous studies have demonstrated that epidural analgesia provides superior pain relief and improves pulmonary function tests when compared to intravenous (IV) opioids for patients with rib fractures.[4-6] However, no previous study has demonstrated that the use of epidural analgesia actually improves outcome for these patients. We sought to determine if epidural analgesia would reduce the risk of nosocomial pneumonia and duration of mechanical ventilation when compared to IV opioids.

Presented at the 65th Annual Meeting of the Society of University Surgeons, St. Louis, Missouri, February 11-14, 2004.
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0039-6060/$ - see front matter

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METHODS

All patients admitted to our Level 1 trauma center who were older than 18 years and had 3 or more rib fractures were screened for enrollment from March 1, 2000, through December 15, 2003. Patients who had chest wall pain requiring IV opioids were evaluated for eligibility to receive thoracic epidural analgesia. Patients were excluded if they had any acute spine fracture or pre-existing spine deformity, severe traumatic brain or spinal cord injury, or severe altered mental status such that pain could not be assessed, unstable pelvic

Table III. Adjusted outcome parameters

	OR/IRR	*95% CI*	P *value*
Nosocomial pneumonia*	OR, 6.0	1.0-35	.05
Ventilator days†	IRR, 2.0	1.6-2.6	<.001

[Surgery 2004;136:426-30]

Epidural Narcotics / Anesthetics

❖ Disadvantage

- Insertion may be technically demanding.
- Hypotension
- Epidural infection.
- Spinal cord trauma
- Inadvertent “high block”-respiratory depression
- Limitation for multiple Trauma, incooperation
- Nursing intensity in monitoring

Thoracic Paravertebral Block

Continuous Thoracic Paravertebral Infusion of Bupivacaine for Pain Management in Patients With Multiple Fractured Ribs*

Manoj K. Karmakar, MD; Lester A.H. Critchley, MD; Anthony M.-H. Ho, MD, FCCP; Tony Gin, MD; Tak Wai Lee, MBBS; and Anthony P.C. Yim, MD, FCCP

Study objective: **To evaluate the efficacy of a continuous thoracic paravertebral infusion of bupivacaine for pain management in patients with unilateral multiple fractured ribs (MFR).**
Design: **Prospective nonrandomized case series.**
Setting: **Multidisciplinary tertiary hospital.**
Patients: **Fifteen patients with unilateral MFR.**
Interventions: **Insertion of a catheter into the thoracic paravertebral space. We administered an initial injection of 0.3 mL/kg (1.5 mg/kg) bupivacaine 0.5% with 1:200,000 epinephrine followed 30 min later by an infusion of bupivacaine 0.25% at 0.1 to 0.2 mL/kg/h for 4 days.**
Measurements and results: **The following parameters were measured during the initial assessment before thoracic paravertebral block (TPVB), 30 min after the initial injection, and during follow-up on day 1 and day 4 after commencing the infusion of bupivacaine: visual analog pain score at rest and during coughing; respiratory rate; arterial oxygen saturation (Sao_2); bedside spirometry (*ie*, FVC, FEV_1, FEV_1/FVC ratio, and peak expiratory flow rate [PEFR]); arterial blood gas measurements; and O_2 index (*ie*, Pao_2/fraction of inspired oxygen ratio). There were significant improvements in pain scores (at rest, $p = 0.002$; during coughing, $p = 0.001$), respiratory rate ($p < 0.0001$), FVC ($p = 0.007$), PEFR ($p = 0.01$), Sao_2 ($p = 0.04$), and O_2 index ($p = 0.01$) 30 min after the initial injection, which were sustained for the 4 days that the thoracic paravertebral infusion was in use ($p < 0.05$). $Paco_2$ did not change significantly after the initial injection, but on day 4 it was significantly lower than the post-TPVB value ($p = 0.04$). One patient had an inadvertent epidural injection, and another developed transient ipsilateral Horner syndrome with sensory changes in the arm. No patient exhibited clinical signs of inadvertent intravascular injection or local anesthetic toxicity.**
Conclusion: **Our results confirmed that continuous thoracic paravertebral infusion of bupivacaine is a simple and effective method of providing continuous pain relief in patients with unilateral MFR. It also produced a sustained improvement in respiratory parameters and oxygenation.**
(CHEST 2003; 123:424–431)

Key words: analgesia; anesthetic technique; blunt chest trauma; bupivacaine; pain control; paravertebral anesthetic; paravertebral catheter; regional anesthetic; rib fracture; trauma

Abbreviations: FIO_2 = fraction of inspired oxygen; MFR = multiple fractured ribs; Sao_2 = arterial oxygen saturation; TPVB = thoracic paravertebral block; VAS = visual analog scale

Multiple fractured ribs (MFR) cause severe pain that adversely affects a patient's ability to cough and breath deeply, predisposing the patient to sputum retention and respiratory insufficiency. Effective analgesia, chest physiotherapy, and respiratory care are the cornerstones of management. Effective analgesia is vital because it allows patients to breath deeply, cough effectively, and comply with chest physiotherapy.

Thoracic paravertebral block (TPVB), which produces multidermatomal, ipsilateral, somatic, and sympathetic nerve blockade,[1,2] is one of the thera-

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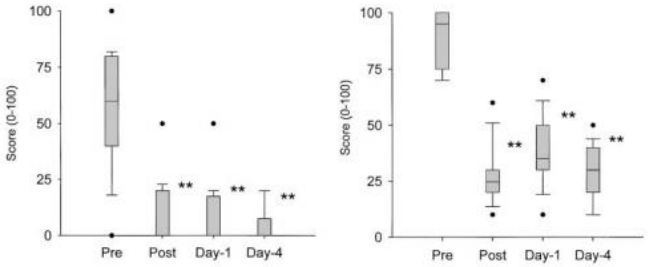

FIGURE 3. Changes in the VAS pain score, at rest and during coughing. Values are represented as box plots (25th to75th percentiles). Bars = the median and the 10th and 90th percentiles; ● = extreme values; * = $p < 0.05$ (compared to pre-TPVB values); and ** = $p < 0.01$ (compared to pre-TPVB values).

Conclusion: **Our results confirmed that continuous thoracic paravertebral infusion of bupivacaine is a simple and effective method of providing continuous pain relief in patients with unilateral MFR. It also produced a sustained improvement in respiratory parameters and oxygenation.**
(CHEST 2003; 123:424–431)

Intrapleural Anesthesia

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EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

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Intrapleural intercostal nerve block associated with mini-thoracotomy improves pain control after major lung resection☆

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Received 24 September 2005; received in revised form 29 December 2005; accepted 3 January 2006; Available online 14 February 2006

Abstract

Objective: To prospectively assess the impact of intrapleural intercostal nerve block (IINB) associated with mini-thoracotomy on postoperative pain and surgical outcome after major lung resections. **Methods:** Between January 2004 and February 2005, we randomly assigned 120 consecutive patients undergoing mini-thoracotomy (10–13 cm) for major lung resections, to receive or not IINB from the 4th to the 8th space at the moment of thoracotomy using 20 ml (7.5 mg/ml) ropivacain injection at the dose of 4 ml for each space. Postoperative analgesia consisted of continuous intravenous infusion of tramadol (10 mg/h) and ketoralac tromethamine (3 mg/h) for 48 h for all patients. **Results:** The two groups (60 patients each) were comparable for age, sex, pulmonary function, type and duration of the procedure. Mortality and morbidity were 0% and 10%, respectively, for the IINB group and 3.3% and 15%, respectively, for the non-IINB group ($p > 0.05$, NS). Mean postoperative pain measured by the 'Visual Analogue Scale' were as follows: 2.3 ± 1 at 1 h, 2.2 ± 0.8 at 12 h, 1.8 ± 0.7 at 24 h, and 1.6 ± 0.6 at 48 h for the IINB group; and 3.6 ± 1.4 at 1 h, 3.4 ± 2 at 12 h, 2.9 ± 1.2 at 24 h, and 2.0 ± 1 at 48 h for the non-IINB group. Differences were significant at 1 h, 12 h, 24 h, and 48 h ($p < 0.05$). Mean postoperative hospital stay was 5.7 days in the IINB group and 6.5 days in the non-IINB group ($p < 0.05$). **Conclusion:** IINB associated with mini-thoracotomy reduces postoperative pain and contributes to improve postoperative outcome after major pulmonary resections.

Keywords: Intercostal nerve block; Postoperative analgesia; Mini-thoracotomy; Major lung resection

1. Introduction

Postthoracotomy pain control represents a crucial problem in the clinical management after lung resection. Pain strongly limits pulmonary ventilation resulting in a functional lung restriction. Coughing and secretion clearing may be compromised, determining possible bronchial obstruction, atelectasis and/or parenchymal lung infection. Pain is, therefore, considered a major independent factor responsible for increased perioperative morbidity and mortality.

Although a number of methods have been proposed for postthoracotomy analgesia [1–6], including systemic use of opioids and non-steroid drugs, epidural analgesia, intercostal nerve block, and cryoanalgesia, the optimal strategy is still to be defined, and pain control remains an open challenge in thoracic surgery.

Increasing knowledge and technical refinements in all surgical disciplines have shown that reduced tissue damage consequent to the use of limited surgical approaches may prove effective in significantly decreasing early postoperative pain [7,8]. In thoracic surgery, the use of muscle-sparing mini-thoracotomies for lung resections has proven to produce more tolerable pain and allow quicker functional recovery and lower postoperative complications [7,9,10].

Following these premises we have associated a minimally discomfortable analgesic technique such as intrapleural intercostal nerve block (IINB) performed during surgery to the routine use of mini-thoracotomy for major lung resections in order to achieve adequate pain control.

The aim of this study was to assess the impact of IINB associated with mini-thoracotomy on postoperative pain and surgical outcome after major lung resections. Comparisons were made between patients who were randomly assigned to receive or not IINB in addition to continuous intravenous analgesia.

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Intercostal Nerve Block

Original Article

JER

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Effectiveness of intercostal nerve block for management of pain in rib fracture patients

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Controlling pain in patients with fractured ribs is essential for preventing secondary complications. Conventional medications that are administered orally or by using injections are sufficient for the treatment of most patients. However, additional aggressive pain control measures are needed for patients whose pain cannot be controlled effectively as well as for those in whom complications or a transition to chronic pain needs to be prevented. In this study, we retrospectively analyzed the medical records of patients in our hospital to identify the efficacy and characteristics of intercostal nerve block (ICNB), as a pain control method for rib fractures. Although ICNB, compared to conventional methods, showed dramatic pain reduction immediately after the procedure, the pain control effects decreased over time. These findings suggest that the use of additional pain control methods (e.g. intravenous patient-controlled analgesia and/or a fentanyl patch) is recommended for patients in who the pain level increases as the ICNB efficacy decreases.

Keywords: Intercostal nerve block, Pain control, Rib fracture

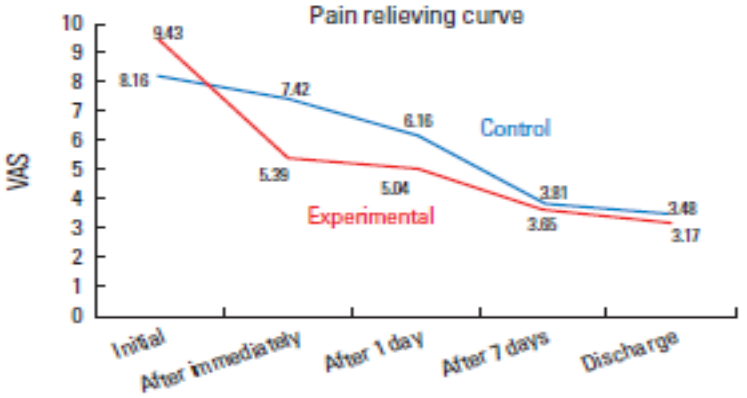

Fig. 2. Pain relief curve.

INTRODUCTION

Thoracic injuries have a number of causes including falls, traffic accidents, sports injuries, and physical assaults. The forms of thoracic injuries are diverse, and they include simple bruises and rib fractures as well as traumatic hemothorax or pneumothorax associated with internal organ damage from rib fractures; in extreme cases, open thoracic trauma with exposure of the thoracic cavity occurs. Among these injuries, the most common forms leading to hospitalization are simple bruises or blunt trauma in the form of a rib fracture, with complaints of tenderness around the injured area and pain during exercising, coughing, and/or breathing. Depending on the chief complaints, the first doctor examining the patient conducts the physical examination and observes a simple chest radiograph, nuclear scan, computed tomography, or thoracic ultrasonogram. In most cases, conservative treatment consisting of an analgesic, muscle relaxant, in the form of injection, or oral medication is administered; however, depending on the patient's degree of pain or the injury severity, hospitalization and more aggressive pain control measures may be required. Thus, depending on the injury severity, differences in treatment methods, hospitalization, and/or treatment duration are determined. Most of the pain is eliminated after 2-3 days of conservative treatment in most common blunt trauma cases, and a prescription of 2-3 weeks of oral analgesics is enough after discharge.

Pain control is essential for not only primary pain relief but also preventing secondary complications such as atelectasis or pneumonia as well as the transition to chronic pain. Accordingly, further steps are now being taken from the conventional pain control medication and techniques by the introduction of more aggressive pain control measures such as the intercostal nerve block (ICNB) (Moore and Bridenbaugh, 1962; Wurnig et al., 2002), transcutaneous electrical nerve stimulation (TENS) (Oncel et al., 2002), and intravenous patient-controlled analgesia (IV PCA). Used early on, these aggressive measures increase patient satisfaction and prevent secondary complications. The purpose of this study was to compare the use of ICNB, as an aggressive pain control measure, with conventional oral or injectable medications in terms of the

Transdermal opioid

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Original Article

The Effectiveness of Transdermal Opioid in the Management Multiple Rib Fractures: Randomized Clinical Trial

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ABSTRACT

Background: The most commonly observed pathology in chest traumas is rib fracture, and the most important clinical symptom is severe pain.

Aims: To investigate the effectiveness of intramuscular opioid (IMO), intravenous patient-controlled analgesia (IVPCA) and the Fentanyl transdermal therapeutic system (TTS) in the management of rib fracture pain.

Study Design: Prospective randomized clinical trial.

Methods: In our prospective and randomised study, we included 45 patients with a diagnosis of multiple rib fractures. There were three groups and intercostal nerve blockage (ICB) in the first day and oral paracetamol for five days was administered to each group as standard. In Group IMO (n=15), 4x40 mg pethidine HCl was administered to the patients, while in Group IVPCA (n=15) this was 5 µg/mL continuous intravenous fentanyl and was 50 µg fentanyl TTS in Group TTS (n=15). The demographics, injury data and vital signs of the patients were recorded. Pain was scored using Visual Analogue Scale (VAS). The pain during lying down (VAS_1) and mobilisation (VAS_m) was detected.

Results: There were no differences between the three groups regarding age, sex, the trauma pattern, the number and distribution of costal fracture localisations, the presence of additional pathology, complications, thoracal catheter and the duration of thoracal catheter. No significant difference between the groups regarding systolic and diastolic arterial tension, number of breaths and beats in a minute was observed (p>0.05). We observed an improvement in the mean VAS score after treatment in all three groups. The mean VASI score significantly decreased after treatment in each group (p<0.05). The mean VAS_1 and VAS_m scores measured on the 1st, 2nd, 3rd, 4th and 5th days were found to be higher in Group IMO than in Groups IVPCA and TTS; however, these differences were not statistically significant (p>0.05).

Conclusion: In the analgesia of patients with multiple rib fractures, TTS administration with ICB showed similar effectiveness with IVPCA administration with ICB. In the management of pain due to multiple rib fractures, TTS administration is a safe, non-invasive and effective procedure.

Key Words: Multiple rib fracture, pain treatment, patient-controlled analgesia, transdermal therapeutic system

Received: *19.11.2012* ***Accepted:*** *25.04.2013*

Introduction

In the management of patients with multiple rib fractures, effective pain treatment, pulmonary physiotherapy and respiratory care are essential components (1, 2). Pain due to multiple rib fractures may complicate the pulmonary damage caused after the trauma. The lack of enough and deep breathing, caused by pain, makes the patients' mobilisation difficult and reduces the effectiveness of pulmonary physiotherapy (1, 3).

In the management of pain due to multiple rib fractures, intercostal blockage and parenteral administration of systemic opioids are among the most commonly applied procedures (4). The opioids used for this purpose can be administered in many different ways and dose intervals (3). The ways in which opioids are administered are mainly intramuscular, intravenously, patient controlled analgesia and thoracic epidural.

Our aim is to observe the effectiveness of the fentanyl transdermal therapeutic system (TTS) in the management of pain secondary to multiple rib fractures.

Material and Methods

Ethical approval was obtained from Afyon Kocatepe University Ethical Committee on the 18th February 2009, with the number 2-9, was obtained to perform the study. Our study was a prospective and randomised study. Randomisation was performed using a 'Random Number Table'. We included patients with three or more rib fractures in our study. The patients' demographics, the trauma patterns, analgesic administration methods, pain and sedation scores and complications were evaluated. The patients' age, sex, trauma characteristics and pathologies accompanying rib fracture, the number of rib fractures, the presence of haemothorax and pneumothorax, and the necessity of chest tube was recorded. Visual Analogue Scale (VAS) was used for scoring pain. The effectiveness of the study was evaluated by scoring VAS during lying down (VAS_1) and VAS during mobilisation (VAS_m). VAS_1 was scored before the treatment and on the 1st, 2nd, 3rd, 4th and 5th days after the treatment. VAS_m was scored on the 1st, 2nd, 3rd, 4th and 5th days after the treatment. The sedation due to opioids was monitored by Ramsey's sedation scale (RSS) and

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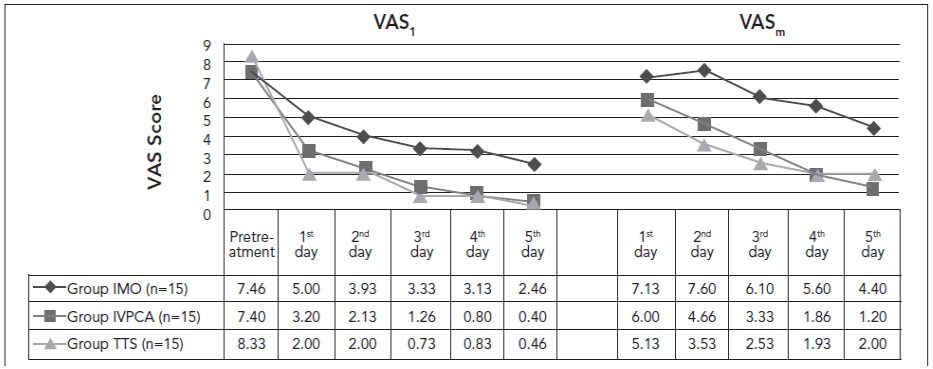

	Pretre-atment	1st day	2nd day	3rd day	4th day	5th day		1st day	2nd day	3rd day	4th day	5th day
Group IMO (n=15)	7.46	5.00	3.93	3.33	3.13	2.46		7.13	7.60	6.10	5.60	4.40
Group IVPCA (n=15)	7.40	3.20	2.13	1.26	0.80	0.40		6.00	4.66	3.33	1.86	1.20
Group TTS (n=15)	8.33	2.00	2.00	0.73	0.83	0.46		5.13	3.53	2.53	1.93	2.00

Conclusion

TTS, as a non-invasive opioid administration technique, has advantages for both the patient and the nurse. The administration of ICB combined with TTS provided similar efficacy as the administration of ICB combined with IVPCA in the analgesia of our patients with multiple rib fractures. TTS is a safe, non-invasive and effective method in the treatment of pain secondary to multiple rib fractures.

Lidocaine 5% Patch

Randomized, Double-Blind, Placebo-Controlled Trial Using Lidocaine Patch 5% in Traumatic Rib Fractures

Nichole K Ingalls, MD, Zachary A Horton, MD, Matthew Bettendorf, MD, Ira Frye, MD, Carlos Rodriguez, MD, FACS

BACKGROUND: The lidocaine patch 5% was developed to treat postherpetic neuralgia. Anecdotal experience at our institution suggests the lidocaine patch 5% decreases narcotic usage in patients with traumatic rib fractures. This trial was developed to define the patch's efficacy.

STUDY DESIGN: Patients with rib fractures admitted to the trauma service at our Level I trauma center were enrolled and randomized in a 1 to 1 double-blind manner to receive a lidocaine patch 5% or placebo patch. Fifty-eight patients who met the inclusion criteria were enrolled from January 2007 to August 2008. Demographic and clinical information were recorded. The primary outcomes variable was total narcotic use, analyzed using the 1-tailed Mann-Whitney test. The secondary outcomes variables included non-narcotic pain medication, average pain score, pulmonary complications, and length of stay. Significance was defined based on a 1-sided test for the primary outcome and 2-sided tests for other comparisons, at $p < 0.05$.

RESULTS: Thirty-three patients received the lidocaine patch 5% and 25 received the placebo patch. There were no significant differences in age, number of rib fractures, gender, trauma mechanism, preinjury lung disease, smoking history, percent of current smokers, and need for placement of chest tube between the lidocaine patch 5% and placebo groups. There was no difference between the lidocaine patch 5% and placebo groups, respectively, with regard to total IV narcotic usage: median, 0.23 units versus 0.26 units; total oral narcotics: median, 4 units versus 7 units; pain score: 5.6 ± 0.4 versus 6.0 ± 0.3 (mean ± SEM); length of stay: 7.8 ± 1.1 versus 6.2 ± 0.7; or percentage of patients with pulmonary complications: 72.7% versus 72.0%.

CONCLUSIONS: The lidocaine patch 5% does not significantly improve pain control in polytrauma patients with traumatic rib fractures. (J Am Coll Surg 2010;210:205–209. © 2010 by the American College of Surgeons)

Rib fractures are seen in up to 10% of all traumatic injuries and 40% of blunt trauma injuries, making them the most common thoracic injury.[1] Although they may arise in the setting of minor trauma, rib fractures are often seen in severely injured multisystem trauma patients. The pain associated with these fractures can lead to poor pulmonary function and associated complications. This is more pronounced in the elderly, and it has been shown that patients 65 years and older with 3 or 4 rib fractures experience a 19% mortality rate and 31% rate of pneumonia.[2] All of these factors lead to an increase in the length of stay and use of health-care resources. With optimal pain management, patients are expected to have a shorter length of stay and fewer pulmonary complications.

Anecdotal evidence at our institution suggested that the lidocaine patch 5% (Lidoderm [Endo Pharmaceuticals]) placed on the chest wall over the rib fracture reduced the amount of narcotics required for pain relief in trauma patients. The lidocaine patch 5% is currently FDA approved for use in postherpetic neuralgia. The patch is 10 × 14 cm and is composed of an adhesive material containing 5% lidocaine, which is applied to a nonwoven polyester felt backing.[3] Each patch contains 700 mg of lidocaine, and, when used according to the recommended dosing instructions, only 3% of the dose applied is expected to be absorbed.[4]

There have been studies examining the use of the lidocaine patch 5% in clinical scenarios beyond postherpetic neuralgia. These applications include acute and chronic lower back pain,[5] postoperative pain associated with laparoscopic ventral hernia repair,[6] Dercum's disease,[7] complex

Disclosure Information: Nothing to disclose.

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Table 3. Outcomes Comparison of Lidocaine and Placebo Groups

Variable	Lidocaine group	Placebo group	p Value
Total IV narcotics used (units)*			
All patients†	0.23 (0.07, 1.02)	0.26 (0.08, 0.59)	0.56
Patients with at least a 72-h hospital stay‡	0.38 (0.13, 1.38)	0.28 (0.10, 0.92)	0.63
Total oral narcotics used (units)*			
All patients†	4 (2, 10)	7 (2.5, 14)	0.11
Patients with at least a 72-h hospital stay‡	5 (2, 13)	7 (3.5, 15)	0.20
Pain score§	5.6 ± 0.4	6.0 ± 0.3	0.39
Pulmonary complications‖	72.7% (24/33) 95% CI: 55.8, 84.9	72% (18/25) 95% CI: 52.4, 85.7	0.95
Length of stay, d¶	7.8 ± 1.1	6.2 ± 0.7	0.28

Conclusion

This is the first randomized, controlled trial using the lidocaine patch 5% in traumatic rib fractures. There was no significant difference between the lidocaine and placebo groups in the amount of narcotic medications used. There were also no significant differences in pain scores, pulmonary complications, or length of stay between the 2 groups. At this time, there is no evidence that the lidocaine patch 5% improves pain control in traumatic rib fractures.

What can be used for pain control

Table 1 Readily Available Options for Controlling Rib Fracture Pain

Technique	Advantages	Disadvantages/Side Effects	Contraindications*
Systemic opioids	Simplicity, no need for positioning, utility as a supplement	CNS and respiratory depression, nausea, cough suppression	CNS depression, hypotension
Intercostal LA	Highly effective for 8–24 h with each injection, no CNS depression	Risk of pneumothorax, difficulty with first to seventh ribs, not suitable for posterior rib fractures, multiple injections, patient discomfort, high blood LA levels with potential for LA toxicity§	
Intercostal LA (extrapleural with catheter)	No CNS depression, single placement for multiple injections	Risk of pneumothorax, limited dermatomal spread, high blood LA levels with potential for LA toxicity§	
Epidural LA	Superior analgesia, no CNS depression, opioid sparing, bilateral analgesia, high success rate	Hypotension, risk of dural puncture and spinal cord injury, motor blockade, urinary retention, may mask signs of intra-abdominal injury	Aortic or mitral stenosis, ↑ ICP, previous back surgery, spinal injury, hypovolemia, bleeding disorders
Epidural opioids	Low dosage requirement, bilateral analgesia, hemodynamic stability, intact sensory and motor functions	Pruritus, urinary retention, nausea, risk of delayed respiratory depression, breakthrough pain	↑ ICP, previous back surgery, spinal injury, hemostatic defects
Epidural LA plus opioids	Improved analgesia with fewer side effects, bilateral analgesia	As for epidural LA and epidural opioids	Same as epidural LA
Interpleural LA	No CNS depression, no need for multiple and repeated injections	Reduced efficacy in the presence of pleural fluids and adhesions, interruption of chest tube drainage required, high blood LA levels with potential for LA toxicity§	
Paravertebral LA	Technically simple, safer and easier to perform than thoracic epidural, palpation of rib not necessary and scapula does not interfere with needle placement, uninterrupted chest tube drainage, no CNS depression, maintains hemodynamic stability, preserves bladder sensation and lower limb motor power, no additional nursing surveillance required	Risk of pneumothorax, dermatomal spread not as predictable as epidural anesthesia, high blood LA levels with potential for LA toxicity§	
Oral analgesics and NSAIDs	Simplicity, lack of CNS or cardiovascular side effects, utility as a supplement	Risk of peptic ulcerations, platelet dysfunction, risk of renal damage, weak analgesic effect	Peptic ulcer disease, hemostatic defects, renal dysfunction, and hypoperfusion
TENS	Simplicity, safety, superior to NSAIDs	Limited experience and published data, inadequate analgesic effect	

J Trauma. 2003;54:615–625.

What can be used for pain control

Table 2 Reported Drugs and Dosage for the Various Regional Analgesic Techniques Used in Patients with Multiple Fractured Ribs*

Method of Analgesia	Drugs	Dosage Schedule	Average Duration of Analgesia after Bolus Injection
Intercostal nerve block	Bupivacaine 0.25–0.5%[11,13,16,17,18,19] Bupivacaine 0.25–0.5% with epinephrine 1:200,000[13,18,86]	Bolus: Multiple level injection: 2–4 mL/segment[18,23] Single level injection: 20 mL[11,17,18] Regular dosing via catheter: Bupivacaine 0.5%: 10–20 mL every 6–8 h[11,17] Infusion: Bupivacaine 0.25%: 3 mL/h[18]	8–12 h[16,17] 4.7 ± 0.5–31.3 ± 1.7 h[19]; Chung et al found that the duration of analgesia was progressively more prolonged after serial injections[19]
Interpleural analgesia	Lidocaine 1%[21] Bupivacaine 0.25–0.5%[22,23] Bupivacaine 0.5% with epinephrine 1:200,000[24] Bupivacaine 0.25% plus 1% lidocaine with 1:400,000 epinephrine[25]	Bolus: 10–20 mL[36,46,47,49] Regular dosing via catheter: Bupivacaine 0.5% with epinephrine 1:200,000: 15–20 mL every 4–6 h (400–450 mg/day)[24] Bupivacaine 0.5% 20 mL every 8 h[22] Bupivacaine 0.25% plus 1% lidocaine with 1:400,000 epinephrine[25]: 20 mL every 6 h[25] Infusion: Bupivacaine 0.5% with 1:200,000 epinephrine at 5 mL/h[26]	3–3.5 h[46,49]
Thoracic paravertebral block	Bupivacaine 0.5%[27,28,29] Bupivacaine 0.5% with 1:200,000 epinephrine[30,31]	Bolus: Bupivacaine 0.5%: 20–25 mL[67,68,70,72] or 0.3 mL/kg[31] Regular dosing via catheter: Bupivacaine 0.5%: 10–25 mL every 6–8 h[27,29] Infusion: Bupivacaine 0.25%: 0.1–0.2 mL/kg/h[31]	9.9 h[32]
Epidural opioid	Lumbar route Fentanyl[12] Morphine[33] Buprenorphine[6]	Bolus: Fentanyl (5 μg/mL): 1 μg/kg[12] Morphine: 5 mg diluted to 10 mL with NS[33] Buprenorphine: 0.1–0.3 mg diluted in 10–20 mL NS[6] Regular dosing via catheter: Morphine 5 mg in 10 mL with NS every 6 h[33] Infusion: Fentanyl: 1.03 ± 0.32 μg/kg/h,[12] 50 μg/h (5 μg/mL)[34]	DNA
	Thoracic route Morphine[9,35] Fentanyl plus Morphine[14] Fentanyl 100 μg plus duramorph 5 mg[36]	Bolus: Morphine 2 mg diluted to 10 mL with NS[35] Morphine 2 mg in 4 mL NS[9] Fentanyl 50 μg plus morphine 3 mg[14] Morphine 3 mg diluted with NS ~ 3–10 mL[37] Infusion Morphine 70 μg/mL at 8–10 mL/h[36]	Morphine 2 mg: 6.6 (3–50) h[35]
Epidural local anesthetic	Thoracic route Bupivacaine 0.25–0.5%[9,38]	Bolus: Bupivacaine 0.5%; 5.54 ± 1.7 mL[38] Infusion: Bupivacaine 0.125% at 8–10 mL/h[33]	[40]DNA
Epidural local anesthetic plus opioid	Thoracic route Bupivacaine plus morphine[37] Bupivacaine plus fentanyl (PWH)	Bolus: Morphine 3 mg diluted with NS ~ 3–10 mL[37] Infusion: Bupivacaine 0.25% plus morphine (0.005%) at 4–6 mL/h[14] Bupivacaine 0.125% plus fentanyl (2.5 μg/mL) at 0.1–0.2 mL/kg/h (PWH)	DNA
Intrathecal opioid	Lumbar route Morphine[39,40]	Bolus: Morphine 1 mg diluted with 4 mL NS,[39] morphine 1–2 mg[40]	30 (9–72) h[40]

What can be used for pain control

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Comparison Thoracic Epidural and Intercostal Block to Improve Ventilation Parameters and Reduce Pain in Patients with Multiple Rib Fractures

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ABSTRACT

Introduction: Chest wall blunt trauma causes multiple rib fractures an associated with significant pain and may compromise ventilator mechanics great roll in rib fracture therapies, opioid are useful, but when used as sole a such high dose that they produce respiratory depression, especially in e analgesia for a severe chest wall injury is a continuous epidural infusion of This provides complete analgesia allowing inspiration and coughing witho respiratory depression. *Methods*: sixty adult patients who with multiple ri enrolled in this study. They were divided into Group A or thoracic epidural 0.125 % +1mg/5ml morphine and group B or intercostal block with 0.25% b patients were assessed through ICU and hospital stay length, ventilation fur score among the patients was measured with verbal rating scale, b administration of the analgesia. *Results*: We found a significant improveme function tests during the 1st, 2nd, and 3rd days after epidural analgesia co intercostal block ($P < 0.004$). Changes in the visual Analogue Scale were marked improvement regarding pain at rest and pain caused by coughing an in group A compared group B... ICU and hospital stay markedly reduc *Conclusion*: thoracic epidural analgesia is superior to intercostals block rega of rib fractures. Patients who received epidural analgesia had significantly l at all studied times.

Conclusion

Thoracic epidural analgesia of the patients with multiple rib fractures considerably lead to improvement of respiratory parameters in comparison with intercostal block which is due to improvement of tidal volume, minute volume, arterial oxygen pressure and arterial pH .All mentioned factors would consequently lead to considerable decreased hospital stay and provide better control of pain than intercostal block.

Introduction

Multiple rib fractures and blunt chest traumas are accompanied by considerable mortality and morbidity. One third of these patients suffer from pulmonary complications as well and 30% of them suffer from pneumonia.[1-3] Patients who are over 65 years old are susceptible to serious complications which are due to blunt chest trauma.[1,4-6] Lung morbidity for the patients with pure rib fractures reported 38%. Blunt chest traumas can directly cause death (due to pulmonary and non pulmonary complications). The rate of the mortality which is due to these traumas is 6% from which 65% is directly related to secondary lung complications.[7] The rate of mortality of the patients suffering from flail chest is 16%.[8] Multiple rib fractures cause considerable pain compromising respiratory mechanics, exacerbating underlying lung injury and predisposing the patients to respiratory failure. Oxygenation of patients suffering from chest wall injury is directly affected by pain relief. Multiple rib fractures due to blunt chest traumas are caused by road accident, fall and....The bases of treatment for the patients who suffer from fractures analgesia, pain relief and pulmonary toilet Opioid analgesics are useful but may cause respiratory depression especially if it is used in high doses. [9,10] Intercostals block and epidural block are other two alternative methods. In this study, intercostals block and thoracic epidural analgesia are compared regarding respiratory parameters, ICU stay and pain score.

Materials and methods

60 patients with multiple and severe rib fractures were compared in this clinical trial study. 30 patients were

Journal of Cardiovascular and Thoracic Research, 2011, 3(3), 87-91

Surgical management.

Pain as an Indication for Rib Fixation: A Bi-Institutional Pilot Study

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Background: In trauma patients, open reduction and internal fixation of rib fractures remain controversial. We hypothesized that patients who have open reduction and internal fixation of rib fractures would experience less pain compared with controls and thus require fewer opiates. Further, we hypothesized that improved pain control would result in fewer pulmonary complications and decreased length of stay.

Methods: This is a retrospective bi-institutional matched case-control study. Cases were matched 1:2 by age, injury severity Score, chest abbreviated injury severity score, head abbreviated injury severity score, pulmonary contusion score, and number of fractured ribs. The daily total doses of analgesic drugs were converted to equianalgesic intravenous morphine doses, and the primary outcome was inpatient narcotic administration.

Results: Sixteen patients between July 2005 and June 2009 underwent rib fixation in 5 ± 3 days after injury using an average of 3 (1–5) metallic plates. Morphine requirements decreased from 110 mg ± 98 mg preoperatively to 63 ± 57 mg postoperatively ($p = 0.01$). There were no significant differences between cases and controls in the mean morphine dose (79 ± 63 vs. 76 ± 55 mg, $p = 0.65$), hospital stay (18 ± 12 vs. 16 ± 11 days, $p = 0.67$), intensive care unit stay (9 ± 8 vs. 7 ± 10 days, $p = 0.75$), ventilation days (7 ± 8 vs. 6 ± 10, $p = 0.44$), and pneumonia rates (31% vs. 38%, $p = 0.76$).

Conclusion: The need for analgesia was significantly reduced after rib fixation in patients with multiple rib fractures. However, no difference in outcomes was observed when these patients were compared with matched controls in this pilot study. Further study is required to investigate these preliminary findings.

Key Words: Chest trauma, Rib fractures, Rib fixation, Flail chest.

(*J Trauma.* 2011;71: 1750–1754)

Thoracic injuries account for 25% of mortality after trauma, and rib fractures represent the most frequent type of chest injury. Rib fractures occur in 10% to 40% of all trauma admissions,[1–3] and the number of rib fractures is a marker of injury severity. As the number of fractures increases, the severity of injury and the mortality increases. The presence of two rib fractures is associated with a 6% mortality which increases to 34% in those with eight or more fractures.[3]

The history of rib fixation is convoluted as the interest in the concept has waxed and waned since some of the earliest writings in medical history. More recently, there has been a reemergence of interest in repairing more severely injured chest walls. However, the evidence to support its use remains controversial with the procedure being performed sporadically in trauma centers.[4] A recent survey demonstrated that only 26% of surgeons had performed or assisted in a rib fracture repair.[5]

In addition, the indications for surgical stabilization have not been well defined, although benefit has been shown in selected patients with flail chest.[6,7] No other studies examine the use of pain alone as an indication for operation. We hypothesized that patients who had their ribs plated would experience less pain and thus require decreased amount of opiates compared with controls. In addition, we hypothesized that surgically managed patients would have fewer pulmonary complications and length of hospital stay because of improved pain control.

PATIENTS AND METHODS

Patients admitted to the Massachusetts General Hospital and Boston Medical Center between July 2005 and June 2009 who underwent rib fixation were identified from the trauma registry by retrospective chart review. These patients were matched in a 1:2 ratio with controls who did not undergo rib fixation (August 2002 to July 2009). The matching criteria were as follows: age ± 10 years, injury severity score ± 5, chest abbreviated injury severity score (AIS) ± 1, head and neck AIS ± 1, number of fractured ribs ± 2, and pulmonary contusion score ± 1. The presence of pulmonary contusion was evaluated from the chest computed tomography scans during the first 48 hours after the injury. For the calculation of the pulmonary contusion score, a six-point system was used. Each lung was divided into three parts—upper, middle, and lower—and one point is assigned for lesions in each part. Both institutions contributed the same number of cases and the controls from their trauma registries.

The primary outcome was the amount of narcotics

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Presented at the 40th Annual Meeting of the Western Trauma Association,

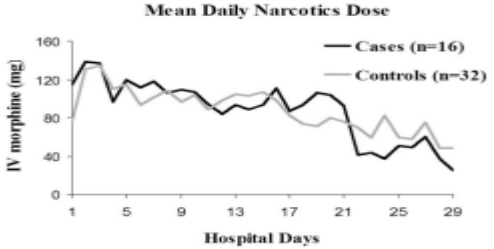


Figure 4. Mean daily dosages of patients with rib fixation versus controls.

TABLE 4. Comparison Between Cases and Controls in Primary and Secondary Outcomes

	Cases (N = 16)	Controls (N = 32)	*p*
Mean IV equivalent morphine dose (mg)	79 ± 63	76 ± 55	0.65
IV narcotics days	10 ± 5	7 ± 5	0.04*
Hospital stay (days)	18 ± 12	16 ± 11	0.67
ICU stay (days)	9 ± 8	7 ± 10	0.75
Ventilation days	7 ± 8	6 ± 10	0.44
Disposition			1.0
Home	5 (31%)	11 (34%)	
Rehabilitation facility	10 (63%)	19 (59%)	
Other	1 (6%)	2 (6%)	
Pulmonary complications	9 (56%)	16 (50%)	0.76
Pneumonia	5 (31%)	12 (38%)	0.76
Analgesic type			
Oral NSAIDs	13 (81%)	29 (91%)	0.50
IV Ketorolac	4 (25%)	8 (25%)	1.0
Oral NSAIDs/narcotics	9 (56%)	18 (56%)	0.79
PCA	9 (56%)	15 (47%)	0.60
Continuous IV narcotics	13 (81%)	18 (56%)	0.12
Epidural	5 (31%)	8 (25%)	0.73
Transdermal patch	5 (31%)	9 (28%)	1.0

NSAIDs, nonsteroidal anti-inflammatory drugs, PCA, patient-controlled analgesia.
* $p < 0.05$.
Pulmonary complications include pneumonia, empyema, lobar collapse/atelectasis, pulmonary embolism, and retained hemothorax.

Conclusion

- There are no absolute method of treatment for pain derived from chest trauma and rib fractures.

- Be selected according to each situation, however, underestimation for pain causes a poor prognosis of trauma patients.

- More aggressive management is need for pain control with rib fractures.

Surgical Treatment of Rib Fixation

PNUH Trauma Center
Jung Joo Hwang

Introduction

- Open surgical treatment

  -Soranus(CE 78-117), Amborise Pare
  -World War II
  -Rush nail fixation(1956)

Introduction

New Technic for Stabilization of the Flail Chest

Bob B. Carlisle, M.D., John P. Sutton, M.D., and Sam E. Stephenson, Jr., M.D.,
Nashville, Tennessee

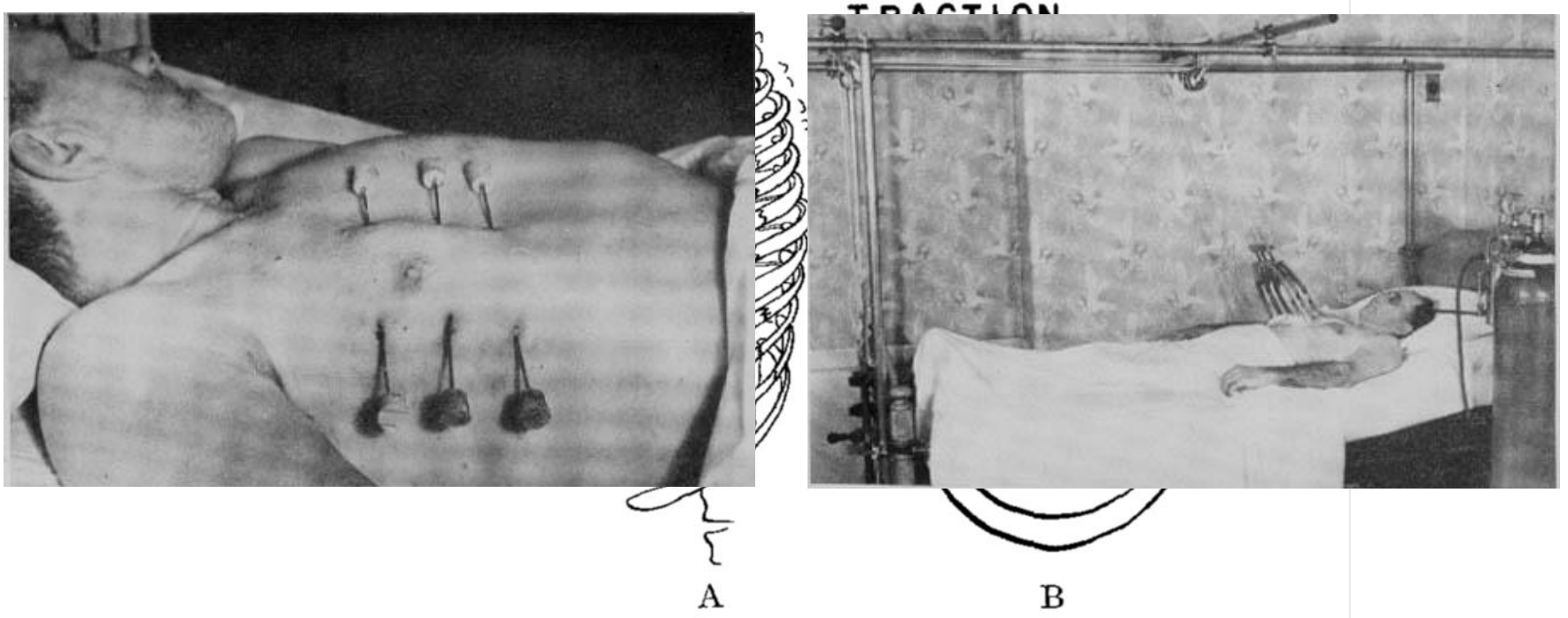


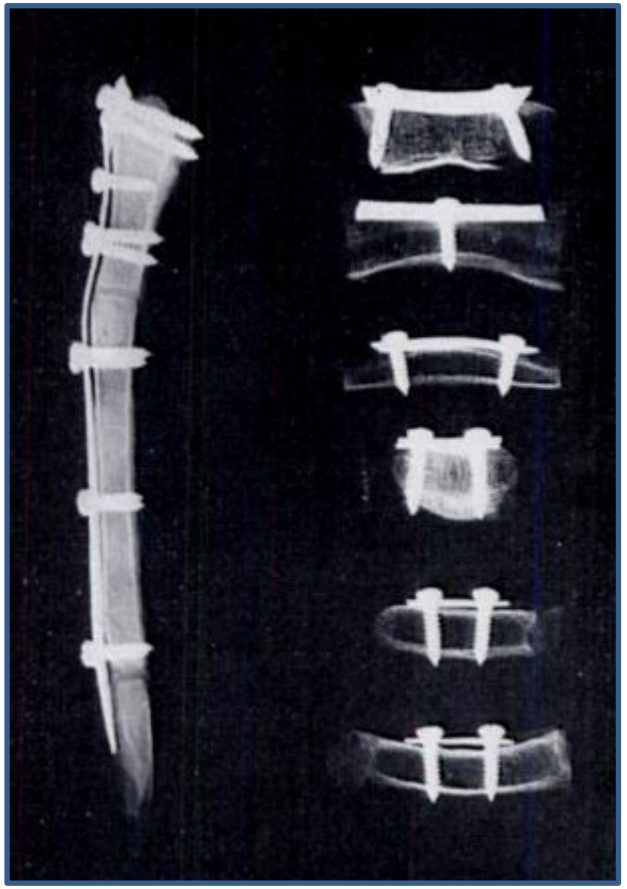
Fig. 4. A and B, lateral and cross-sectional diagram of the chest wall showing the technic of application of Rush nails for stabilization of a crushed chest.

THE CRUSHED CHEST

Management of the Flail Anterior Segment

W. SILLAR, GLASGOW, SCOTLAND

From the Southern General Hospital, Glasgow



Introduction

- Open surgical treatment

  -Soranus(CE 78-117), Amborise Pare
  -World War II
  -Rush nail fixation(1956)

- Mechanical ventilation(1960~)

  -Internal fixation

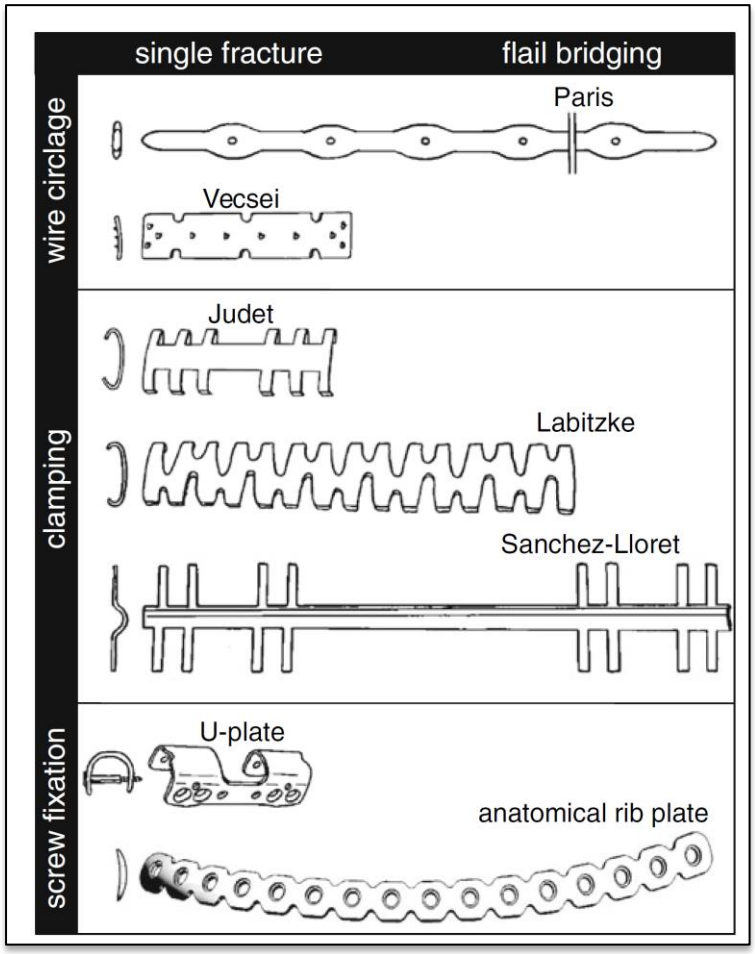
- Complication or problems of internal fixation

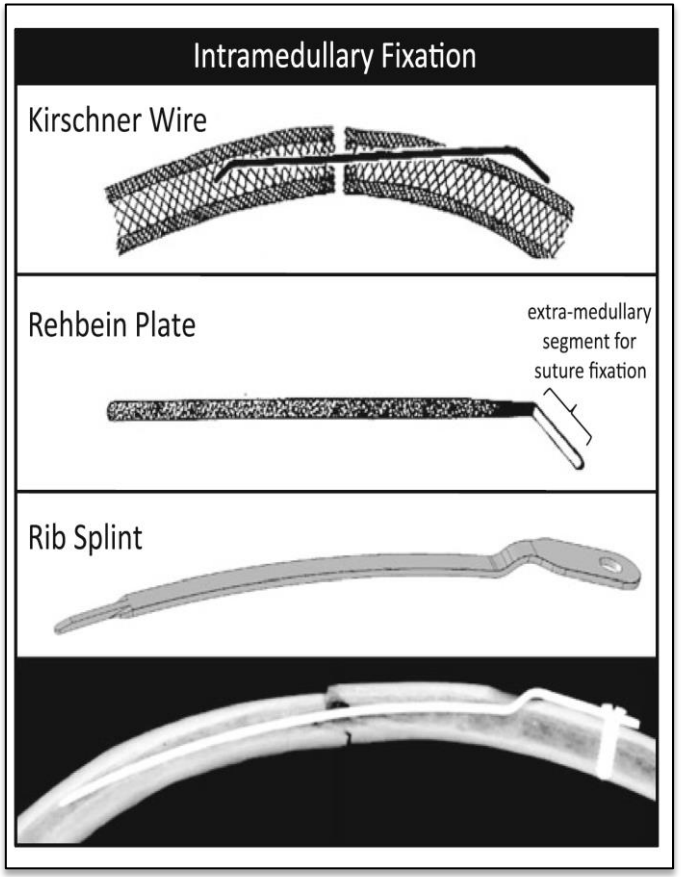
  -Pneumonia(20~77%)

  -Nonunion

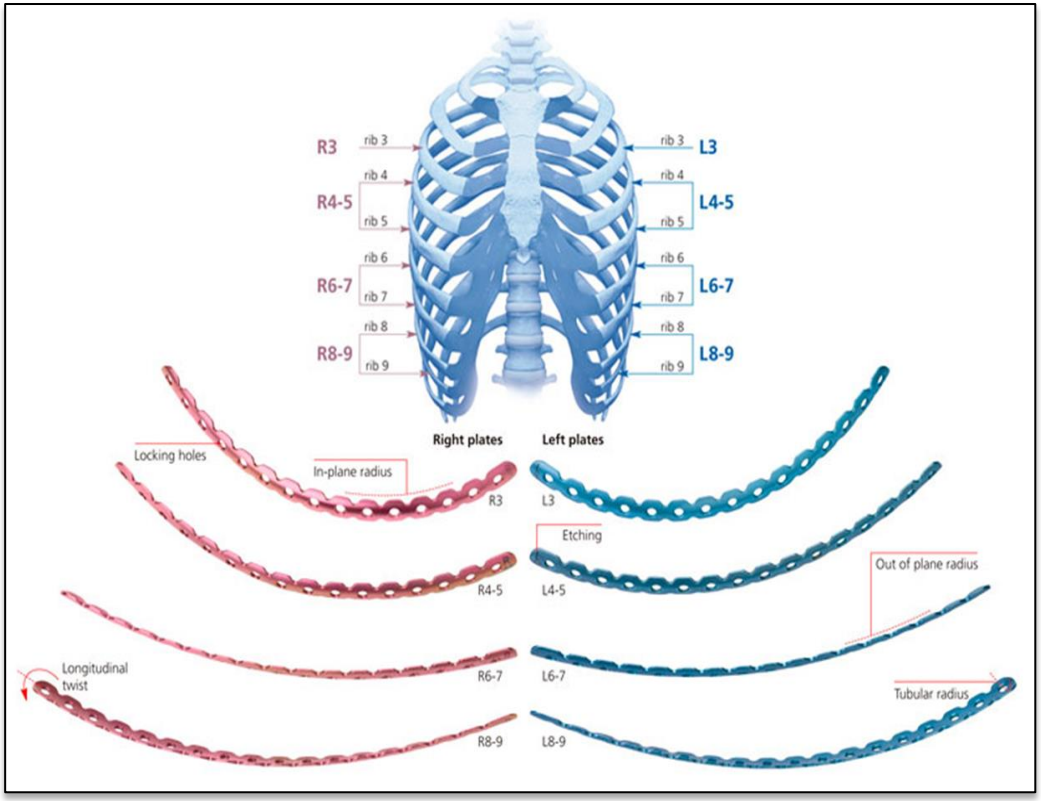
  -Symptomatic chest wall deformity(~64%)

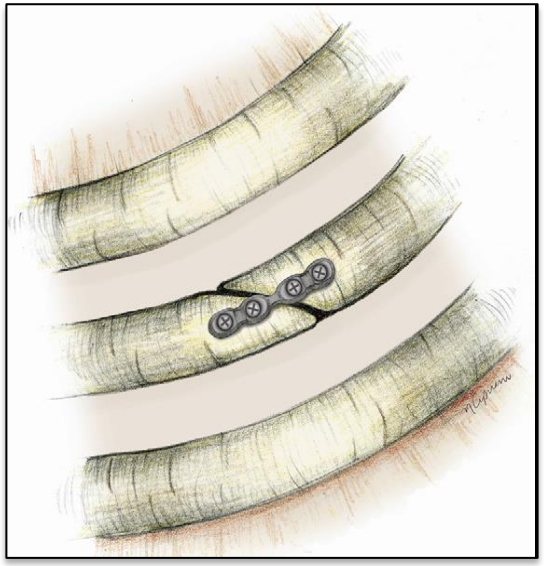
  -High mortality(10~36%)





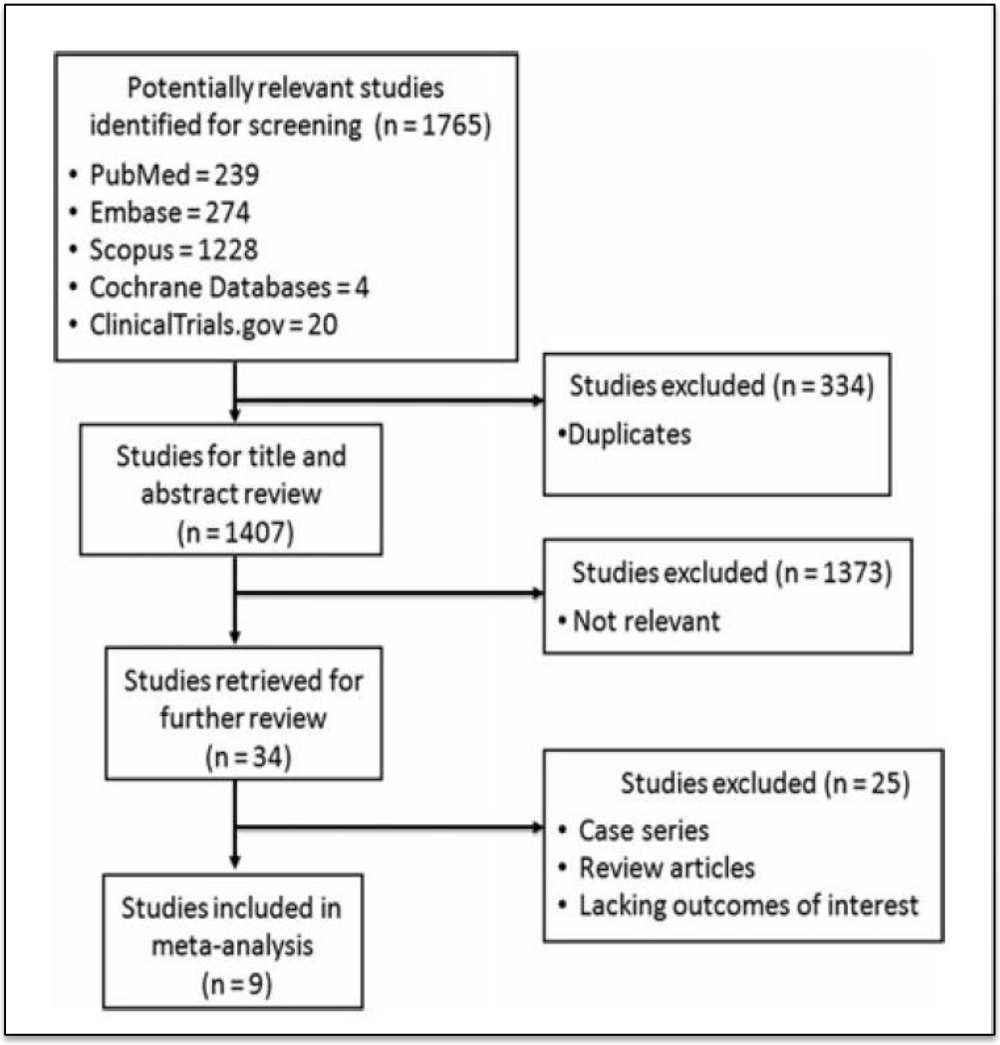
Evolution of rib plates





Locking screw fixator

Meta-Analysis (Operative Management of Rib Fractures)



Jeniffer A. Leinicke et al.(Annals of Surgery , Volume 258, Number 6, December 2013)

Meta-Analysis (Operative Management of Rib Fractures)

TABLE 2. Characteristics of Studies Comparing Operative to Nonoperative Management of Flail Chest

Author	Location	Study Design	n: Operative Patients	n: Nonoperative Patients	Outcomes Reported	Timing of Operative Intervention	Quality Rating*
Ahmed et al[5]	UAE	Cohort	26	38	DMV, ICULOS, mortality, tracheostomy	12–24 h after ICU admission	Fair
Karev[6]	Ukraine	Cohort	40	93	DMV, pneumonia mortality	Within 24 h of hospital admission	Moderate
Voggenreiter et al[7]	Germany	Cohort	20	22	DMV, pneumonia, mortality	Not specified	Moderate
Tanaka et al[8]	Japan	RCT	18	19	DMV, ICULOS, pneumonia, tracheostomy	Mean 8.2 ± 4.1 d after admission; randomized d 5	Moderate
Balci et al[9]	Turkey	Cohort	27	37	DMV, HLOS, mortality, tracheostomy	All but 2 patients within 48 h of hospital admission	Moderate
Granetzny et al[10]	Egypt	RCT	20	20	DMV, ICULOS, HLOS, mortality	24–36 h after ICU admission; randomized 24 h after admission	High
Nirula et al[11]	USA	Case-control	30	30	DMV, ICULOS, HLOS	Mean 3 d after hospital admission	Moderate
Althausen et al[12]	USA	Case-control	22	28	DMV, ICULOS, HLOS, pneumonia, tracheostomy	Mean 2.3 d after hospital admission	Moderate
de Moya et al[13]	USA	Case-control	16	32	DMV, ICULOS, HLOS, pneumonia	Mean 5 d after hospital admission	Moderate

*See Methods section, Data Extraction and Quality Assessment, for detail on determination of Quality Rating.

Jeniffer A. Leinicke et al.(Ann Surg 2013;258:914–921)

Surgical Stabilization of Internal Pneumatic Stabilization? A Prospective Randomized Study of Management of Severe Flail Chest Patients

Hideharu Tanaka, MD, Tetsuo Yukioka, MD, Yoshihiro Yamaguti, MD, Syoichiro Shimizu, MD, Hideaki Goto, MD, Hiroharu Matsuda, MD, and Syuji Shimazaki, MD

Background: We compared the clinical efficacy of surgical stabilization and internal pneumatic stabilization in severe flail chest patients who required prolonged ventilatory support.

Methods: Thirty-seven consecutive severe flail chest patients who required mechanical ventilation were enrolled in this study. All the patients received identical respiratory management, including end-tracheal intubation, mechanical ventilation, continuous epidural anesthesia, analgesia, bronchoscopic aspiration, postural drainage, and pulmonary hygiene. At 5 days after injury, surgical stabilization with Judet struts (S group, n = 18) or internal pneumatic stabilization (I group, n = 19) was randomly assigned. Most respiratory management was identical between the two groups except the surgical procedure. Statistical analysis using two-way analysis of variance and Tukey's test was used to compare the groups.

Results: Age, sex, Injury Severity Score, chest Abbreviated Injury Score, number of rib fractures, severity of lung contusion, and Pao_2/Fio_2 ratio at admission were all equivalent in the two groups. The S group showed a shorter ventilatory period (10.8 ± 3.4 days) than the I group (18.3 ± 7.4 days) ($p < 0.05$), shorter intensive care unit stay (S group, 16.5 ± 7.4 days; I group, 26.8 ± 13.2 days; $p < 0.05$), and lower incidence of pneumonia (S group, 24%; I group, 77%; $p < 0.05$). Percent forced vital capacity was higher in the S group at 1 month and thereafter ($p < 0.05$). The percentage of patients who had returned to full-time employment at 6 months was significantly higher in the S group (11 of 18) than in the I group (1 of 19).

Conclusion: This study proved that in severe flail chest patients, surgical stabilization using Judet struts has beneficial effects with respect to less ventilatory support, lower incidence of pneumonia, shorter trauma intensive care unit stay, and reduced medical cost than internal fixation. Moreover, surgical stabilization with Judet struts improved percent forced vital capacity from the early phase after surgical fixation. Also, patients with surgical stabilization could return to their previous employment quicker than those with internal pneumatic stabilization, even in those with the same severity of flail chest. We therefore concluded that surgical stabilization with Judet struts may be preferably applied to patients with severe flail chest who need ventilator support.

Key Words: Severe flail chest, Surgical stabilization, Long-term follow-up.

J Trauma. 2002;52:727–732.

Institutional report - Thoracic general

Surgical versus conservative treatment of flail chest. Evaluation of the pulmonary status

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Abstract

Through a prospective randomized comparative study, treatment of flail chest by a non-surgical method of packing, strapping, and mechanical ventilation vs. surgical fixation were compared. After management, stability of the chest wall occurred in 85% of the patients in the surgical group. Forty-five percent of patients in this group required ventilatory support after fixation for an average of 2 days. Whereas in the conservative group, stability occurred in 50% of their patients, and 35% of patients required ventilatory support for an average of 12 days. Chest wall deformity in the form of stove-in chest and crowding of ribs was still obvious in 9 patients among the conservatively treated group, compared to only one patient who developed chest wall deformity in the surgically treated group. The pulmonary functions tested two months after management indicated that in the surgical group the patients had a significantly less restrictive pattern. Thus, surgical fixation of a flail segment is a method of great value in the treatment of flail chest, in which stability is achieved without deformity of the chest wall and patients have less restrictive impairment of pulmonary functions.

Keywords: Flail chest; Pulmonary function tests, Chest injuries

Stability of the chest wall in 40 patients with traumatic flail chest after management

Stability of the chest	Conservative group ($N=20$)	Surgical group ($N=20$)			P-value
		Stainless steel and Kirschner wires	Stainless steel only	All	
Stable	10 (50%)	14	3	17 (85%)	
Unstable	10 (50%)	0	3	3 (15%)	0.041

Not significant (n.s.).

Blood gas analysis in 40 patients with traumatic flail chest

		Before management Mean ± S.D.	After management Mean ± S.D.	P-value
Conservative group	pO_2	63.6 ± 9.1	89.3 ± 7.6	<0.001
	pCO_2	39.7 ± 4.0	30.9 ± 2.5	<0.001
	O_2-Saturation	90.7 ± 1.7	96.2 ± 1.7	<0.001
Surgical group	pO_2	56.2 ± 9.2	98.7 ± 21.0	<0.001
	pCO_2	34.2 ± 6.3	31.2 ± 5.9	n.s.
	O_2-Saturation	88.1 ± 3.4	96.8 ± 3.0	<0.001

Post-management data in 40 patients with traumatic flail chest

Post management data	Conservative group ($N=20$)	Surgical group ($N=20$)	P-value
Mechanical ventilation Number of patients (%)	7 (35%)	9 (45%)	n.s.
Mean duration of mechanical Ventilation (days)	12	2	$P<0.001$
Mean ICU stay (days)	14.6	9.6	$P<0.001$
Mean hospital stay (days)	23.1	11.7	$P<0.001$

Pulmonary function tests in the survivors of 40 patients with traumatic flail chest 2 months after management

Pulmonary functions	Group I Mean ± S.D.	Group II Mean ± S.D.	*P*-value
FVC (%)	66.5 ± 6.5	75.0 ± 5.4	$P < 0.001$
FEV_1 (%)	75.0 ± 0.4	75.5 ± 8.7	n.s.
TLC (%)	85.8 ± 11.3	90.7 ± 4.2	$P < 0.001$
PEFR (%)	91.8 ± 1.7	92.2 ± 2	n.s.
FEF_{75} (%)	60.4 ± 13.3	65.6 ± 13.8	$P < 0.001$

Complications	Group I No. (%)	Group II No. (%)	*P*-value
No complications	8 (40%)	13 (65%)	n.s.
Chest infection	10 (50%)	2 (10%)	$P = 0.014$
Empyema	2 (10%)	1 (5%)	n.s.
Pulmonary embolism	1 (5%)	0 (0%)	n.s.
Mediastinitis	0	2 (10%)	n.s.
Wound infection	0	2 (10%)	n.s.
Chest wall deformity	9 (45%)	1 (5%)	$P = 0.008$
Scoliosis	5 (25%)	0 (0%)	$P = 0.047$
Mortality	3 (15%)	2 (10%)	n.s.

Prospective Randomized Controlled Trial of Operative Rib Fixation in Traumatic Flail Chest

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BACKGROUND: Traumatic flail chest injury is a potentially life threatening condition traditionally treated with invasive mechanical ventilation to splint the chest wall. Longer-term sequelae of pain, deformity, and physical restriction are well described. This study investigated the impact of operative fixation in these patients.

STUDY DESIGN: A prospective randomized study compared operative fixation of fractured ribs in the flail segment with current best practice mechanical ventilator management. In-hospital data, 3-month follow-up review, spirometry and CT, and 6-month quality of life (Short Form-36) questionnaire were collected.

RESULTS: Patients in the operative fixation group had significantly shorter ICU stay (hours) postrandomization (285 hours [range 191 to 319 hours] for the surgical group vs 359 hours [range 270 to 581 hours] for the conservative group; $p = 0.03$) and lesser requirement for noninvasive ventilation after extubation (3 hours [range 0 to 25 hours] in the surgical group vs 50 hours [range 17 to 102 hours] in the conservative group; $p = 0.01$). No differences in spirometry at 3 months or quality of life at 6 months were noted.

CONCLUSIONS: Operative fixation of fractured ribs reduces ventilation requirement and intensive care stay in a cohort of multitrauma patients with severe flail chest injury. (J Am Coll Surg 2013;216:924–932. © 2013 by the American College of Surgeons)

Table 1. Patient Demographics

Variable	Operative group (n = 23)	Nonoperative group (n = 23)	p Value
Age, y, mean ± SD	57.8 ± 17.1	59.3 ± 10.4	0.72
Sex male/female, n	20/3	20/3	1.00
Body mass index, kg/m^2, mean ± SD	27.9 ± 4.6	29.0 ± 6.8	0.55
Smoking history, n (%)			
Ex smoker	5 (22)	2 (9)	0.22
Current smoker	8 (35)	3 (13)	0.08
Nonsmoker	10 (43)	18 (78)	0.02
Underlying lung disease, n (%)			
Asthma	3 (13)	1 (4)	
COPD	2 (9)	1 (4)	
Mechanism of injury, n (%)			0.86
Motor vehicle accident	17 (74)	14 (61)	
Pedestrian vs car	2 (9)	3 (13)	
Crush injury	1 (4)	2 (9)	
Fall from height	3 (13)	4 (17)	
NISS, mean ± SD	36.4 ± 10.3	42.9 ± 13.3	0.07
ISS, mean ± SD	35.0 ± 11.4	30.0 ± 6.3	0.13
TRISS, mean ± SD	0.8 ± 0.2	0.8 ± 0.2	0.77
GCS at scene, mean ± SD	13.4 ± 2.8	13.6 ± 2.6	0.74
Best GCS within first 48 h, mean ± SD	11.0 ± 4.5	9.9 ± 4.7	0.43
Head injury AIS code 2 or above, n (%)	0 (0)	2 (9)	0.49
Bony spinal injury, n (%)	15 (65)	14 (61)	0.76

AIS, Abbreviated Injury Score; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; NISS, New Injury Severity Score; TRISS, Trauma and Injury Severity

Table 4. Spirometry Results at 3-Month Follow-Up

Percent predicted value	Operative group (n = 17)	Nonoperative group (n = 17)	p Value
FEV1	74.3 ± 15.0	80.2 ± 18.3	0.31
FVC	77.9 ± 15.7	84.8 ± 14.0	0.19
MMEF	76.2 ± 36.9	82.1 ± 35.0	0.64
PEF	62.8 ± 28.5	68.1 ± 36.5	0.63
TLC	84.0 ± 24.4	88.2 ± 23.4	0.61
FEV1/FVC	95.6 ± 9.8	95.0 ± 17.3	0.92

Table 6. Short Form-36 Quality of Life Questionnaire Results at 6 Months Postinjury

SF-36 domains	Operative group (n = 19)	Nonoperative group (n = 18)	p Value
Physical functioning	33.4 ± 13.0	38.4 ± 12.0	0.24
Physical role	32.1 ± 7.9	35.1 ± 11.4	0.36
Bodily pain	42.2 ± 9.4	37.9 ± 11.0	0.22
General health	45.2 ± 11.8	44.0 ± 12.2	0.77
Vitality/energy	44.1 ± 10.8	46.3 ± 8.2	0.49
Social functioning	36.0 ± 15.0	37.2 ± 12.5	0.79
Emotional role	37.6 ± 14.5	37.8 ± 13.5	0.97
Mental health	45.9 ± 13.2	46.5 ± 9.1	0.87
PCS	33.6 ± 9.8	35.2 ± 10.7	0.65
MCS	45.1 ± 13.8	45.2 ± 9.2	0.98

Table 3. Outcomes

Outcomes	Operative group (n = 23)	Nonoperative group (n = 23)	p Value
Duration of ICU stay prerandomization, h, mean ± SD	61.6 ± 36.1	81.3 ± 84.2	0.31
Duration of ICU stay between randomization and surgery, h, mean ± SD	49.4 ± 35.9	N/A	
Duration of IMV postrandomization, h, mean ± SD	151.8 ± 83.1	181.0 ± 130.2	0.37
Duration of ICU stay postrandomization, h, median (IQR)	285 (191–319)	359 (270–581)	0.03
Total ICU stay, h, median (IQR)	324 (238–380)	448 (323–647)	0.03
Failed extubation, n (%)	3 (13)	1 (4)	0.61
Received NIV postextubation, n (%)	13 (57)	19 (83)	0.05
Duration of NIV postextubation, h, median (IQR)	3 (0–25)	50 (17–102)	0.01
Tracheostomy, n (%)	9 (39)	16/23 (70)	0.04
Patients requiring blood product transfusion, n	18	19	0.78
Packed cell transfusion during inpatient stay, mL, median (IQR)	620 (0–3,100)	1,240 (620–3,100)	0.39
Total blood products transfused, mL, median (IQR)	930 (620–1,860)	900 (500–1,395)	0.57
Readmission to ICU, n (%)	2/23 (9)	2/23 (9)	0.99
ICCs required, n, median (IQR)	2 (1–4)	2 (1–4)	0.99
Pneumonia, n (%)	11/23 (48)	17/23 (74)	0.07
Duration of hospital stay, d, median (IQR)	20 (18–28)	25 (18–38)	0.24
In hospital mortality, n	0	1	0.87

ICC, intercostal catheter; IMV, invasive mechanical ventilation; IQR, interquartile range; NIV, noninvasive ventilation.

Issue date: October 2010

NHS
National Institute for
Health and Clinical Excellence

Insertion of metal rib reinforcements to stabilise a flail chest wall

1 Guidance

1.1 Current evidence on insertion of metal rib reinforcements to stabilise a flail chest wall is limited in quantity but consistently shows efficacy. In addition, there are no major safety concerns in the context of patients who have had severe trauma with impaired pulmonary function. Therefore the procedure may be used provided that normal arrangements are in place for clinical governance, consent and audit.

1.2 Patient selection should be carried out by critical care specialists, chest physicians and thoracic surgeons with appropriate training and experience.

2 The procedure

2.1 Indications and current treatments

2.1.1 Chest wall injury is common as a result of major blunt trauma (for example, motor vehicle accidents). It varies in severity from minor bruising or an isolated rib fracture, to severe crush injuries leading to respiratory compromise.

2.1.2 A flail chest occurs when a segment of the thoracic cage moves independently from the rest of the chest wall. A flail chest causes paradoxical movement of this segment of the chest wall – in-drawing on inspiration and moving outwards on expiration – and this segment of chest wall fails to contribute to lung expansion. Flail chest has been defined in a variety of ways, but at least 2 fractures per rib in at least 2 ribs are needed to produce a flail segment. Large flail segments may extend bilaterally or involve the sternum, and may compromise respiration sufficiently to require mechanical ventilation.

2.1.3 Management of chest wall injury is directed towards protecting the underlying lung, achieving adequate ventilation and oxygenation, and preventing infection. Analgesia sufficient to allow normal respiration and coughing may be adequate for mild cases. More severe cases require ventilatory support, and suction to remove mucus or secretions from the airways to prevent atelectasis.

2.2 Outline of the procedure

2.2.1 Surgical stabilisation with metal rib reinforcements aims to allow earlier weaning from ventilatory support, reduce acute complications, and avoid chronic pain sometimes associated with permanent deformity of the chest wall.

2.2.2 With the patient under general anaesthesia, an incision is made over the rib fractures to be treated, and the fractured ribs are reduced. The affected ribs are stabilised using struts or metal plates, fixed with screws or intramedullary wires. These metal plates and screws are usually left in place in the long term.

2.2.3 There are many variations in the materials and techniques used to stabilise flail chest with metal rib reinforcements. It should be noted that Kirschner wires, used alone, are not covered by this guidance.

Sections 2.3 and 2.4 describe efficacy and safety outcomes from the published literature that the Committee considered as part of the evidence about this procedure. For more detailed information on the evidence, see the overview, available at **www.nice.org.uk/IP825overview**

2.3 Efficacy

2.3.1 A randomised controlled trial (RCT) of 37 patients treated by surgical stabilisation (n = 18) or mechanical ventilation (n = 19) reported a significantly lower proportion of patients with pneumonia at day 21 in the surgical stabilisation group compared with the mechanical ventilation group (22% [4/18] vs 89% [17/19]) ($p < 0.05$).

2.3.2 The RCT of 37 patients reported a mean critical care stay of 16.5 days in the surgical stabilisation group and 26.8 days in the mechanical ventilation group ($p < 0.05$).

2.3.3 The RCT of 37 patients treated by surgical stabilisation (n = 18) or mechanical ventilation (n = 19) reported a mean percentage of forced vital capacity at 12 months of 96% and 80% respectively ($p < 0.05$). A case series of 66 patients reported that 52% (26/50) of patients had normal pulmonary function at 6-month follow-up.

2.3.4 The RCT of 37 patients reported that a significantly higher percentage of patients had returned to full-time employment at 6 months in the surgical group compared with the mechanical ventilation group (61% [11/18] vs 5% [1/19]) ($p < 0.01$).

2.3.5 The Specialist Advisers listed additional key efficacy outcomes as survival, duration of ventilation, long-term stabilisation of chest wall, reduced pain and patient satisfaction.

2.4 Safety

2.4.1 Death was reported in 30% (3/10) of patients with pulmonary contusion treated by surgical stabilisation in a non-randomised comparative study of 42 patients. Of these deaths, 2 were from massive haemorrhage and 1 was from sepsis with multi-organ failure. No deaths were reported in patients without pulmonary contusion who were treated by surgical stabilisation.

2.4.2 Persistent pain at the operative site was reported in 11% (6/57) and 24% (5/21) of patients in a case series of 66 patients at 6-month follow-up and a case series of 23 patients at 3-month follow-up respectively. This improved in 3 and 2 patients respectively after stabilisation plates and screws were removed at 6 months.

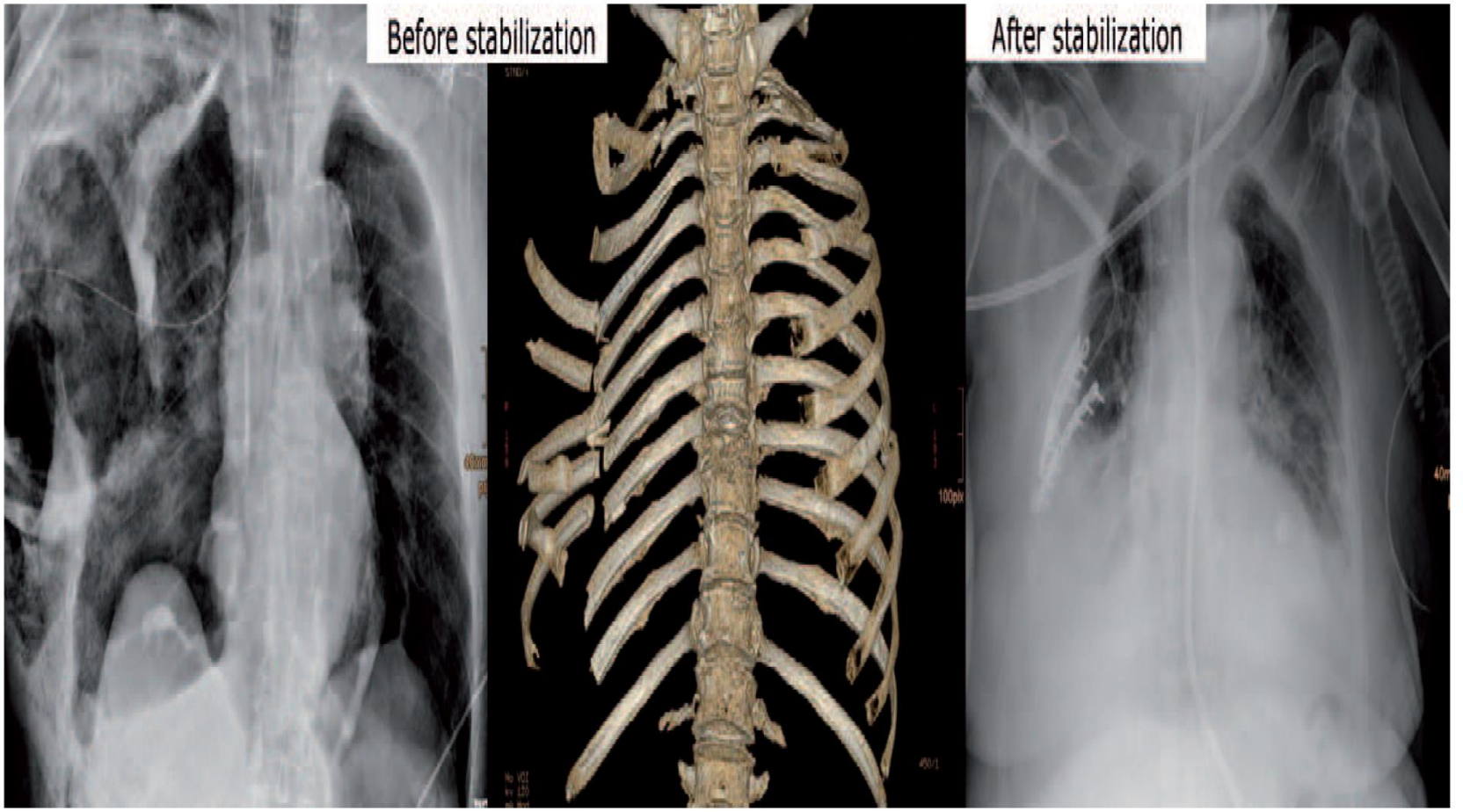
2.4.3 The Specialist Advisers considered theoretical adverse events to include migration of metalwork, fracture of stabilisers, lung injury from stabilisers, screw loosening or separation, infection and allergy.

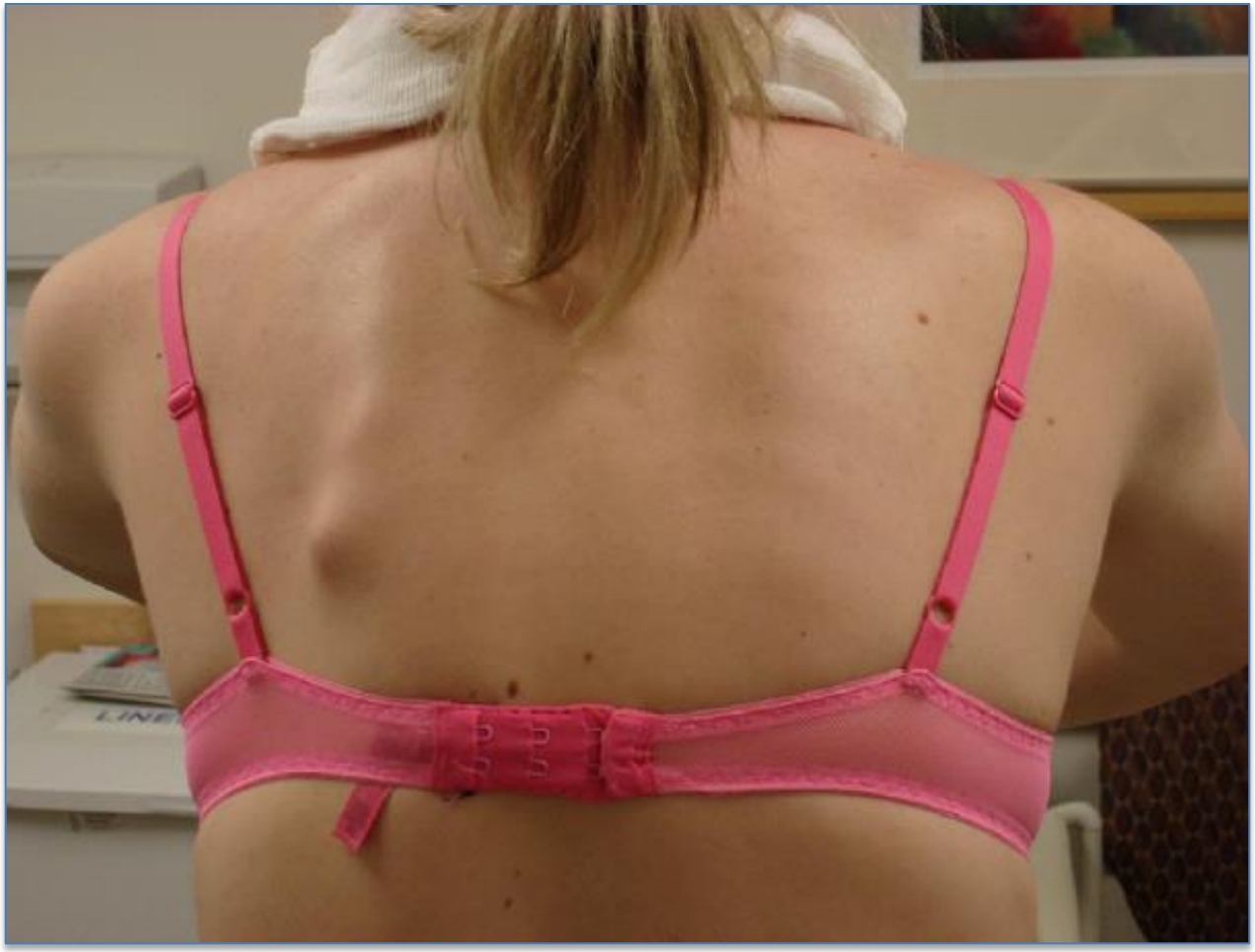
3 Further information

3.1 For related NICE guidance see **www.nice.org.uk**

Information for patients

NICE has produced information on this procedure for patients and carers ('Understanding NICE guidance'). It explains the nature of the procedure and the guidance issued by NICE, and has been written with patient consent in mind. See **www.nice.org.uk/guidance/IPG361/publicinfo**


Before stabilization
After stabilization



Multiple Rib Fracture (Study)

- Duration : 2008. 11 – 2010. 10(60 cases)
- **Lung Volume**(3D-CT) / **PFT** / **ABGA**
- Follow up: 7.4±2.4 months

Functional Data of RFP(n=60)

Characteristics	Value
Age(years, range)	59.5±13.5(16-81)
M : F	45 : 15
Multiple rib fracture	51(85.0%)
Bilateral rib fractures	15(25.0%)
Sternal fracture	7(11.6%)
Hemopneumothorax	44(73.3%)
Numbers of fixation	5.7±3.9
Postoperative PFT FVC(L, %) FEV_1(L, %)	 3.1±0.8(95.7±21.4) 2.5±0.7(93.5±22.8)

Functional Data of RFP(n=60)

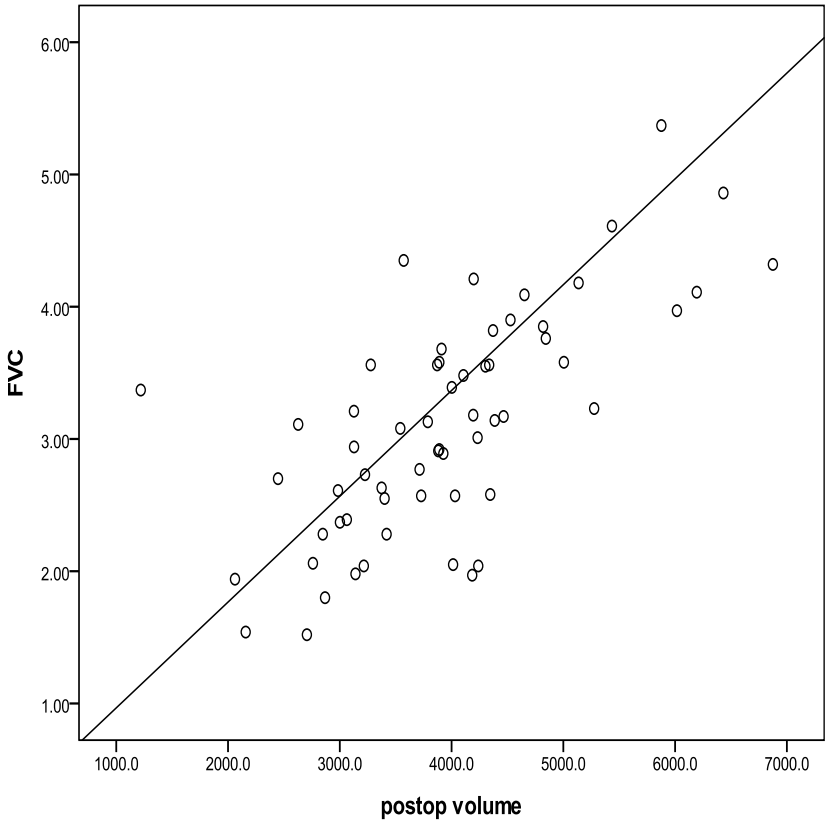
Variables	Preop	Postop	p-value
ABGA			
PaO_2(mmHg)	70.8±12.4	94.1±11.6	<0.001
$PaCO_2$(mmHg)	37.7±6.9	36.1±4.1	0.114
O_2 saturation(%)	92.6±4.9	97.0±1.4	<0.001
Chest CT+3D			
Lung volume(mm^3)	2351±892	3887±1130	<0.001

Functional Data of RFP(n=60)

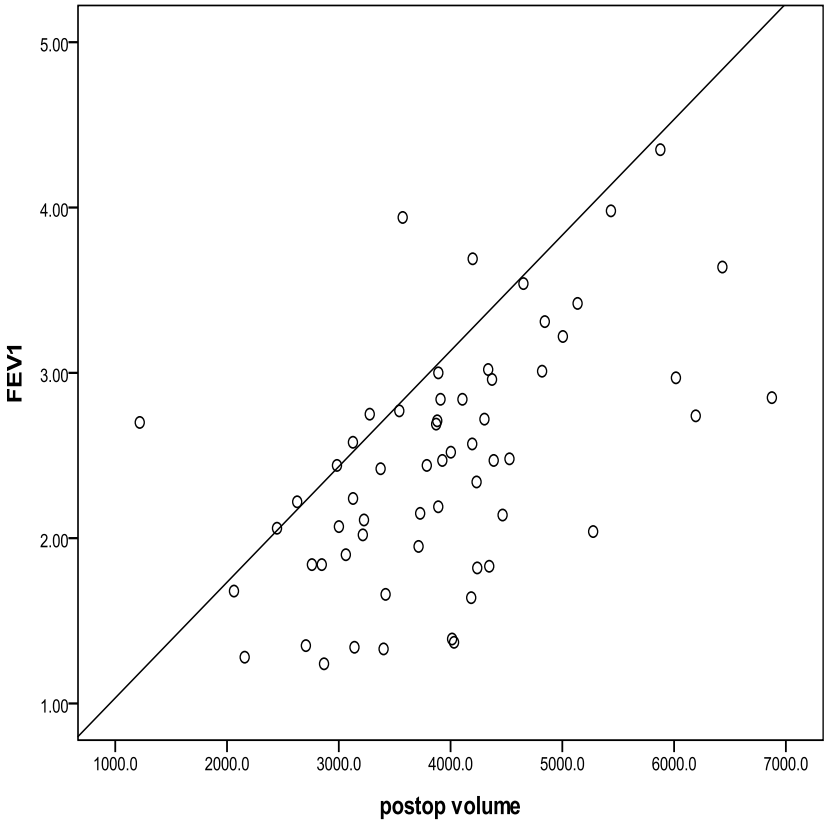
Mechanism of injury	Number
Traffic accident	30(50%)
Fall	16(26.7%)
Slip down	10(16.7%)
Blunt trauma(Cow)	1(1.7%)
CPR(iatrogenic)	1(1.7%)
Unknown	2(3.3%)

Correlation between PFT & LV of chest CT

Lung Volume(LV) can be a reliable parameter of pulmonary function in the severe multiple trauma patients



r=0.696, p<0.001



r=0.555, p<0.001

Flail vs. Multiple fracture

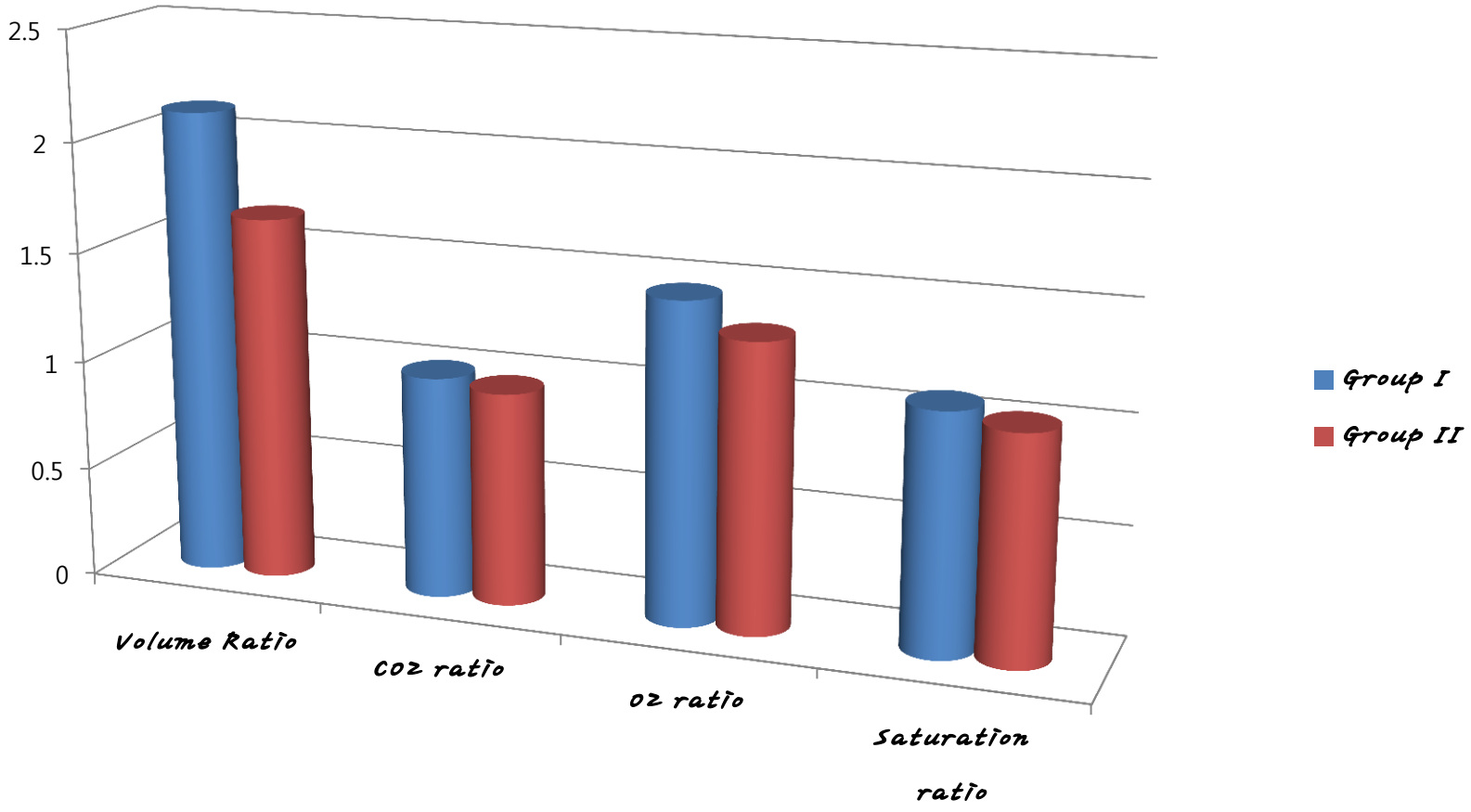
- Flail(group I, 22), Multiple(group II, 38)

- There were no significant differences in age, gender, injury mechanism

Flail vs. Multiple fracture

	Group I	Group II	p value
Preop. Lung volume	2159.97	2461.63	0.210
Postop. Lung volume	3817.76	3910.45	0.758
Volume Ratio	2.12	1.66	**0.047**
FEV1	2.23	2.58	**0.069**
FVC	2.89	3.23	0.128
Preop. CO2	37.63	37.79	0.934
Postop. CO2	37.22	35.39	**0.095**
CO2 ratio	1.01	0.97	0.376
Preop. O2	64.86	74.17	**0.004**
Postop. O2	92.25	95.12	0.305
O2 ratio	1.46	1.31	**0.047**
Preop. Saturation	89.78	94.3	**0.000**
Postop. Saturation	96.8	97.17	0.305
Saturation ratio	1.09	1.03	**0.001**

Flail vs. Multiple fracture



Conclusion

- Functional study of rib fixation
  - Improved lung volume
  - Correlation of lung volume and FVC,FEV1
  - Improved O_2, O_2saturation

- Multi-center clinical trial and guideline
  - to confirm clinical usefulness
  - to solve the problem of health insurance

Active Rehabilitation after Chest Trauma

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Active Rehabilitation after Chest Trauma

1. • General Consensus in Pulmonary Rehabilitation
2. • Concerns after Chest Trauma
3. • Active Rehabilitation after Chest Trauma

General Consensus

Appropriate Conditions for PR
(PR; Pulmonary Rehabilitation)

Obstructive diseases

- **COPD**
- Persistent asthma
- Bronchiectasis
- Cystic fibrosis
- Bronchiolitis obliterans

Restrictive diseases

- Interstitial fibrosis
- Chest wall diseases
- **Neuromuscular diseases**
  - **Myopathy**
  - **ALS**
  - **High cervical cord injury**

Other conditions

- **Lung cancer**
- primary pulmonary hypertension
- **before and after surgery**
- **before and after lung transplantation**
- pediatric patients with respiratory disease
- obesity related respiratory disease
- **post chest trauma**

Respiratory Muscles

Main respiratory muscles

- **Diaphragm**
- Parasternal intercostal muscles (stabilizer of thorax)

Accessory respiratory muscles

- **Scalene**
- **SCM**
- **Pectoralis major**

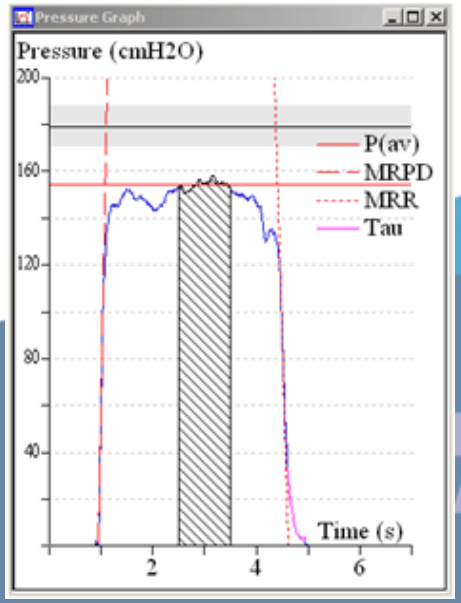
- **Trapezius**
- **Abdominal muscles (coughing)**

Muscle Power

Maximum pressure

inspiratory and expiratory

Same as **limb muscle power**



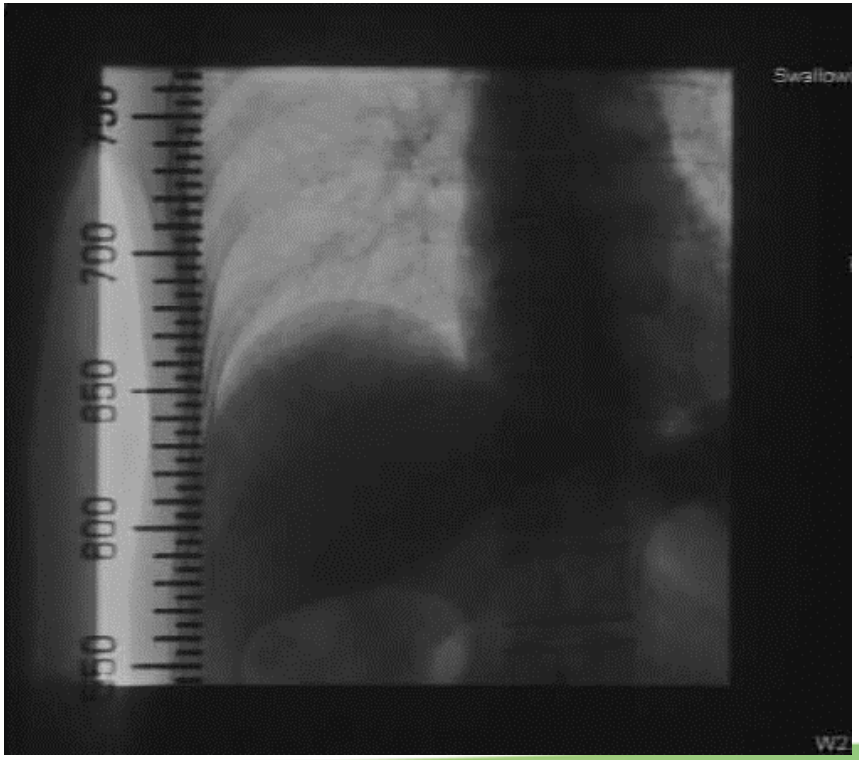
Full inspiration

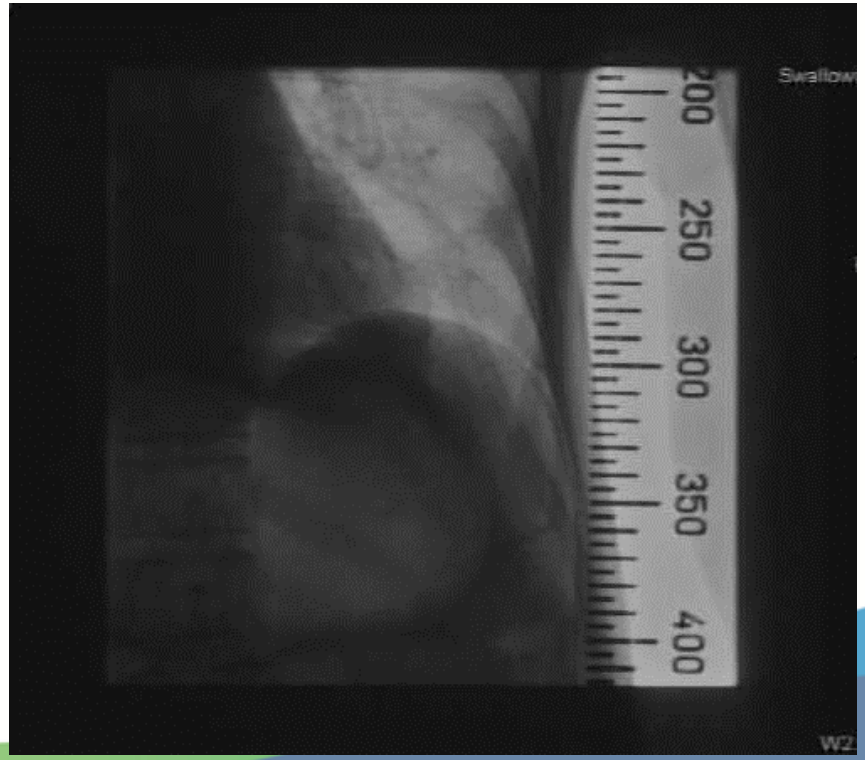
→ expiration for 2~3sec

→Area during plateau 1sec

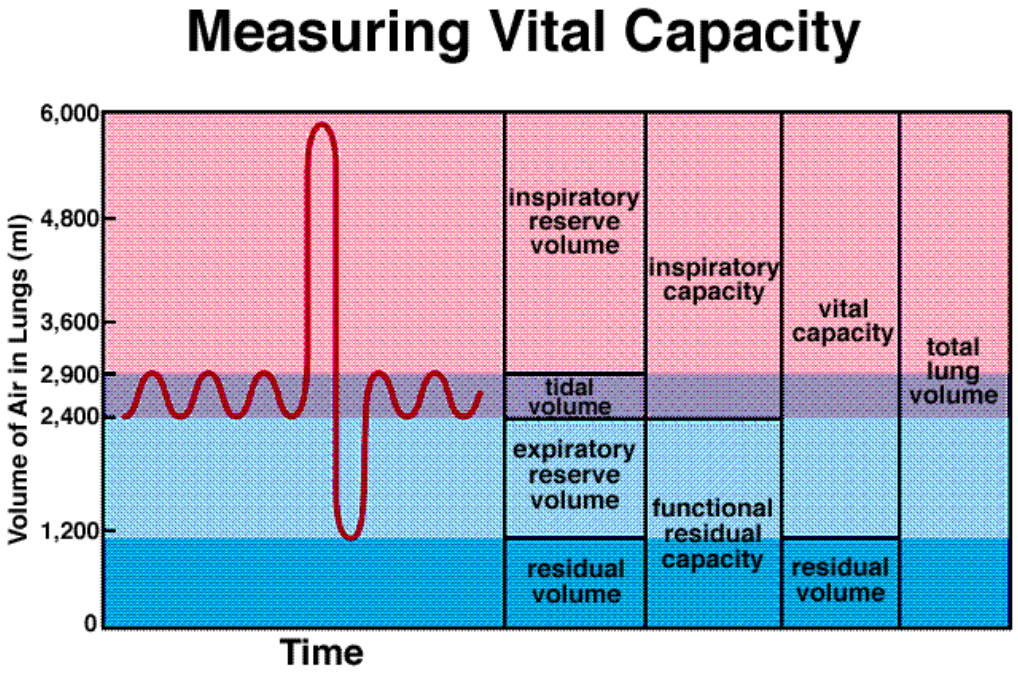
(MEP)

Diaphragm





Evaluation of respiratory system



VC change related to position

Diaphragmatic status

Evaluation of respiratory system

Maximum insufflation capacity (MIC) **ROM**

Sat O2, End-tidal CO2

Pulse oximeter, capnometer

: non-invasive, 24hr

cf) ABGA: hyperventilation d/t pain

Evaluation of respiratory system

Peak cough flow (PCF)

Ability to eliminate secretions (minimum > 160 L/min)

Normal cough : pre-cough inspiration to 85-90 % of TLC

VC < 1500 ml

- **insufflate before assisting a cough**

Normal : 360 - 720 L/min (6 – 12 L/sec)

Usually > 250 L/min → common cold → < 160 L/min

PR Program

- Education
- Respiratory therapy
- **Physical therapy**
- Exercise training or conditioning
- Psycho-social support

Physical therapy for PR

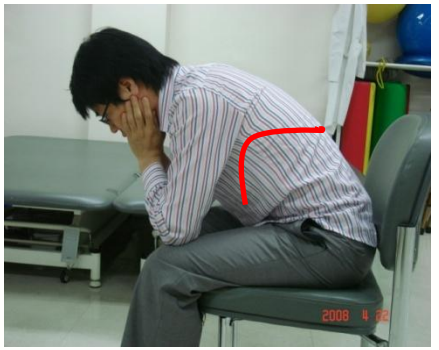
Controlled-breathing technique
Puresd-lips breathing
Positioning technique
Breathing exercise (retraining)
Diaphragmatic-breathing exercise
Segmental-breathing exercise

Relaxation positioning

To help relieve dyspnea

Forward flexion → relax abdominal m

→ fascilitate descent of diaphragm



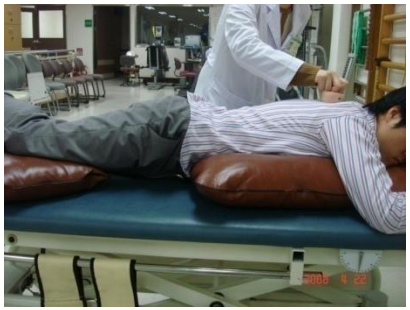
Fixing the arm → more efficient use of the accessory muscles

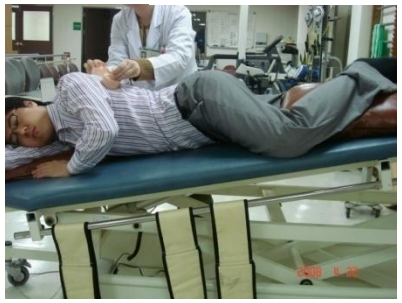
Significant improvement in maximal voluntary ventilation by leaning forward on a rollator during walking

Physical therapy for PR

Treatments to enhance secretion clearance
Postural drainage
Percussion
Shaking or rib springing
Vibration

Postural Drainage



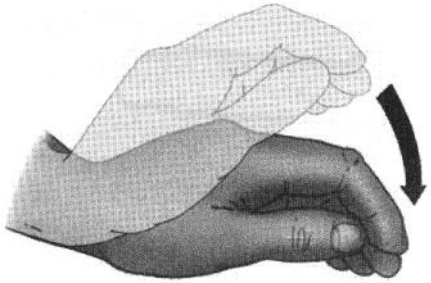


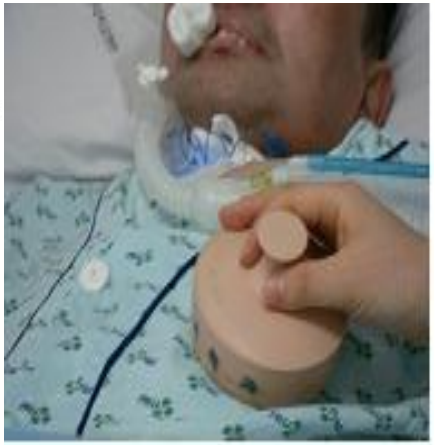
Percussion & Vibration

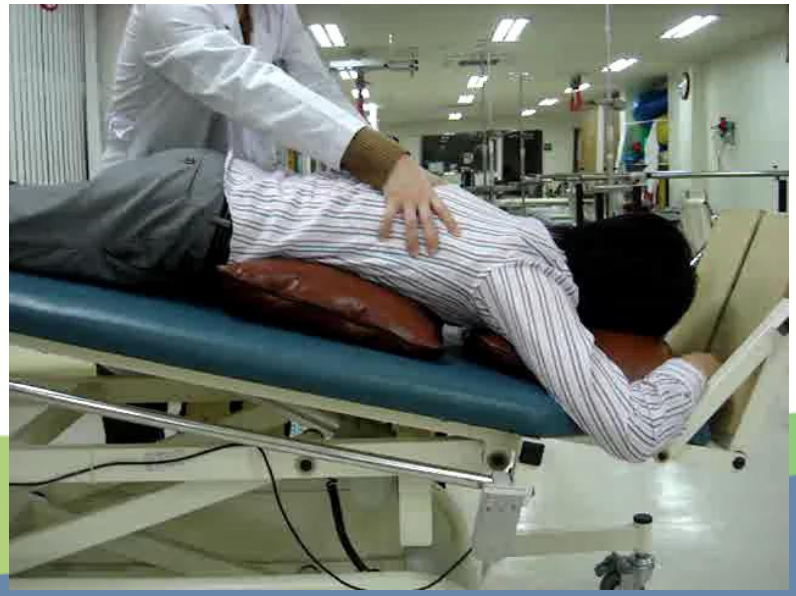
Percussion

Vibration

- Hand / vibrator
- During Expiration (difficult)







Internal vibration with PEP

Flutter breathing

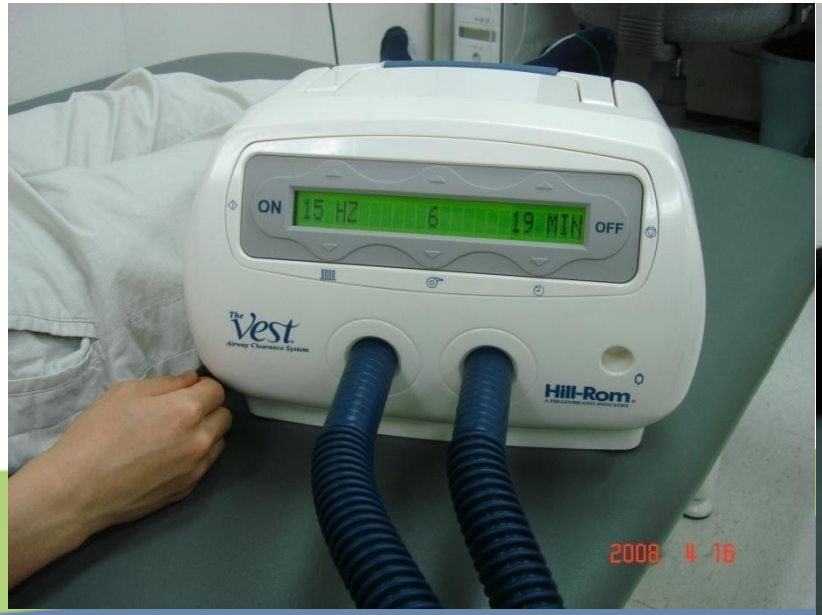
Acapella

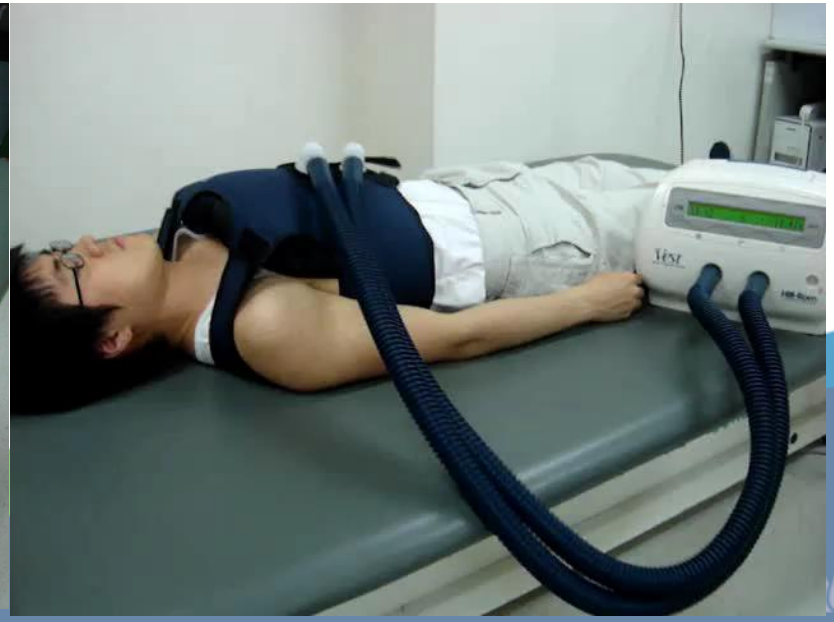
High-frequency wall oscillation

VEST (automatic percussion)

15 Hz, 1 min cycle for 10 min

deep breathing → cough per cycle

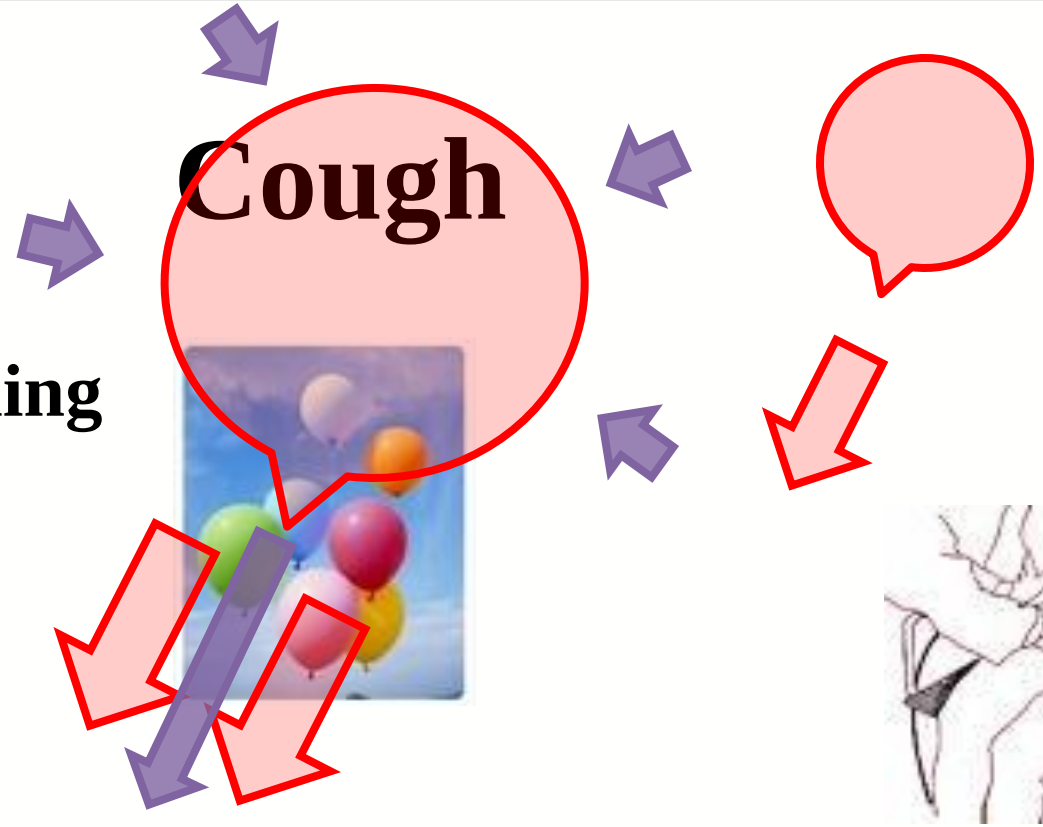




Physical therapy for PR

Treatments to administered to enhance cough
Proper cough training
Huff
Forced expiratory technique

Cough



Assistive Coughing

Increased pre-cough volume

→Increased cough flow

Inspiration aid: ambu-bag

Expiration aid: manual compression

Physical therapy for PR

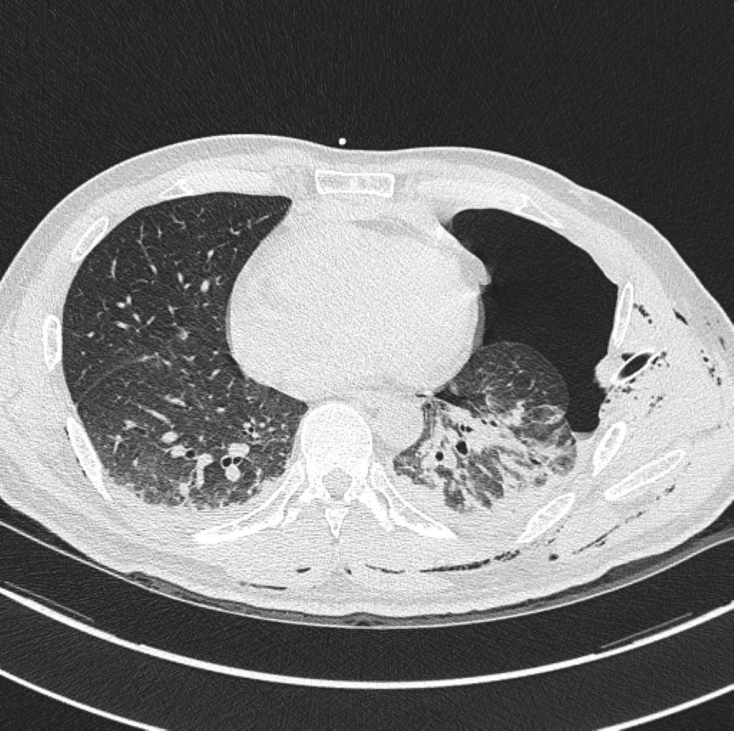
Treatments to administered to reduce pain and enhance chest mobilization and relaxation
Upper extremities and trunk exercise
Pain control include transcutaneous electrical nerve stimulation

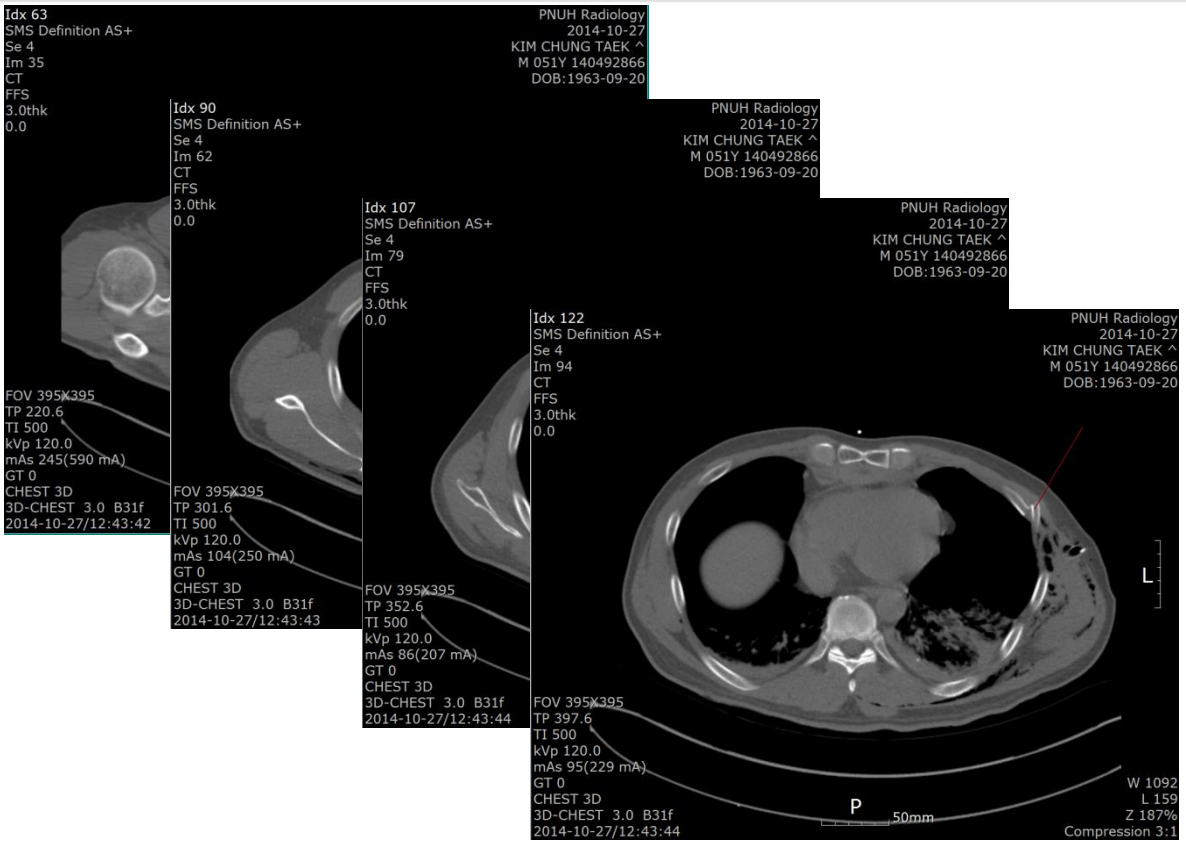
Reconditioning Exercise

Concerns after Chest Trauma

Pulmonary Rehab after Trauma

- ✓ Secretion removal
- ✓ Prevention
  - ✓ LROM of lung alveoli
  - ✓ Atelectasis
  - ✓ Compliance of chest wall
- ✓ Complication?

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Se 4
Im 35
CT
FFS
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0.0
FOV 395X395
TP 220.6
TI 500
kVp 120.0
mAs 245(590 mA)
GT 0
CHEST 3D
3D-CHEST 3.0 B31f
2014-10-27/12:43:42
PNUH Radiology
2014-10-27
KIM CHUNG TAEK ^
M 051Y 140492866
DOB:1963-09-20
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GT 0
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PNUH Radiology
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Im 94
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TP 397.6
TI 500
kVp 120.0
mAs 95(229 mA)
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PNUH Radiology
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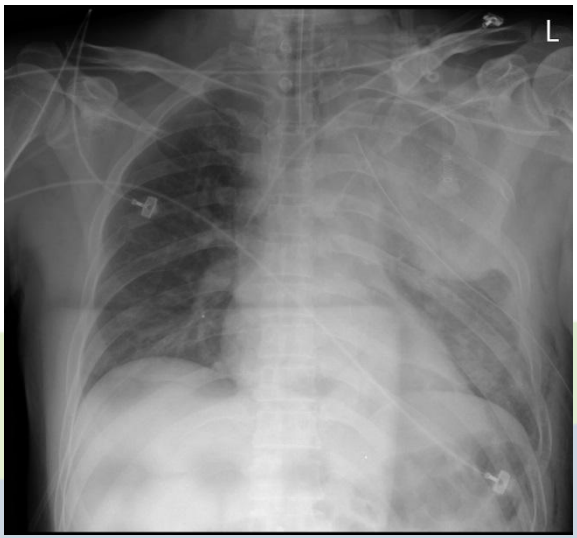
L
P
50mm
W 1092
L 159
Z 187%
Compression 3:1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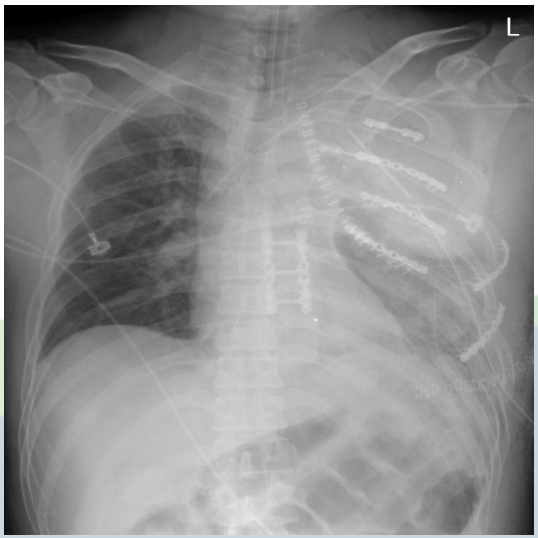
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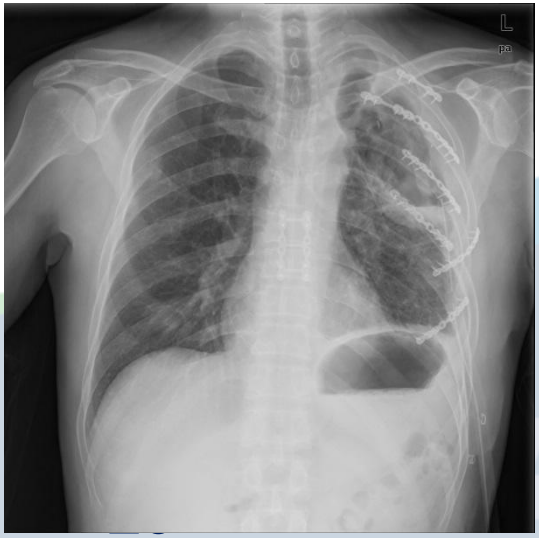

L

Pulmonary Rehab after Trauma

- ✓ **Rib fixation**
  - ✓ Early ambulation
  - ✓ Early chest mobilization
  - ✓ Early active coughing
  - ✓ Pain tolerance
- ✓ **Traumatic pneumothorax and Lung Contusion**
  - ✓ Evidence?

Rib Fractures

10% of all trauma patients

approximately 30%

of all patients with significant chest trauma

A sign of severe trauma

The greater the number of fractured ribs

→ the higher the associated morbidity and mortality

Eur J Cardiothorac Surg 2003;24:133–138.

Rib Fractures, Numbers

A sign of severe trauma

10% mortality

more than 4 rib fractures.

34% mortality

more than 8 rib fractures

Surgery 2005;138:717–725.

Rib Fractures, Ages

more than 4 **rib fractures**

45 yrs of age or more

older than **65 yrs** → **56% mortality rate**

Ann Adv Automot Med 2008;52:73–82.

Rib Fractures, Complication

Flail chest (No surgical treatment)

Mechanical ventilation

Pneumonia	**27-70 %**
Mortality	**25-51 %**

J Trauma 2002;52:727–732.

Rib Fractures

Up to 30% → Pneumonia

Mortality

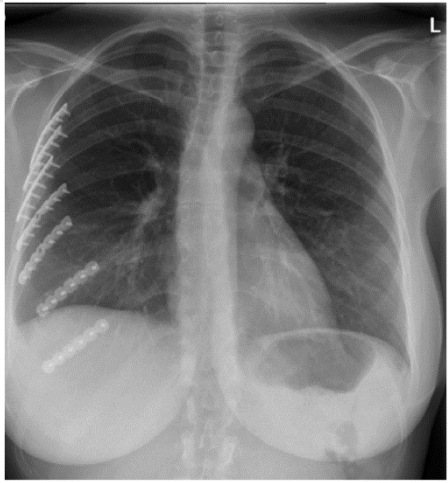
Morbidity

Age (**45** years / 65 years)

Numbers of rib fracture (**4** / 8)

J Trauma 2003;54:478–485.
J Trauma 2000;48:1040–1046.

Rib Fractures



Meta-analysis

↓ duration of mechanical ventilation(MV)

complications associated with MV

length of hospital stay

Mortality

Ann Surg 2013;258:914–921.

Chest Physical Therapy, 1915

MacMahon in a 1915

Tx of the postoperative and **trauma patients**

1. Enabling the collapsed lung to regain normal condition
2. Restoring the normal shape of the chest wall
3. Assisting the discharge of pus through lung inflation
4. Improving general conditioning by exercise

MacMahon C. Lancet, 1915; 769-770.
Phys Ther. 1981 Dec;61(12):1724-36.

Chest Physical Therapy

Breathing Exercise

Positioning, Bronchial Drainage, Manual Techniques

Bronchoscopy / every 4 hours rehab (38%)

atelectasis (68%)

Cough

TENS / NMES

Mobility and Ambulation

become routine~!

Phys Ther. 1981 Dec;61(12):1724-36.

Cough

Decreased inspiratory volume

poor diaphragmatic excursion

pain etc

weak contraction of the abdominal muscles

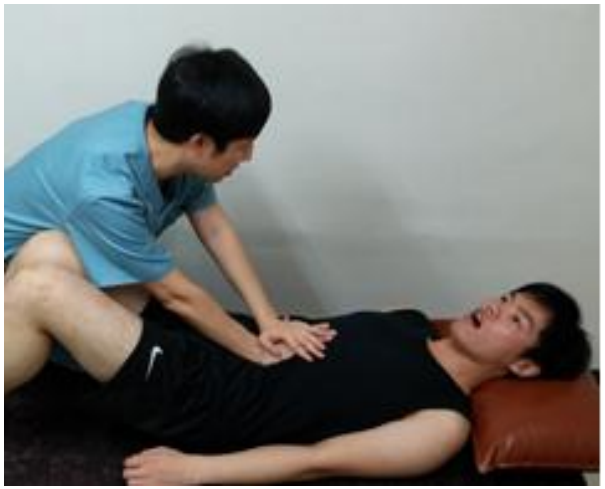
Ex) Coughing after Thoracostomy

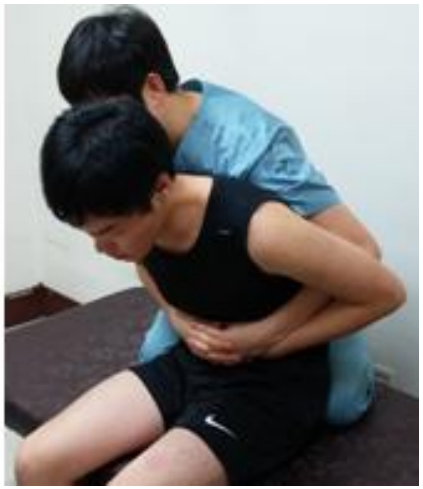
immediately 29 % of the preoperative value

50% in one week after surgery

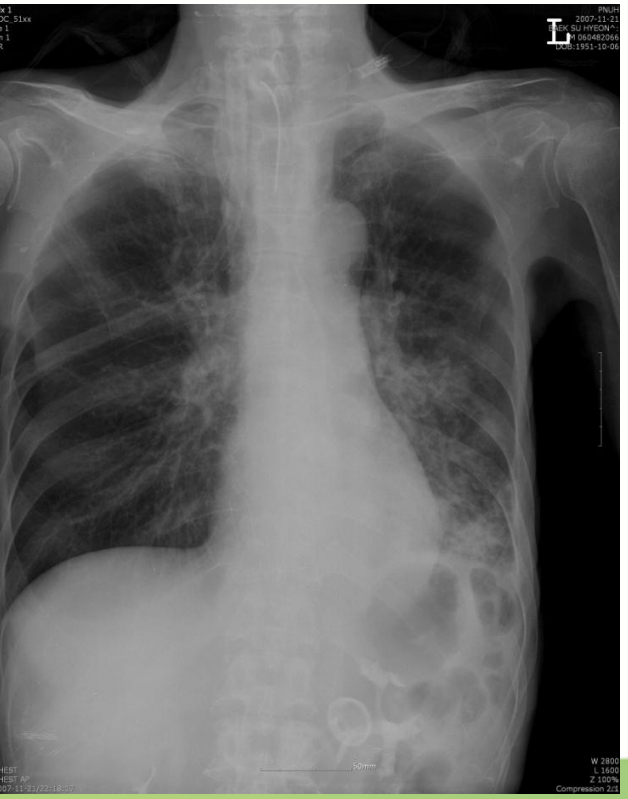
Surg Annu 9:29-59, 1977
Chest 67(6):654-657, 1975

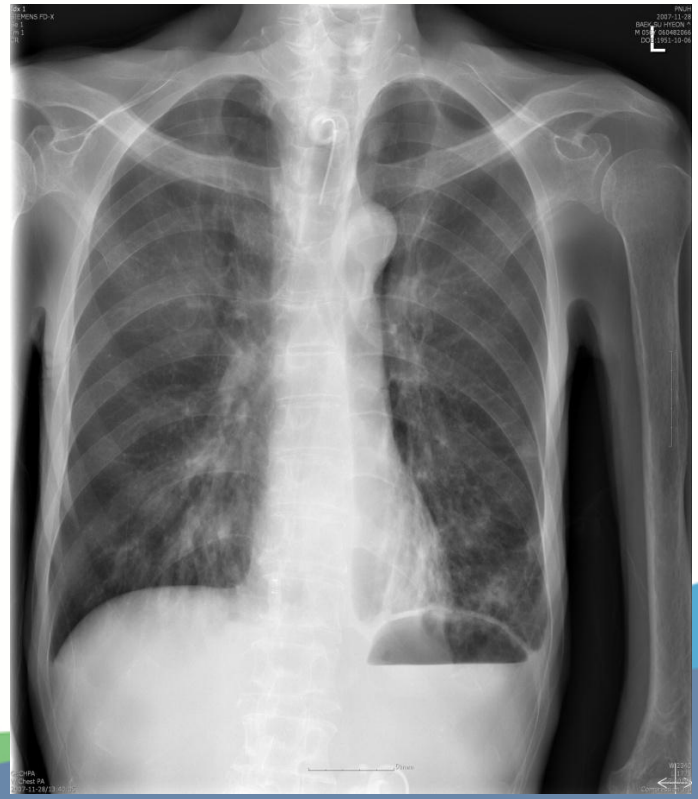
Assist cough & Splint cough





Cough Machine





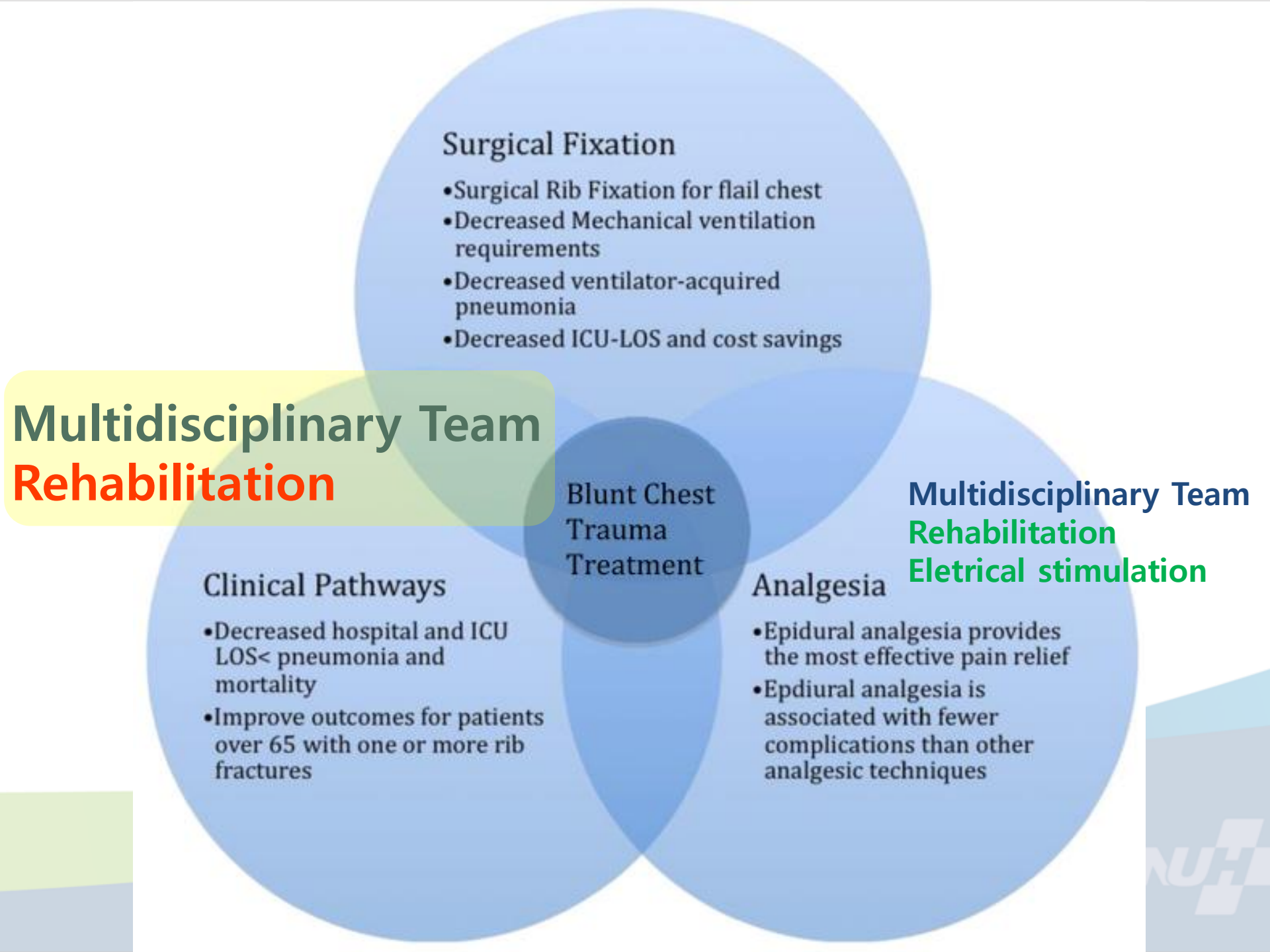
Chest Physical Therapy, 2015

Annalise Unsworth in a 2015

Tx of Blunt chest trauma

1. Effective analgesia
2. Surgical fixation
3. **Chest physiotherapy**
4. Respiratory care
5. **Early mobilization**

Scand J Trauma Resusc Emerg Med. 2015 Feb 8;23(1):17


Surgical Fixation
•Surgical Rib Fixation for flail chest
•Decreased Mechanical ventilation requirements
•Decreased ventilator-acquired pneumonia
•Decreased ICU-LOS and cost savings
Multidisciplinary Team
Rehabilitation
Blunt Chest Trauma Treatment
Multidisciplinary Team
Rehabilitation
Eletrical stimulation
Clinical Pathways
•Decreased hospital and ICU LOS< pneumonia and mortality
•Improve outcomes for patients over 65 with one or more rib fractures
Analgesia
•Epidural analgesia provides the most effective pain relief
•Epdiural analgesia is associated with fewer complications than other analgesic techniques

Early Rehabilitation in ICU

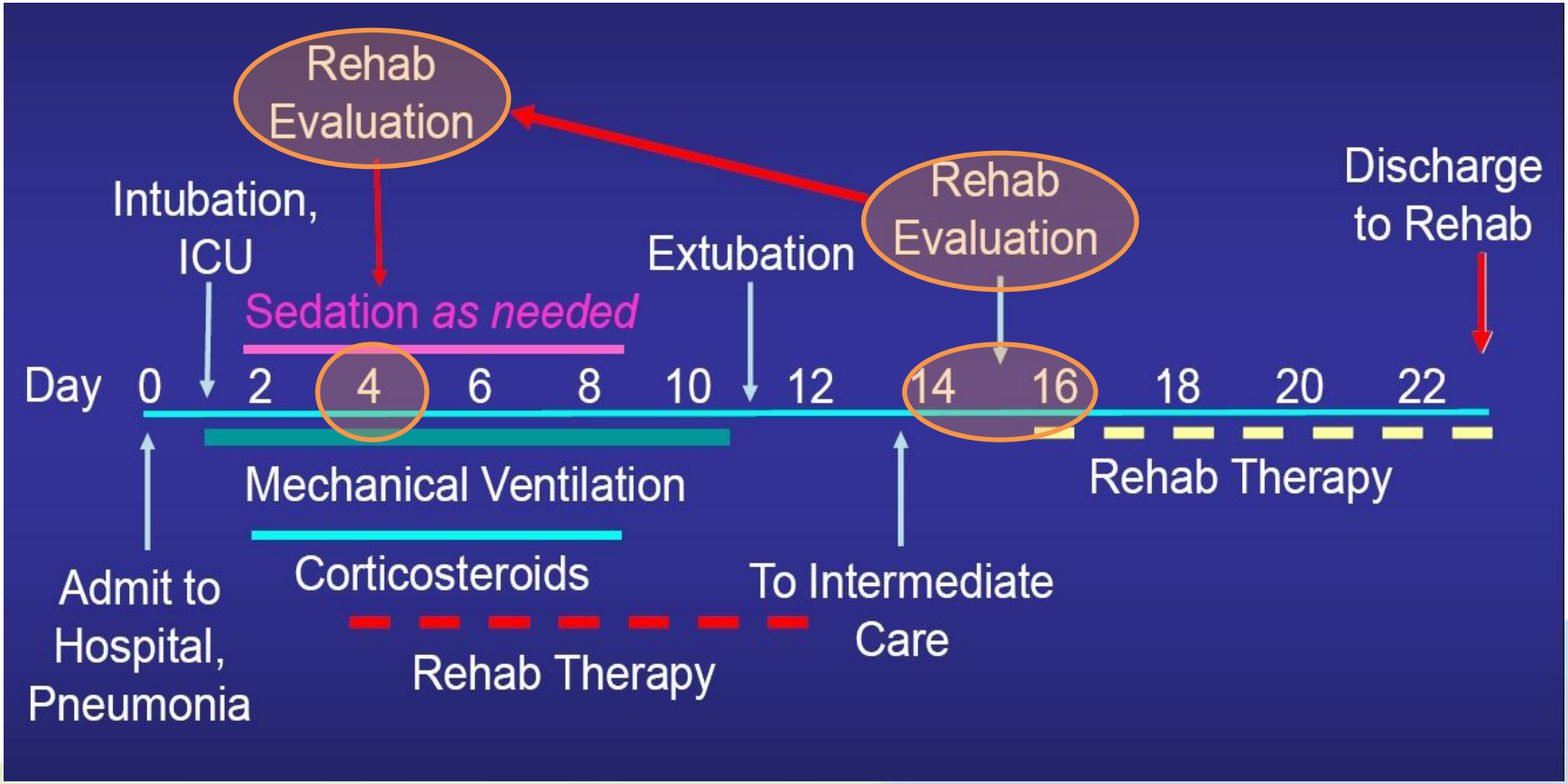
Awake and Active ICU

PNUH 부산대학교병원
Pusan National University Hospital

Paradigm Shift in the ICU at Johns Hopkins University

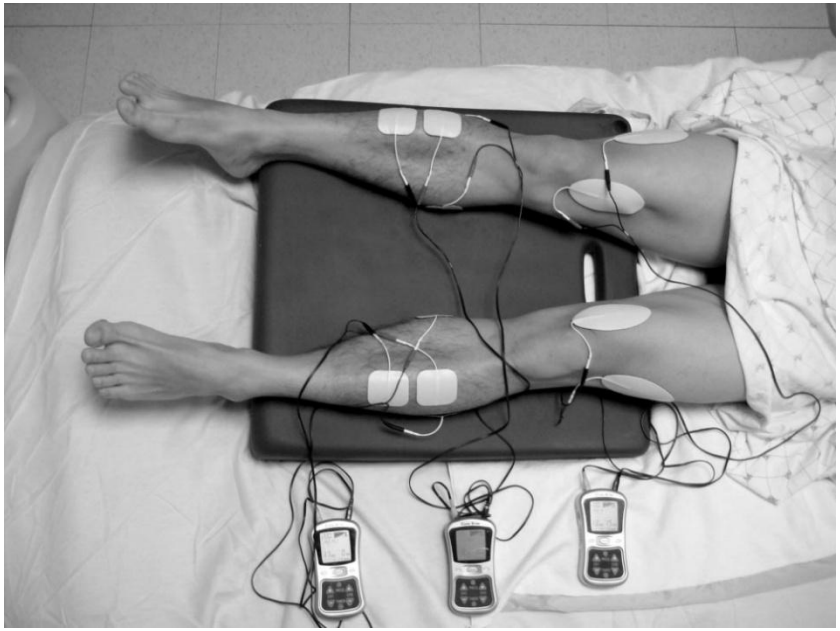
- ✓ **Early Mobility** in the Critically Illness patients
- ✓ **ICU-acquired weakness (ICUAW)**
- ✓ Improving ICU motality
  → focus on **long term outcomes**

Paradigm Shift in the ICU at Johns Hopkins University



MOVER

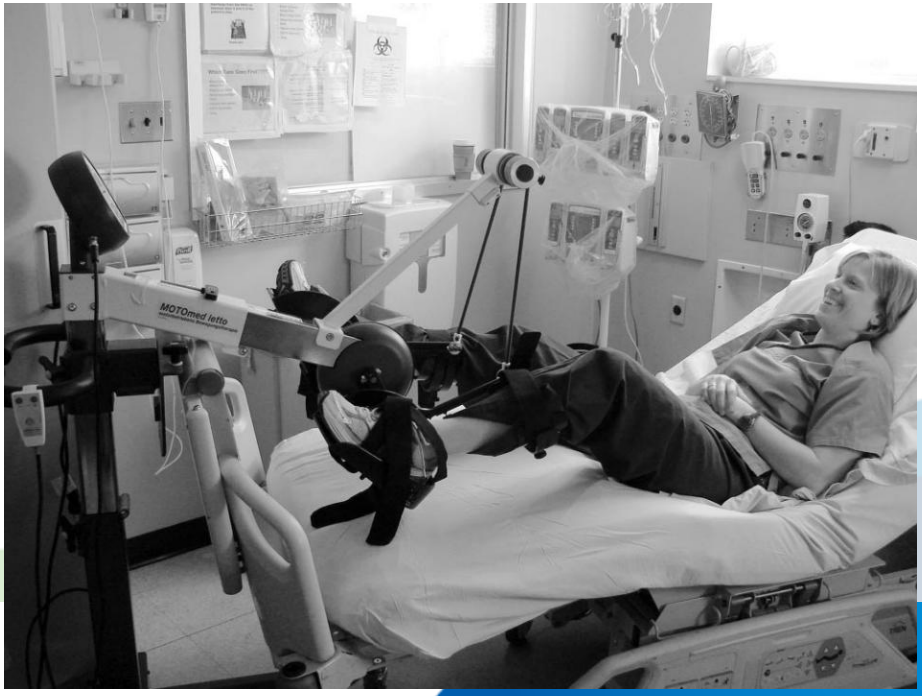
Moving Our patients for Very Early Rehabilitation



NMES

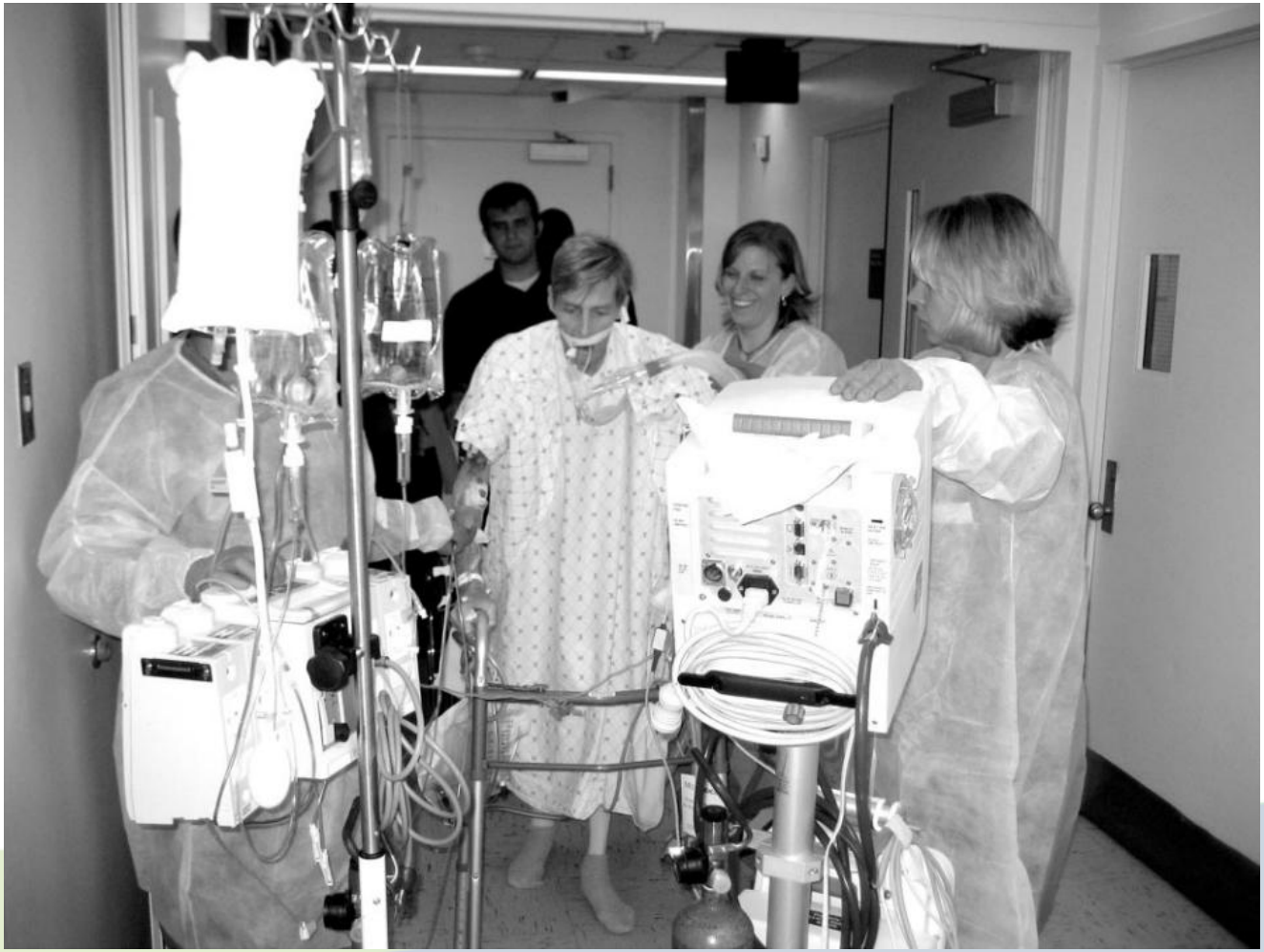
(Neuromuscular electrical stimulation)

Cycle Ergometer



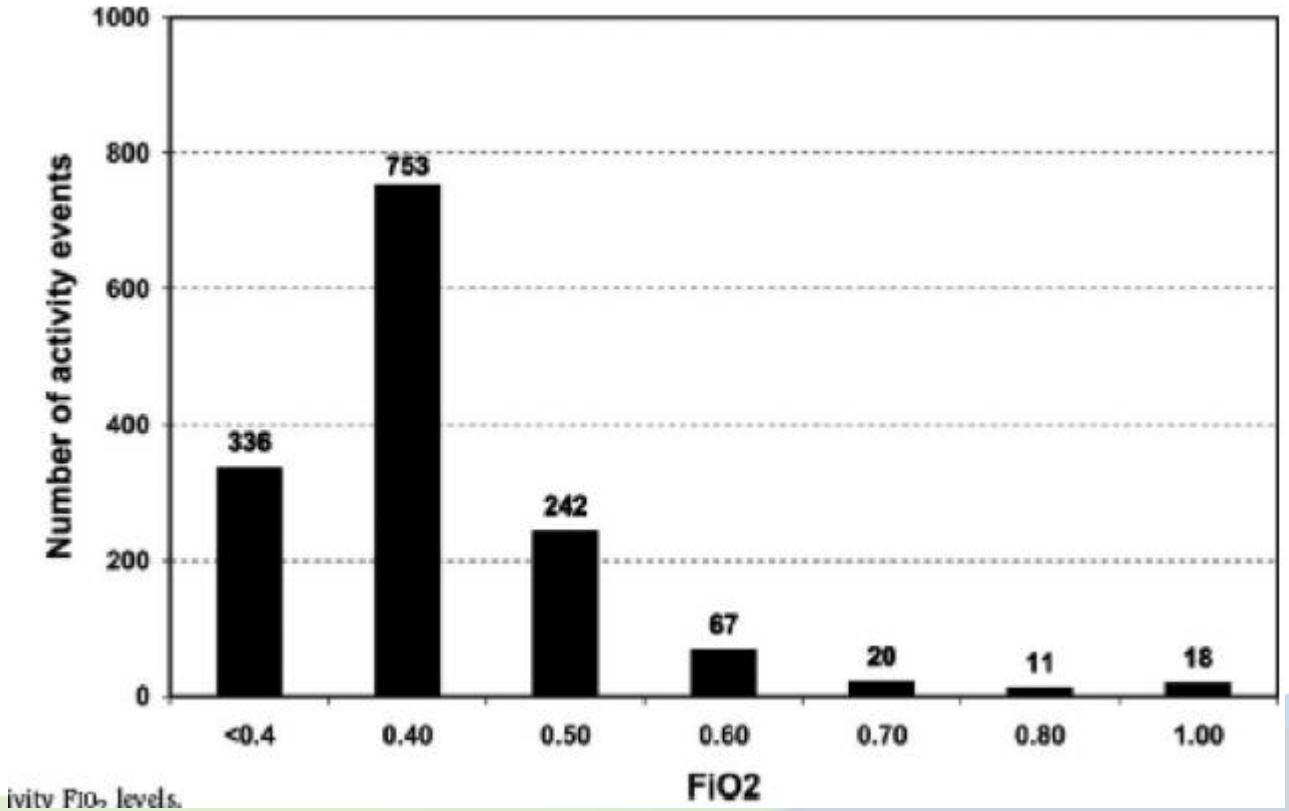
MOVER

Moving **O**ur patients for **V**ery **E**arly **R**ehabilitation



Early Ambulation

Early mobilization of Critically ill patients



ivity F_{IO_2} levels.

Crit Care Med 2007; 35:139–145
Crit Care Med 2008; 36:1119–1124

Early mobilization of Critically ill patients

- ✓ Safety events prospectively defined
  - ✓ 9 pts /w 14 adverse event (<1% of activities)
    - ✓ 5 falls to knees w/o injury
    - ✓ 4 SBP < 90mmHg
    - ✓ 3 O_2 sat < 80%
    - ✓ 1 nasal feeding tube removal
    - ✓ 1 SBP > 200 mmHg
  - ✓ No Extubations
  - ✓ None required added therapy and cost

Crit Care Med 2007; 35:139–145
Crit Care Med 2008; 36:1119–1124

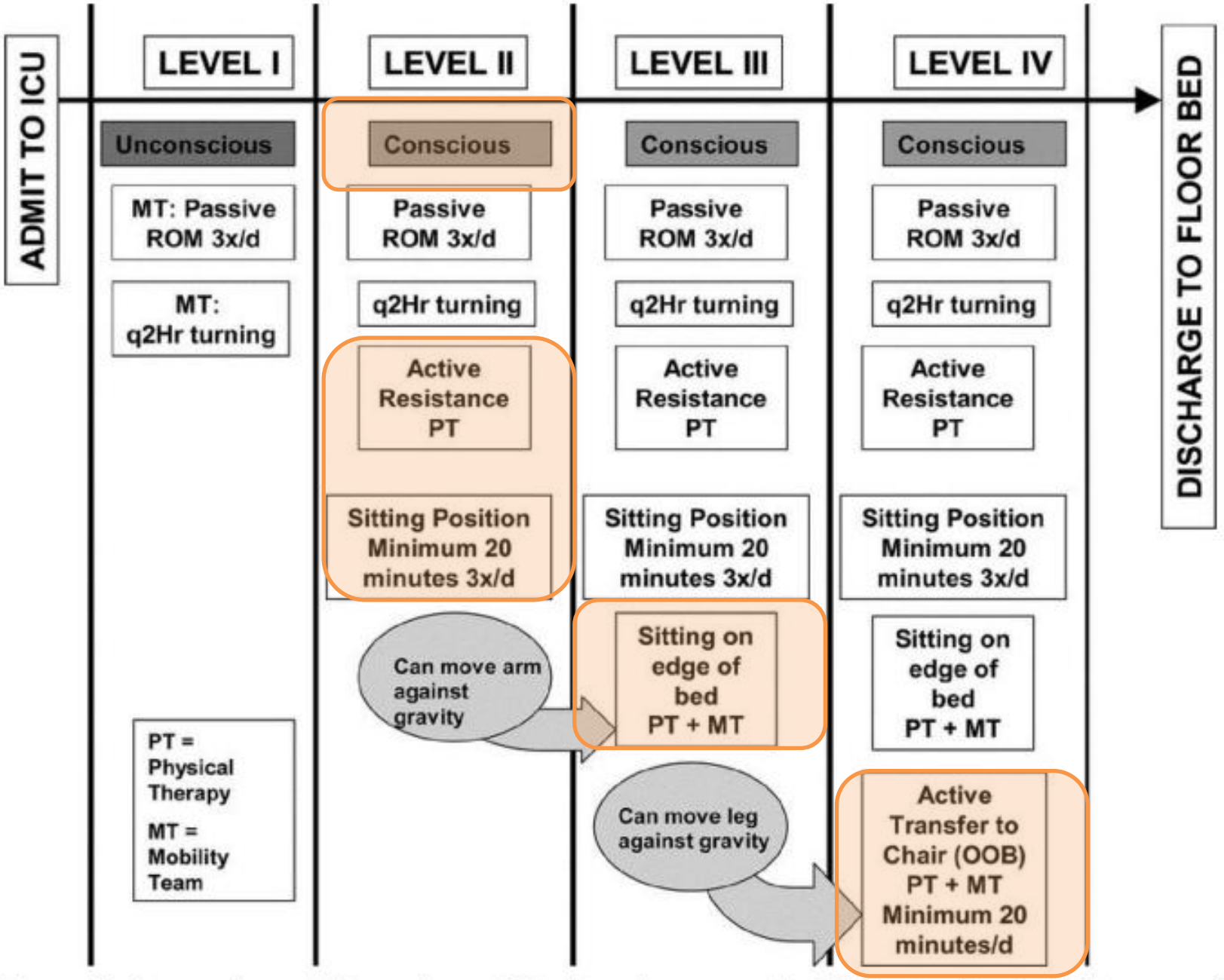


Figure 5. Progressive activity regimen. *ICU*, intensive care unit; *OOB*, out of bed; *ROM*, range of motion. Reprinted with permission from Morris et al (32).

After Chest Trauma

Focused on being physically active

Pulmonary Rehab

+ ICU Rehab
(early mobilization)

= Active Rehabilitation

Our Experiences

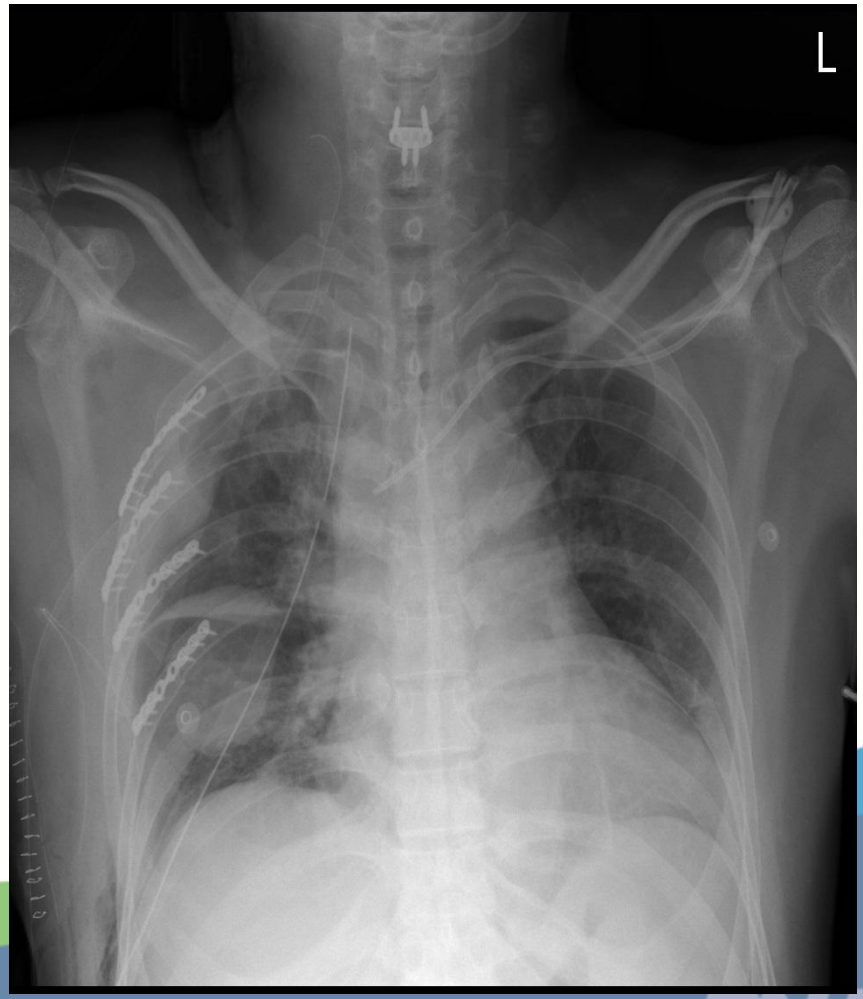
Breathing Retraining (M/53)

Rt. Pneumothorax
Rt. pleural effusion.

Subsegmental atelectasis

Subcutaneous emphysema at right upper chest wall area.

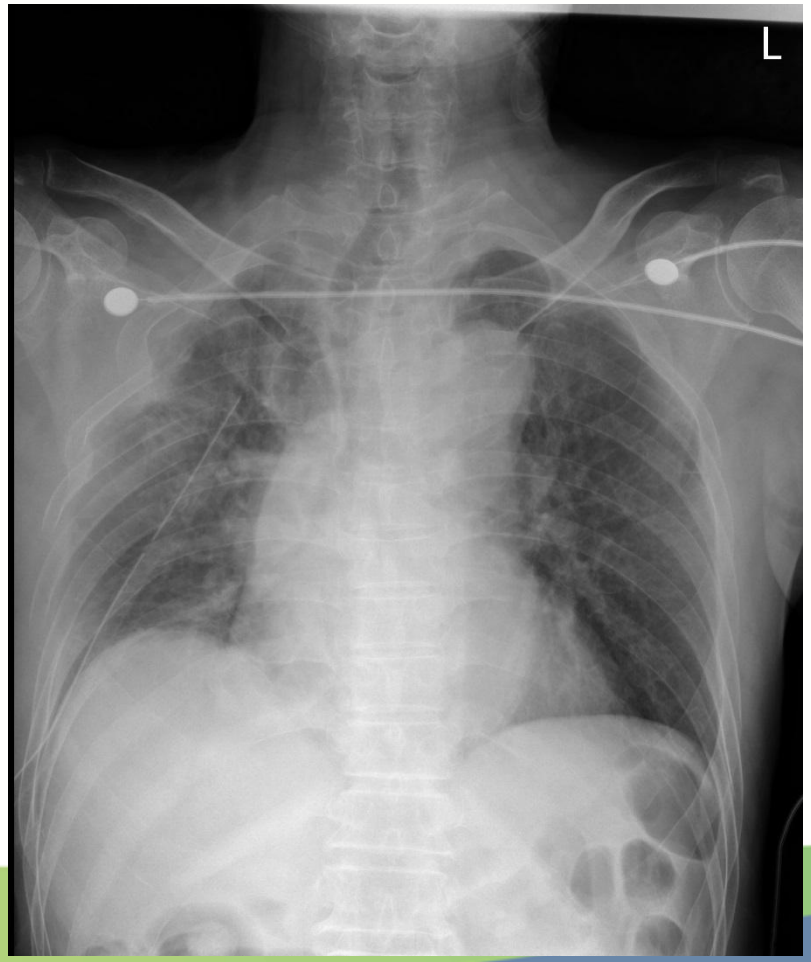
Multiple fractures
- right acromion process
- C2 vertebral body
- Rt 1-6th ribs
- left 1st rib



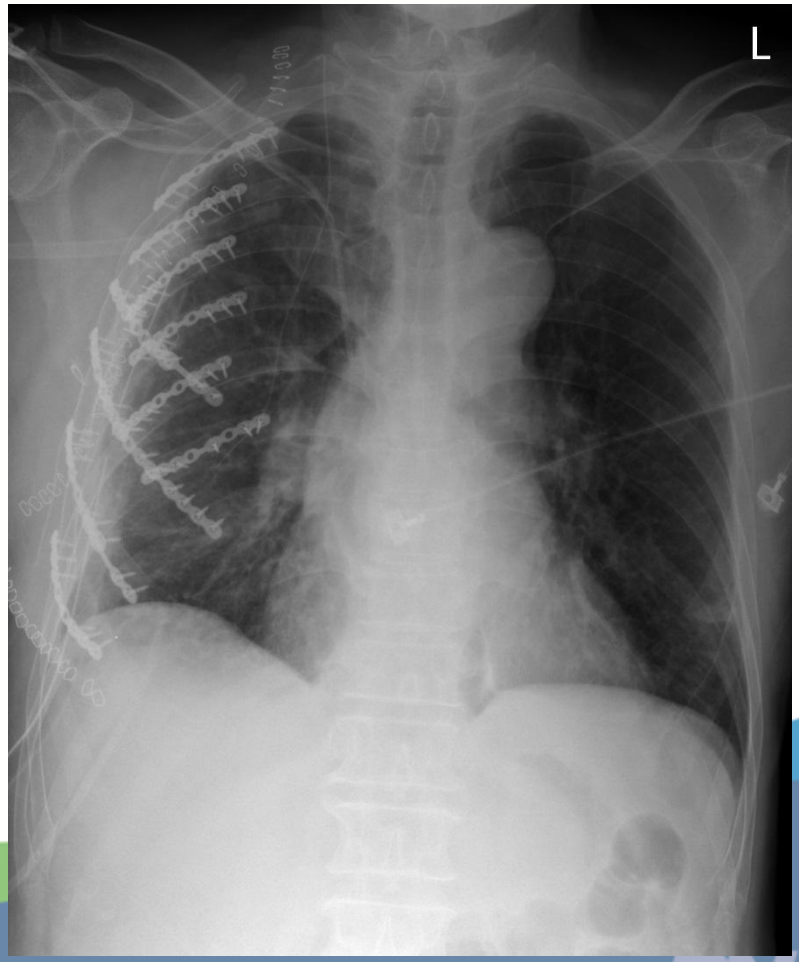
20150504 onset

20150512 (0511 Op.)

Rt. hemopneumothorax.
Rt. Multiple rib fractures. (3rd-9th)
Underlying pulmonary emphysema (M/75)

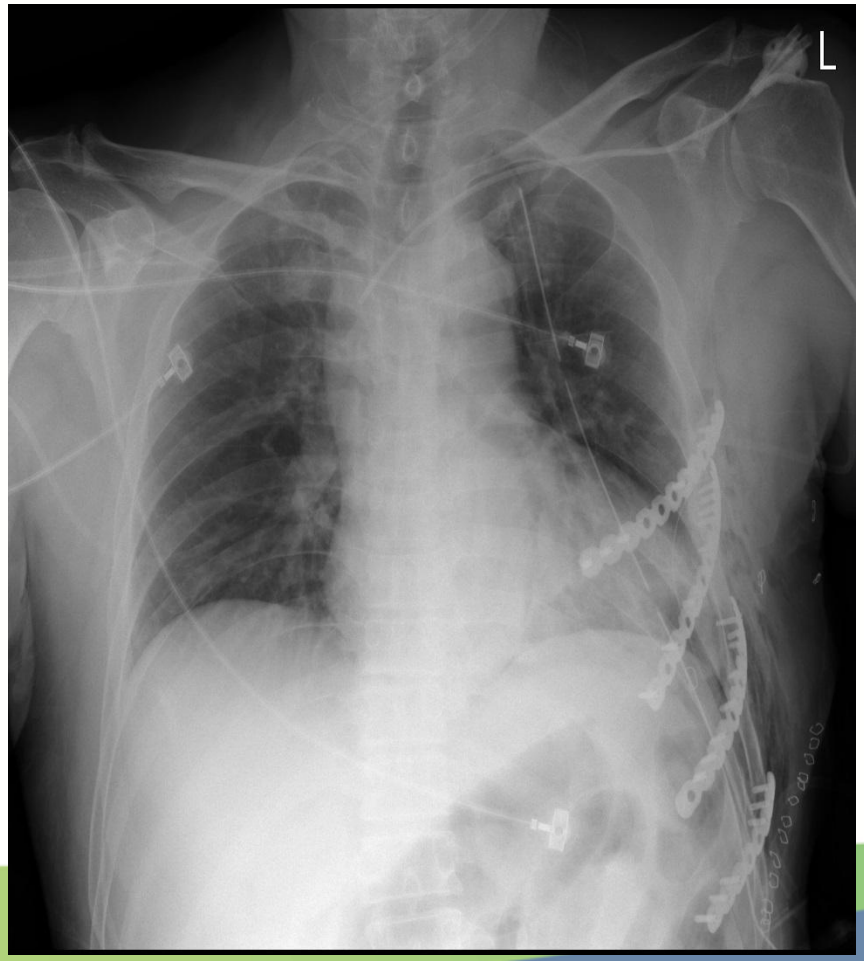


20140318



20140325 (0321 Op.)

complex fractures and segmental fractures: 4-7th left ribs
lung contusion and laceration- suture
(M/59)



20150502

늑골 골절의 추적 관찰

목포한국병원 흉부외과
제갈재기

기침을 하지 못하여, 적적한 가래 배출이 어려운 isolated rib fracture 환자의 경우 입원하여 24시간 동안 경과 관찰하는 것을 고려해야 한다. 기저 폐질환이나 폐기능이 떨어져있는 환자의 경우도 입원을 고려하여야 한다. 고령의 isolated rib fracture 환자는 hypoventilation, hypercarpnia, atelectasis, pneumonia 의 발생률이 높기 때문에 좀더 적극적인 입원 치료가 필요하다. 특히 85세 이상이거나 65세 이상 환자에서 초기 수축기 혈압 90mmHg 이하, 혈흉, 기흉, 3개 이상의 골절, 폐둔상의 경우 입원을 고려한다. 입원은 숨어있는 복부 장기 손상에 대한 경과 관찰을 위해서 필요하기도 하다.

가래를 잘 뱉어낼 수 있는 minor rib injury 의 경우 적적한 진통제를 처방하여 퇴원할 수 있다. 적절한 진통제는 성공적으로 외래 환자를 치료하는데 매우 중요하며, 이는 한 연구에서 응급실에서 늑골 골절 진단 후 부적절한 통증 조절로 조기 외래 방문한 사례가 퇴원환자의 19% 였다는 보고를 통해서도 잘 드러난다. 합병증이 발생한 환자의 대부분이 2주 이내에 발생하므로, 2주 이내 F/U 을 계획해야 한다. CXR 는 기흉을 의심할만한 편측의 호흡음 감소나 malunion이나 nonunion 을 시사하는 통증의 지속이 없는 한 수상 후 수일후의 routine CXR f/u은 필요하지 않다. 하지만, 흉부 둔상 후에 발생한 지연성 기흉, 혈흉에 관한 한 연구에서 기흉은 4~48시간, 혈흉은 48시간에서 14일까지 보고되었고, 초기 손상 정도와 상관없이 모든 늑골 골절 환자의 routine f/u을 수상 후 적어도 2주동안 권고하고 있다.

대부분의 늑골 골절은 6주이내에 회복되고 많은 환자들이 그것보다 더 빨리 일상생활로 돌아갈 수 있다.

최근 국내에서 늑골 고정술을 시행한 환자들을 대상으로 CT 를 이용한 폐용적, 폐기능검사, 동맥혈가스분석 결과를 비교 분석하는 연구들이 이루어지고 있고, 우리 실정에 맞는 진료 지침 계발의 필요성이 대두되고 있어, 늑골 골절의 추적 관찰에 있어서 다기관 연구가 가능하도록 프로토콜을 일원화하는 작업이 필요할 것으로 생각된다.

HEMORRHAGIC SHOCK AND MANAGEMENT

Sung Wook Chang, MD
Trauma Center
Department of Thoracic and Cardiovascular Surgery
Dankook University Hospital

INTRODUCTION

Traumatic cardiopulmonary arrest

- ✓ The most severe and critical illness
- ✓ The reported survival rates

  1998: 4.5% (Branney SW et al. J Trauma 1998;45(1):87-94)

  2005: 2.2% (Soar J et al. Resuscitation 2005; 67S1: S135—70)

  2013: 2.4% (Moriwaki Y et al. J Emerg Trauma Shock 2013;6:37-41)

Not Improved, at all !

INTRODUCTION

Traumatic hemorrhagic shock

- ✓ Several challenges has been done
- ✓ The reported survival rates

1992: 33% (Burch JM et al. Ann Surg 1992;215(5):476-83)

1993: 55% (Rotondo MF et al. J Trauma 1993;35(3):375-82)

2004: 70% (Gutierrez G et al. Crit Care 2004;8(5):373-81)

Excellently Improved !

INTRODUCTION

Traumatic hemorrhagic shock

- ✓ Damage Control Surgery
  - Early stop the bleeding
- ✓ Damage Control Resuscitation
  - Restore circulating blood volume
  - Permissive hypotension from bleeding
  - Correct acidosis/Avoid hypothermia (tissue hypoxia)
  - Transfusion (Hgb level of 7-8 g/dl vs. 10 g/dl) (massive/adjusted)

INTRODUCTION

Traumatic hemorrhagic shock management

- ✓ Damage Control Surgery
- ✓ Damage Control Resuscitation
  - Resuscitative thoracotomy
  - ECMO
  - ACC (Aortic Cross Clamp)
  - REBOA (Resuscitative Endovascular Balloon Occlusion of the Aorta)

RESUSCITATIVE THORACOTOMY

Traumatic Cardiac Arrest: Who Are the Survivors?

David Lockey, FRCA, FIMC, RCS(Ed)
Kate Crewdson, MB, BS, BSc
Gareth Davies, FFAEM, FRCP

From the London Helicopter Emergency Medical Service, Royal London Hospital, London, United Kingdom.

Study objective: Survival from traumatic cardiac arrest is poor, and some consider resuscitation of this patient group futile. This study identified survival rates and characteristics of the survivors in a physician-led out-of-hospital trauma service. The results are discussed in relation to recent resuscitation guidelines.

Methods: A 10-year retrospective database review was conducted to identify trauma patients receiving out-of-hospital cardiopulmonary resuscitation. The primary outcome measure was survival to hospital discharge.

Results: Nine hundred nine patients had out-of-hospital cardiopulmonary resuscitation. Sixty-eight (7.5% [95% confidence interval 5.8% to 9.2%]) patients survived to hospital discharge. Six patients had isolated head injuries and 6 had cervical spine trauma. Eight underwent on-scene thoracotomy for penetrating chest trauma. Six patients recovered after decompression of tension pneumothorax. Thirty patients sustained asphyxial or hypoxic insults. Eleven patients appeared to have had "medical" cardiac arrests that occurred before and was usually the cause of their trauma. One patient survived hypovolemic cardiac arrest. Thirteen survivors breached recently published guidelines.

Conclusion: The survival rates described are poor but comparable with (or better than) published survival rates for out-of-hospital cardiac arrest of any cause. Patients who arrest after hypoxic insults and those who undergo out-of-hospital thoracotomy after penetrating trauma have a higher chance of survival. Patients with hypovolemia as the primary cause of arrest rarely survive. Adherence to recently published guidelines may result in withholding resuscitation in a small number of patients who have a chance of survival. [Ann Emerg Med. 2006;48:240-244.]

LONDON'S AIR AMBULANCE

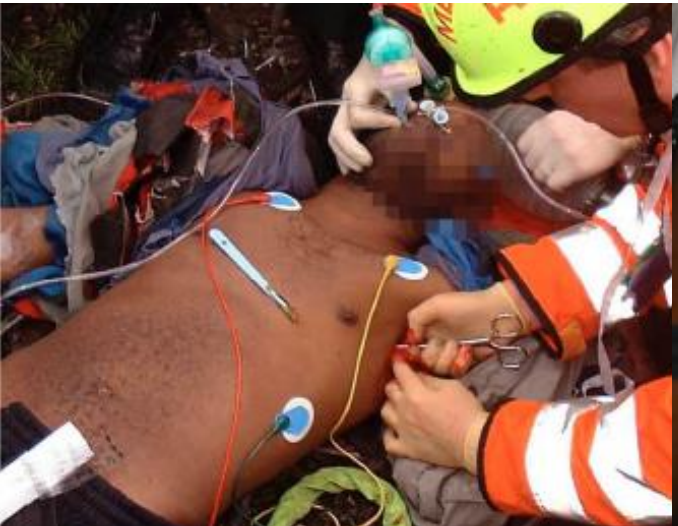
Resuscitation (2007) 75, 276–285

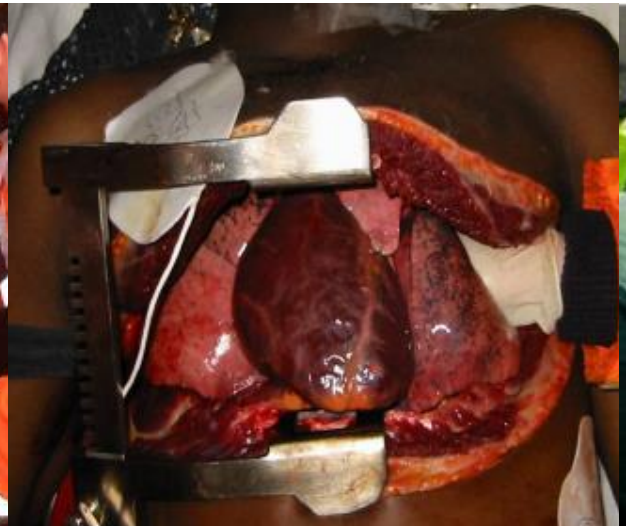
Outcome in 757 severely injured patients with traumatic cardiorespiratory arrest☆

Stefan Huber-Wagner[a,*], Rolf Lefering[b], Mike Qvick[a], Michael V. Kay[a], Thomas Paffrath[b], Wolf Mutschler[a], Karl-Georg Kanz[a],

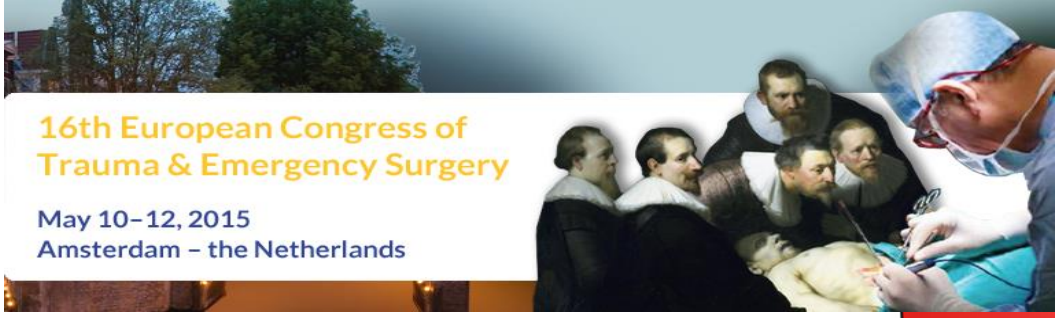
Working Group on Polytrauma of the German Trauma Society (DGU)[1]

Conclusions: Prehospital chest tube insertion was found to be a strong predictor for survival. On-scene chest decompression of TCRA patients is recommended in case of the decision to start with ECC. Based on our data, resuscitation after severe trauma seems to be more justified than the current guidelines state.





RESUSCITATIVE THORACOTOMY



✓ **Evaluation of prehospital resuscitative thoracotomy in Japanese doctor delivery system**

-Mashiko et al. Chiba Hokusoh shock & trauma center

- 2011.10 – 2014.09, 47 cases (16-87 yrs, median 62)

- 45:ACC, 5:pericardiotomy, 2:hilar clamping

Outcome	Asystole(n=23)	PEA/VF(n=24)	P value
Prehospital ROSC	2 (8.7%)	13 (54.2%)	*p*=0.001
24 hour survival rate	0 (0%)	6 (25.0%)	*p*=0.01
30 days survival rate	0 (0%)	4 (16.7%)	*p*=0.04

RESUSCITATIVE THORACOTOMY

✓ **AIM**

- To relieve cardiac tamponade
- To perform open cardiac massage
- To occlude the thoracic aorta

  (to improve cerebral and coronary circulation & decrease intra-abdominal hemorrhage)
- To control life-threatening intrathoracic hemorrhage

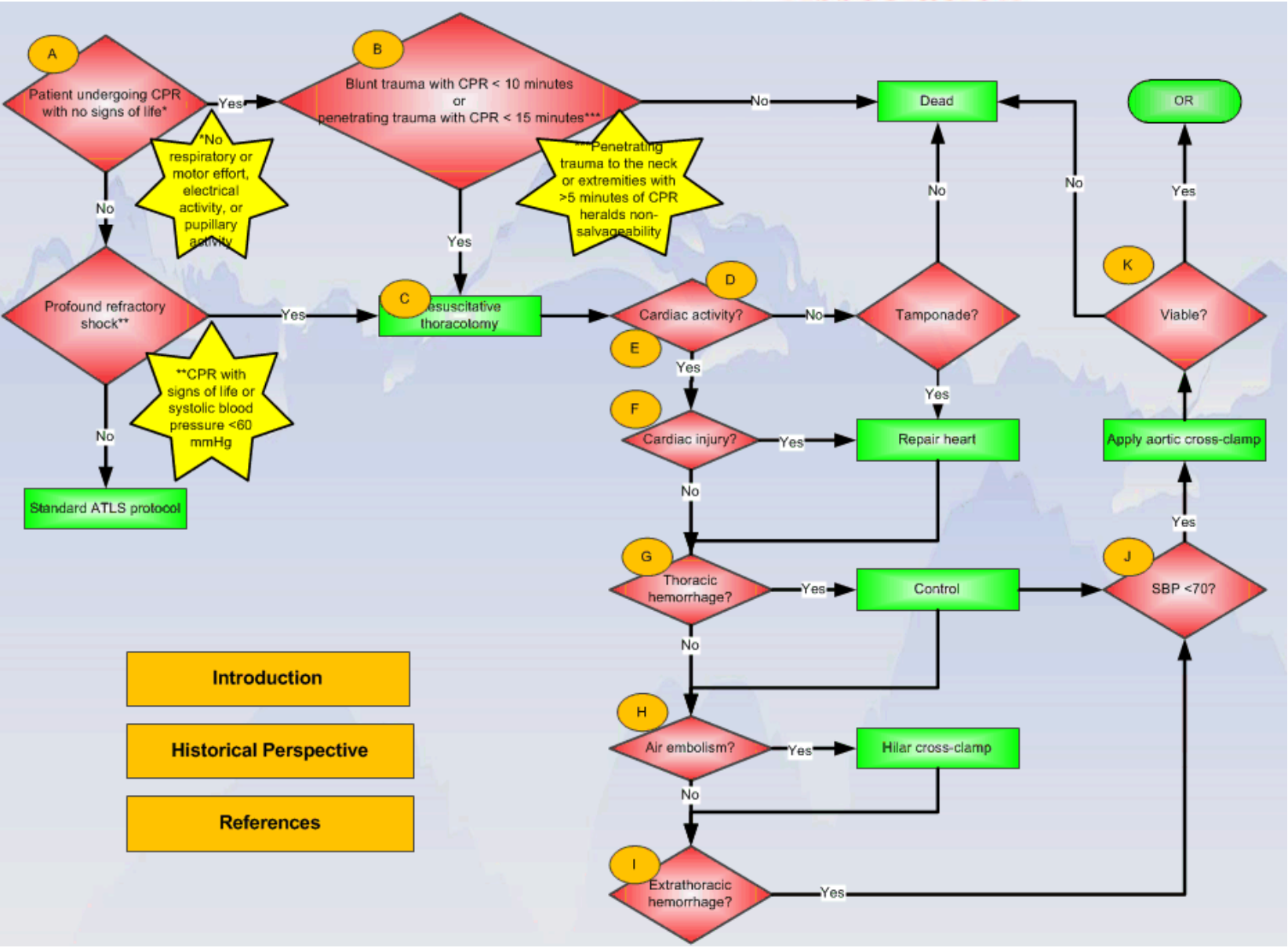
RESUSCITATIVE THORACOTOMY

- ✓ **INDICATION**
  - **- Shock or arrest with a suspected correctable intrathoracic lesion**
  - **- Specific diagnosis (cardiac tamponade, penetrating cardiac lesion, or aortic injury)**
  - **- Evidence of ongoing thoracic hemorrhage**
- ✓ **CONTRAINDICATION: NO SIGNS OF LIFE**
  - **- Blunt trauma > 5-10 min of CPR**
  - **- Penetrating trauma > 15 min of CPR**

RESUSCITATIVE

Physicians of all specialties committed to improving trauma care

Western Trauma Association



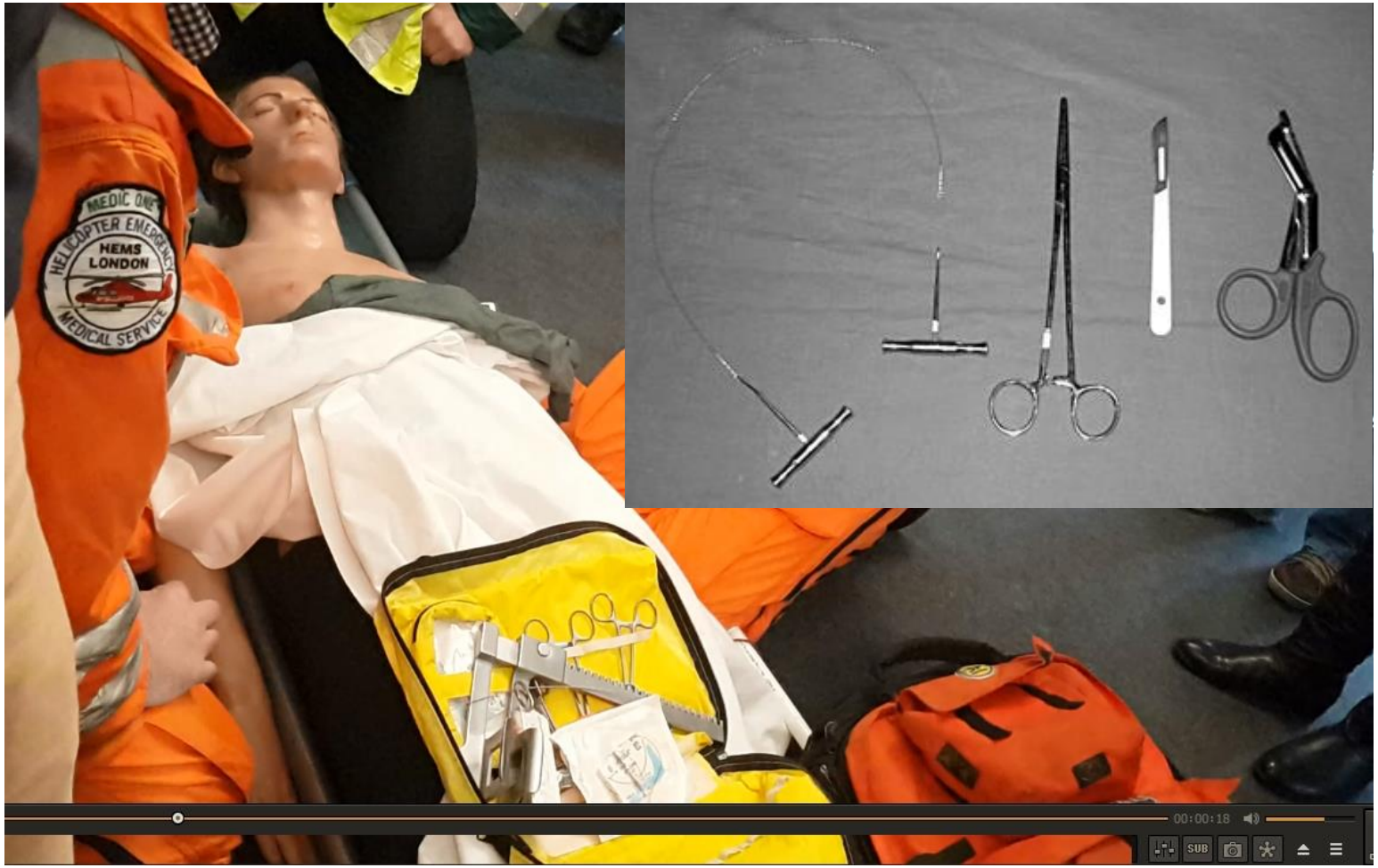
Introduction

Historical Perspective

References

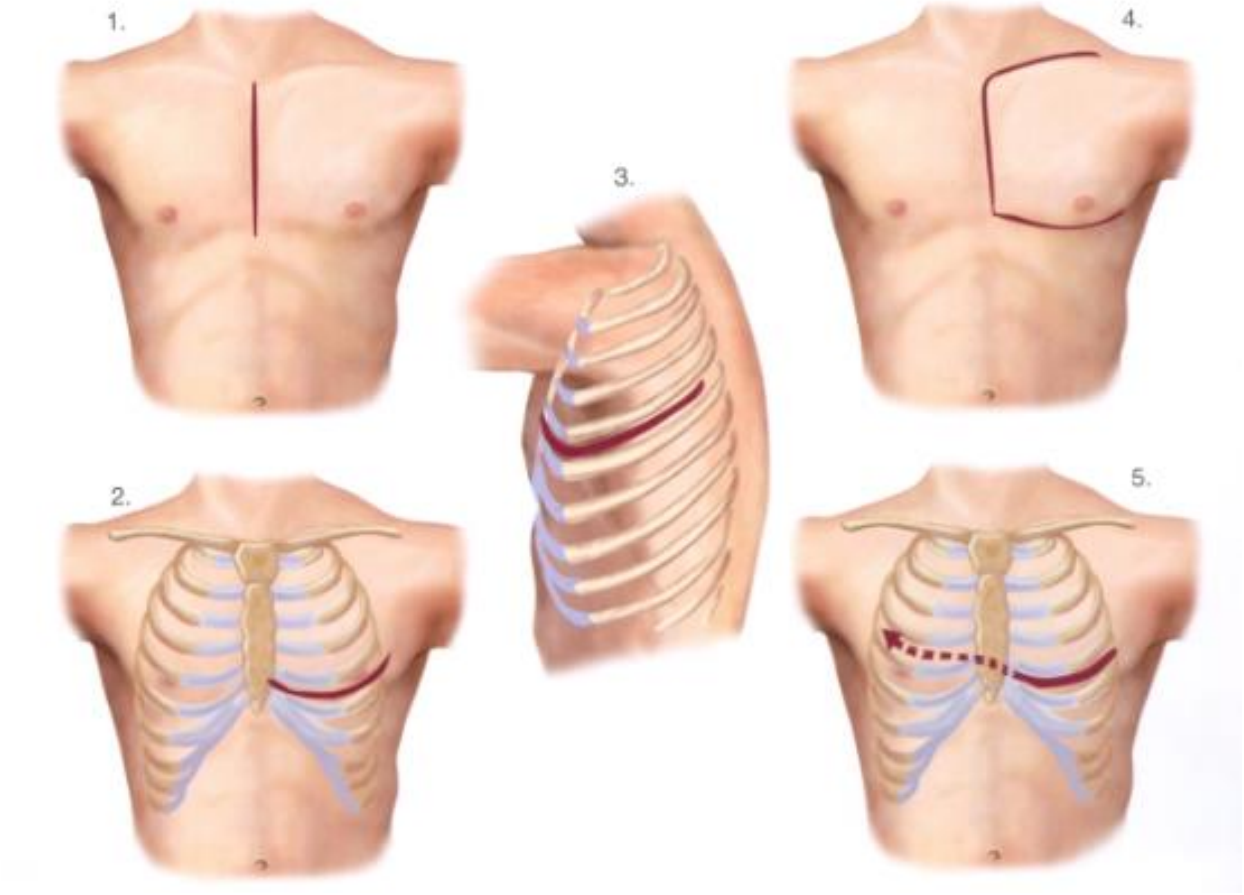
RESUSCITATIVE THORACOTOMY

✓ SET



RESUSCITATIVE THORACOTOMY

✓ INCISION



RESUSCITATIVE THORACOTOMY

ECMO

FIRST SUCCESSFUL ECMO Pt. 1971

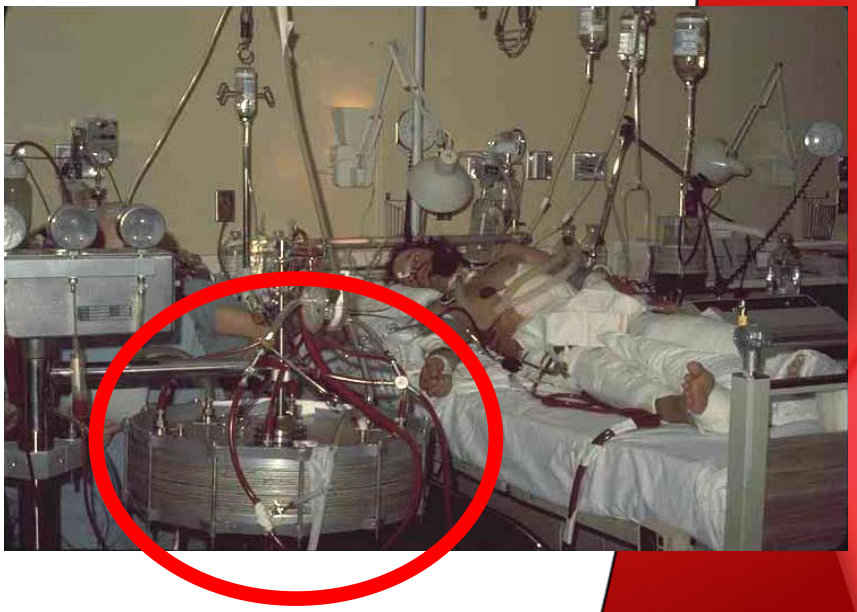
PROLONGED EXTRACORPOREAL OXYGENATION FOR ACUTE POST-TRAUMATIC RESPIRATORY FAILURE (SHOCK-LUNG SYNDROME)

Use of the Bramson Membrane Lung

J. Donald Hill, M.D., Thomas G. O'Brien, M.D., James J. Murray, M.D., Leon Dontigny, M.D., M. L. Bramson, A.C.G.I., J. J. Osborn, M.D., and F. Gerbode, M.D.

Hill JD et al.,
N Engl J Med 1972;286:629-634.

- ✓ **M/24, Motor Vehicle Accident**
- ✓ **Transection of thoracic aorta and multiple orthopedic injuries**
- ✓ **Respiratory failure after 4 days**
- ✓ **Partial venoarterial perfusion via peripheral cannulation using Bramson-membrane heart-lung machine, during 72hrs**



Extracorporeal life support in patients with multiple injuries and severe respiratory failure: A single-center experience?

J Trauma Acute Care Surg 2013 Volume 75. Number 5 907-12

Philippe Biderman, MD, Sharon Einav, MD, Michael Fainblut, MD, Michael Stein, MD, Pierre Singer, MD, *and* **Benjamin Medalion, MD,** *Jerusalem, Israel*

BACKGROUND: The use of extracorporeal life support in trauma casualties is limited by concerns regarding hemorrhage, particularly in the presence of traumatic brain injury (TBI). We report the use of extracorporeal membrane oxygenation (ECMO)/interventional lung assist (iLA) as salvage therapy in trauma patients. High-flow technique without anticoagulation was used in patients with coagulopathy or TBI.

METHODS: Data were collected from all adult trauma patients referred to one center for ECMO/iLA treatment owing to severe hypoxemic respiratory failure.

RESULTS: Ten casualties had a mean (SD) Injury Severity Score (ISS) of 50.3 (10.5) (mean [SD] age, 29.8 [7.7] years; 60% male) and were supported 9.5 (4.5) days on ECMO (n = 5) and 7.6 (6.5) days on iLA (n = 5). All experienced blunt injury with severe chest injuries, including one cardiac perforation. Most were coagulopathic before initiation of ECMO/iLA support. Among the seven patients with TBI, four had active intracranial hemorrhage. Complications directly related to support therapy were not lethal; these included hemorrhage from a cannulation site (n = 1), accidental removal of a cannula (n = 1), and pressure sores (n = 3). Deaths occurred owing to septic (n = 2) and cardiogenic shock (n = 1). Survival rates were 60% and 80% on ECMO and

CONC

LEVEL
KEY W

Exclusion criteria

1. Older than 60 years
2. Prolonged mechanical ventilation (>7 days) with peak airway pressures exceeding 30 cm H2O and/or FIO2 of 0.8 or greater
3. Patients with septic shock and multiple-organ failure
4. Staff/family noncommitment

Extracorporeal life support in patients with multiple injuries and severe respiratory failure: A single-center experience?

J Trauma Acute Care Surg 2013 Volume 75. Number 5 907-12

Philippe Biderman, MD, Sharon Einav, MD, Michael Fainblut, MD, Michael Stein, MD, Pierre Singer, MD, *and* Benjamin Medalion, MD, *Jerusalem, Israel*

ECMO/iLA (5ECMO and 5 iLA)
Upgrade??? Change???

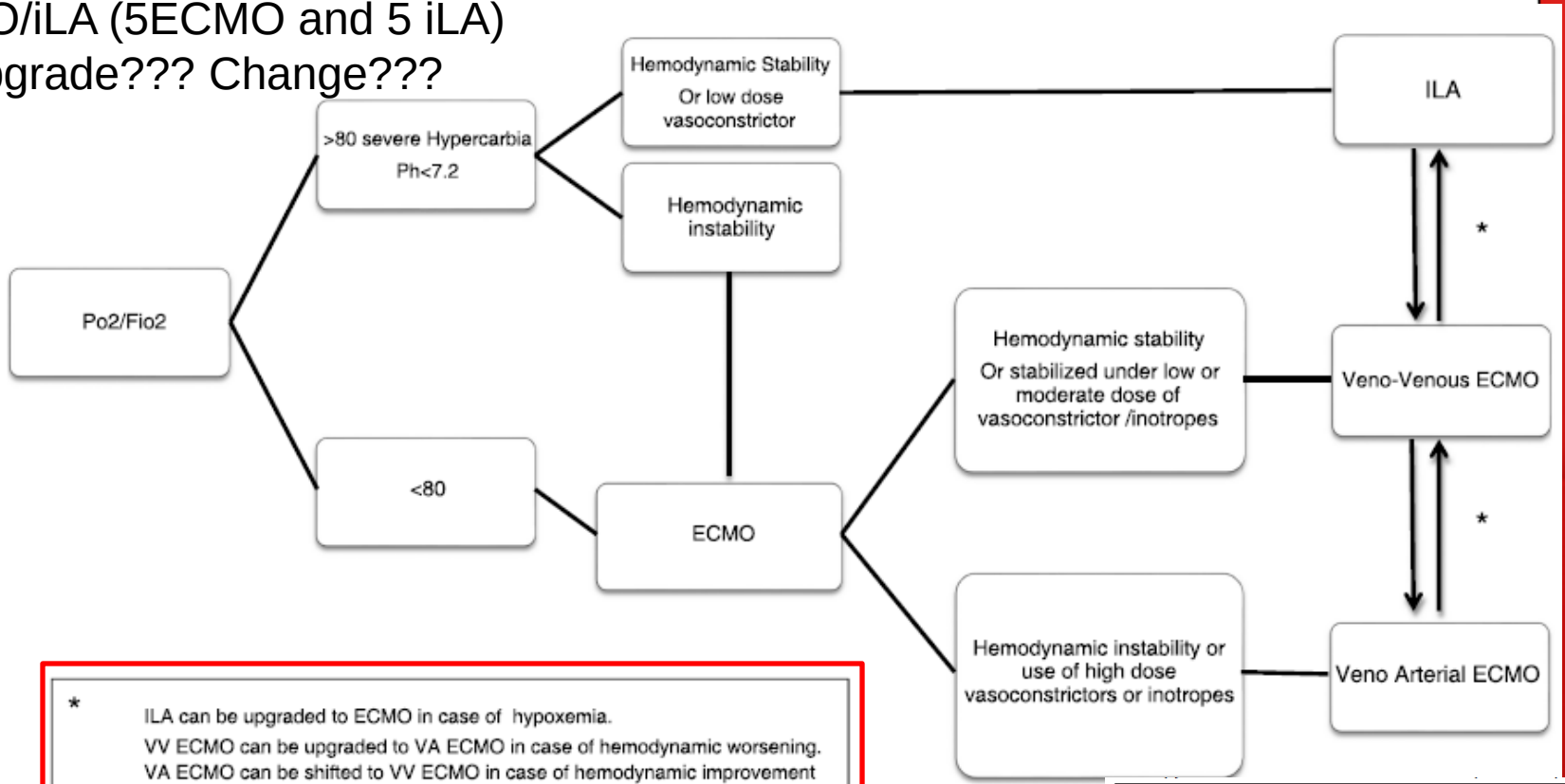


Figure 1. Decision making flow chart.

	Arterial Blood Gases			Time From Injury to Support, d
	Pao_2/FIO_2	$Paco_2$, mm Hg	pH	
ECMO	62 (35–82)	62 (48–95)	7.21 (7.05–7.28)	3 (1–7)
iLA	92 (78–140)	85 (65–150)	7.12 (6.9–7.7.25)	5 (3–8)

ECMO

✓ INDICATION

- Acute, severe, cardiac or pulmonary failure unresponsive to optimal management, with recovery expected in 2-4 weeks.

✓ CONTRAINDICATION

BJA British Journal of Anaesthesia
Volume 113. Issue 6
Pp. 1058-1059.

Table 1 Multivariate analysis (multivariate logistic regression stepwise model) of significant predictors associated with ECLS failure revealed by univariate analysis. ISS, injury severity score; SEM, standard error of arithmetic mean; CI, confidence interval

Patient' s data	Regression coefficient	SEM	Odds ratio	95% CI	P-value
ISS>63	1.45273	0.1754	4.2748	1.373–13.314	0.0407
pH<7.01 (mean of last 3 evaluations)	1.97044	0.1716	7.1738	2.480–20.752	0.0137
Blood lactates >14.4 mmol litre^{-1} (mean of last 3 evaluations)	2.52623	0.69933	12.5063	4.473–34.974	0.0251

ECMO

✓ CONTRAINDICATION

Currently ?
Bridge to transplant
Donor management

??? ContrIx ➔ Ix

Malignancy

Irreversible pulmonary fibrosis

Severe LV dysfunction

PIP > 30cmH_2O or FiO_2> 0.8 for 7days

ContraIx to heparinization, Bleeding disorder

CNS damage, Severe brain injury

etc.

ECMO

Is it useful in trauma patients? Limited by

- ✓ The risk of hemorrhage during/after cannulation in the presence of consumption coagulopathy
- ✓ Contraindications to the anticoagulation treatment recommended during ECMO
- ✓ Decreased venous return secondary to packing of the abdomen during damage-control surgery
- ✓ The risk of secondary intracranial hemorrhage following traumatic brain injury (TBI).

Rescue extracorporeal membrane oxygenation in a young man with a stab wound in the chest

Giuseppe Gatti[a,*], Gabriella Forti[a], Alessandro Bologna[a], Gianfranco Sagrati[a], Gianfranco Gustin[a], Renata Korcova[b], Elisabetta Benci[c], Luca Visintin[d]

[a] Department of Cardiac Surgery, Ospedali Riuniti, Trieste, Italy
[b] Department of Cardiology, Ospedali Riuniti, Trieste, Italy
[c] Department of Thoracic Surgery, Ospedali Riuniti, Trieste, Italy
[d] Department of Emergency, Ospedali Riuniti, Trieste, Italy

Injury, Int. J. Care Injured 45 (2014) 1509–1511

ABSTRACT

A 27-year-old man with haemorrhagic shock and acute cardiac tamponade due to a stab in the chest underwent successful resuscitation and surgical repair of the right ventricular perforation thanks to the use of extracorporeal membrane oxygenation (ECMO) in the emergency department. To the best of the authors' knowledge, this is the first report around the use of ECMO to rescue a victim of a penetrating cardiac trauma. The physicians who have portable ECMO device should be aware of this option when a life-threatening internal bleeding in haemodynamically unstable patients could be quickly controlled by surgery, even if performed in ill-suited settings.

V-A ECMO
in Emergency department

ECMO

Extracorporeal membrane oxygenation in severe trauma patients with bleeding shock☆

Matthias Arlt*, Alois Philipp, Sabine Voelkel, Leopold Rupprecht, Thomas Mueller, Michael Hilker, Bernhard M. Graf, Christof Schmid

University Hospital Regensburg, Germany

Resuscitation 81 (2010) 804–809

Aim of the study: Death to trauma is caused by disastrous injuries on scene, bleeding shock or acute respiratory failure (ARDS) induced by trauma and massive blood transfusion. Extracorporeal membrane oxygenation (ECMO) can be effective in severe cardiopulmonary failure, but preexisting bleeding is still a contraindication for its use. We report our first experiences in application of initially heparin-free ECMO in severe trauma patients with resistant cardiopulmonary failure and coexisting bleeding shock retrospectively and describe blood coagulation management on ECMO.

Methods: From June 2006 to June 2009 we treated adult trauma patients ($n = 10$, mean age: 32 ± 14 years, mean ISS score 73 ± 4) with percutaneous veno-venous (v-v) ECMO for pulmonary failure ($n = 7$) and with veno-arterial (v-a) ECMO in cardiopulmonary failure ($n = 3$). Diagnosis included polytrauma ($n = 9$) and open chest trauma ($n = 1$). We used a new miniaturised ECMO device (PLS-Set, MAQUET Cardiopulmonary AG, Hechingen, Germany) and performed initially heparin-free ECMO.

Results: Prior to ECMO median oxygenation ratio (OR) was 47 (36–90) mmHg, median $paCO_2$ was 67 (36–89) mm Hg and median norepinephrine demand was 3.0 (1.0–13.5) mg/h. Cardiopulmonary failure was treated effectively with ECMO and systemic gas exchange and blood flow improved rapidly within 2 h on ECMO in all patients (median OR 69 (52–263) mm Hg, median $paCO_2$ 41 (22–85) mm Hg. 60% of our patients had recovered completely.

Conclusions: Initially heparin-free ECMO support can improve therapy and outcome even in disastrous trauma patients with coexisting bleeding shock.

ECMO

As a rescue therapy

Rapid action to make ECMO therapy possible

AOTIC CROSS CLAMP

(ACC)

ACC

Blood volume redistribution during ACC

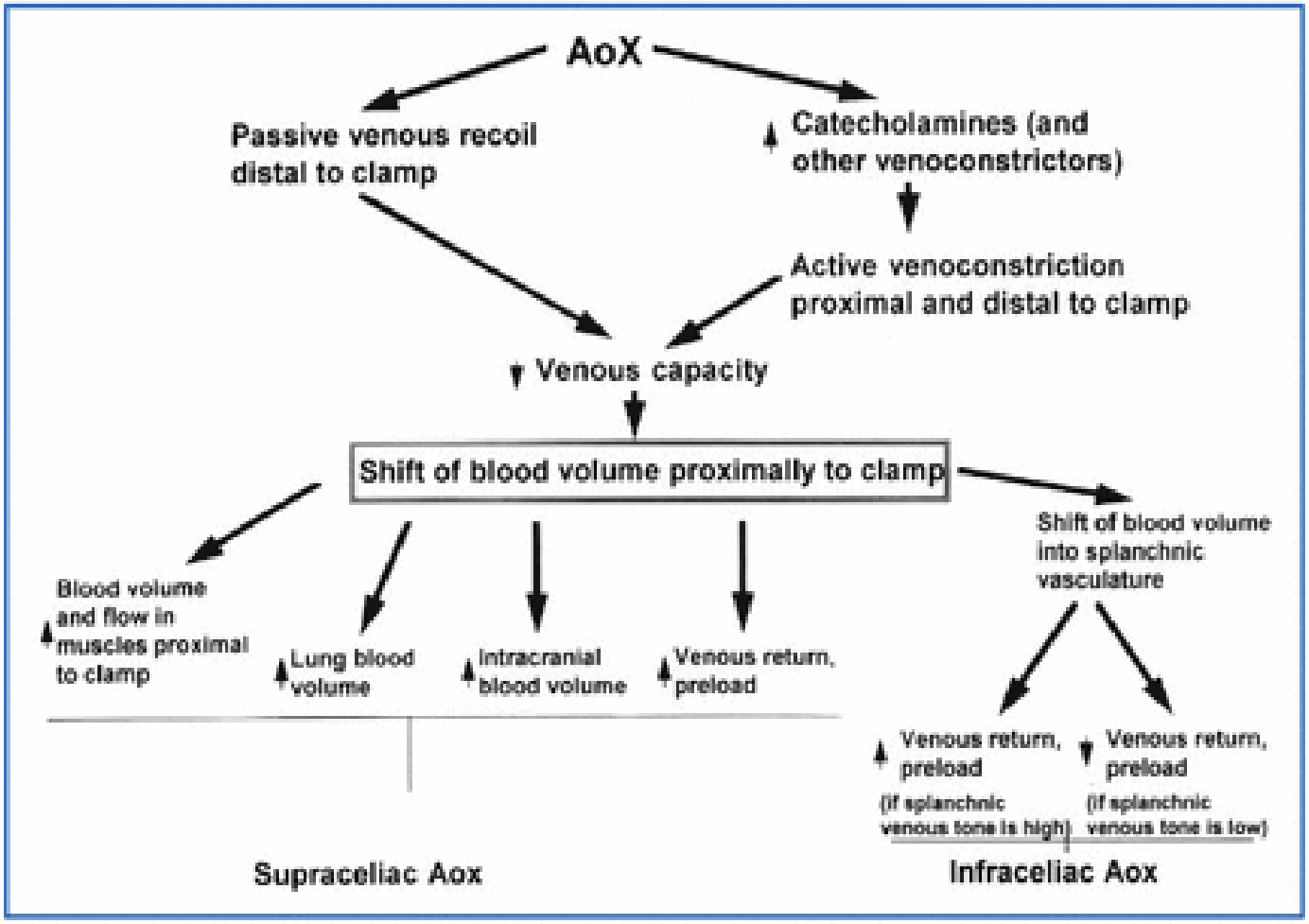
- ✓ Descending thoracic aorta is used routinely
- ✓ Redistribution blood flow to the coronary vessels, lungs and brain
- ✓ To reduce exsanguination from injuries in the lower torso
- ✓ Clamp time: 30 minutes or less because of organ ischemia including spinal cord
- ✓ Removal of clamp → reperfusion injuries

ACC

Cuzick LM et al. Pathophysiology of Aortic Cross-clamping. Thoraco-Abdominal Aorta 2011, pp 65-72

Blood volume redistribution during ACC

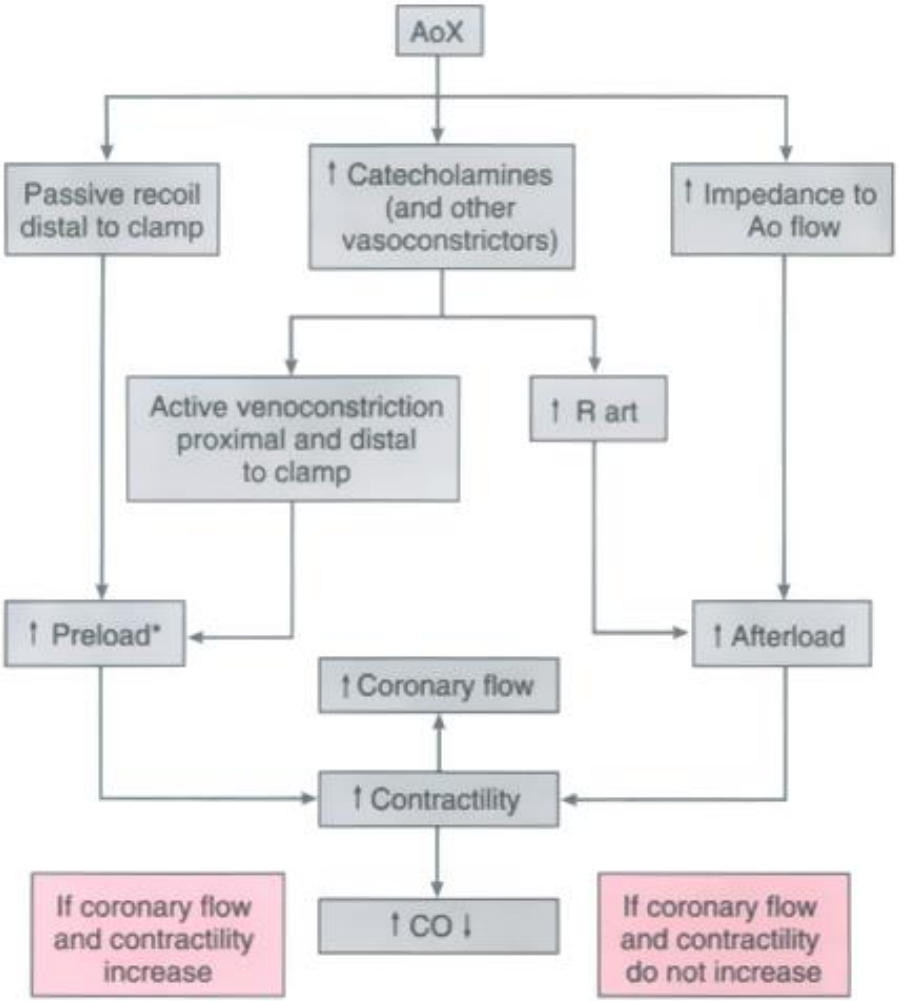
Fig. 6.1 Blood volume redistribution during aortic cross-clamping (*AoX*). The resulting decrease in venous capacity changes the distribution of blood volume between the portions of the vasculature that are proximal and distal to the clamp site. If the aorta is clamped above the splanchnic system, the blood volume travels to the heart, increasing preload and blood volume in all organs and tissues proximal to the clamp. However, if the aorta is clamped below the splanchnic system, blood volume may shift into the splanchnic system or into the vasculature of other tissues proximal to the clamp, depending upon the splanchnic vascular tone. The distribution of this blood volume between the splanchnic and non-splanchnic vasculature determines changes in preload. Reproduced from [1], with permission



ACC

Gelman S. et al. The pathophysiology of aortic cross-clamping and unclamping. Anesthesiology1995; 82:1026–1060.

Systemic hemodynamic response to ACC

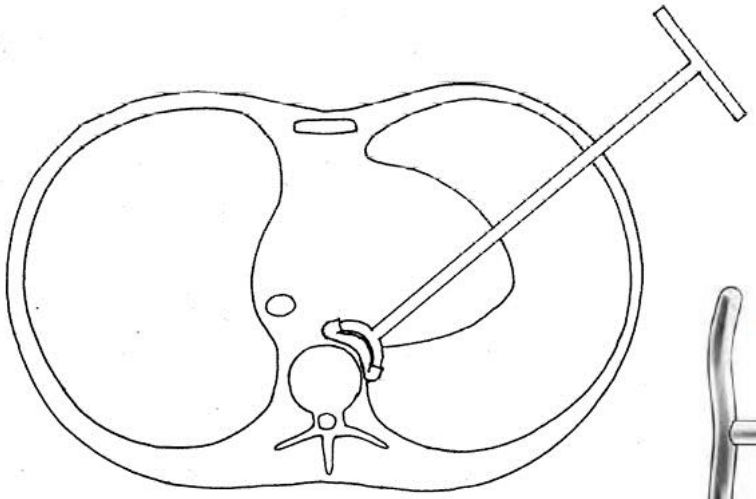


ACC

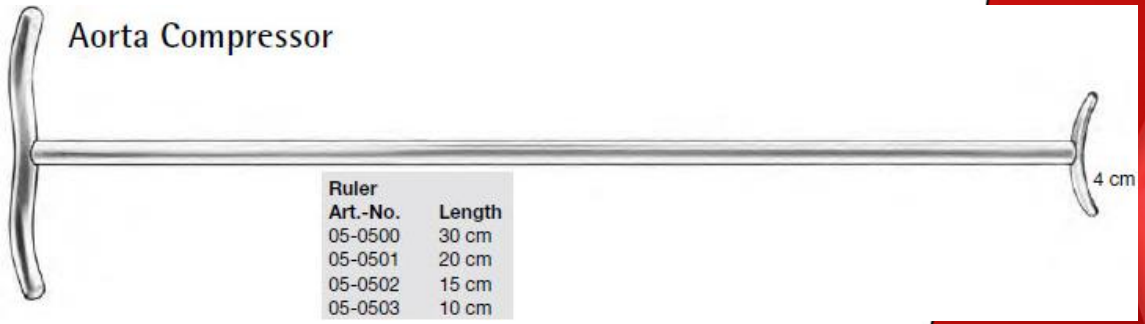
- ✓ **Ideal level: diaphragm**

  (to maximise spinal cord perfusion)

- ✓ **Just below the left pulmonary hilum.**



Ruiz aortic compressor pressing the descending thoracic aorta against the vertebral column



ACC

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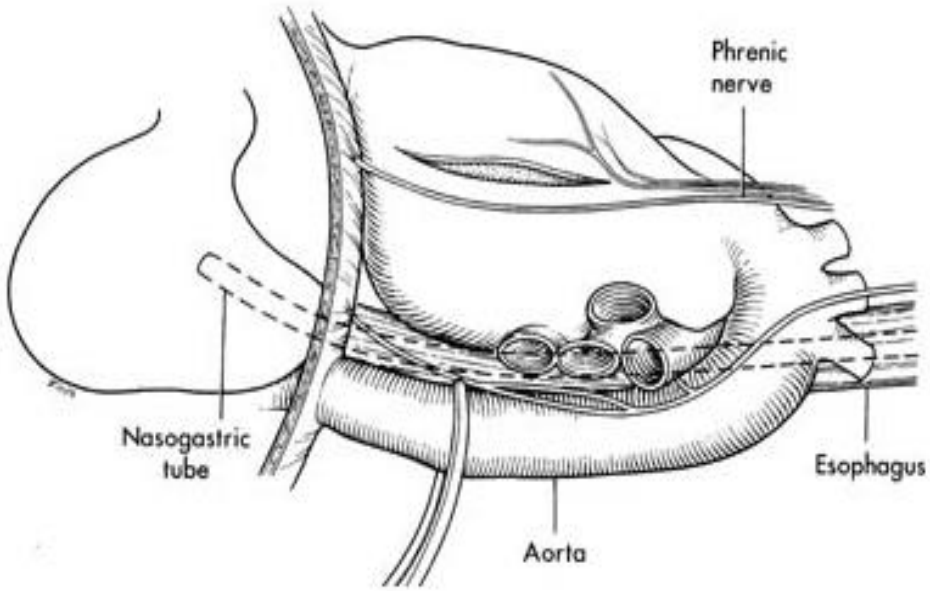
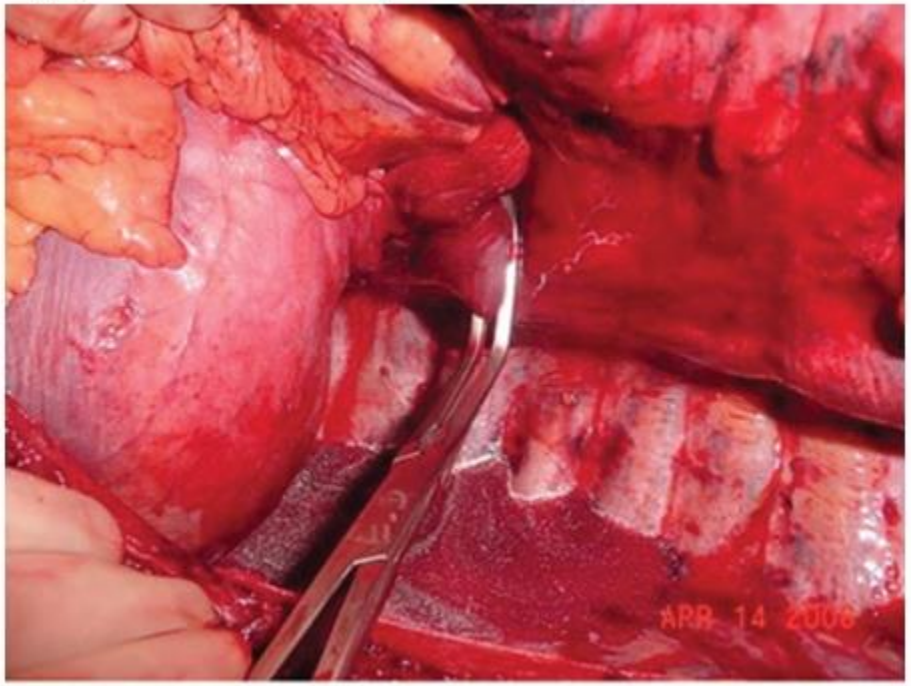




RESUSCITATIVE ENDOVASCULAR BALLOON OCCLUSION OF THE AORTA (REBOA)

REBOA

- **Resuscitative aortic occlusion with a balloon**
  - **– as early as the Korean War**

  (Hughes CW et al. Use of an intra-aortic balloon catheter tamponade for controlling intraabdominal hemorrhage in man. Surgery. 1954;36:65–68.)
- **Fomoral arterial line**
- **Percutaneously or Open femoral a. cut down**
- **Ultrasound or Direct surgical identification**
- **Thoraco-abdominal injuries, pelvic injuries**

REBOA

Sequence of steps, REBOA

Stannard A, et al. Resuscitative Endovascular Balloon Occlusion of the Aorta(REBOA) as an Adjunct for Hemorrhagic Shock J Trauma. 2011 Dec;71(6):1869-72

TABLE 1. Sequence of Steps for Performance of REBOA Along With Technical Considerations, Potential Hazards, and Maneuvers to Reduce the Risk of Complication

Steps	Options	Considerations	Hazards	Measure to Avoid
Arterial access	Ultrasound-guided percutaneous	18-gauge hollow needle and 0.035-inch wire into common femoral artery. The initial sheath is 5–8 Fr and 8–15 cm long; considered as the initial sheath	High (proximal) entry into iliac artery or low (distal) entry into superficial femoral artery Assuming groin crease is the inguinal ligament Inadvertent entry into venous system	Draw line marking the inguinal ligament and access artery 1 cm below this line Ultrasound-guided access to artery, identification of pulsatile blood return, or direct visualization of artery via open cut down
	Open exposure (cut down) Use of existing arterial line	Line between anterior superior iliac spine and pubic tubercle marks the inguinal ligament and proximal common femoral artery		
Balloon selection and positioning	Position with fluoroscopic guidance to aortic zone I or III	Preceded by placement of long (260 cm) working wire into the aortic arch	Inadvertent movement of stiff wire too proximal or distal risking injury to aortic root or carotid arteries	Fluoroscopic guidance and marking of length of wire outside of entry site when in desired position
		Followed by removal of the initial sheath and placement of large diameter long sheath over this wire		"Pin" or secure wire to prevent advancement or withdraw as devices are positioned over its axis
		Finally, large diameter, compliant balloon is placed over wire under fluoroscopic guidance		Create generous skin opening around the wire entry site with scalpel
Balloon inflation	Inflate with fluoroscopic guidance using mixture of contrast and saline	Inflate balloon until it adopts the aortic wall profile and then stop and turn stopcock to maintain inflation	Overinflation of balloon and damage to aortic wall	Inflate under fluoroscopic observation and stop when balloon adopts the aortic wall profile
		Inflation and balloon occlusion may result in dramatic increase in central aortic pressure	Distal migration of balloon, sheath, and wire with pulsation against the inflated balloon	Assign an assistant to secure apparatus in desired location and communicate arterial pressure
Balloon deflation	Turn stopcock and deflate balloon port	Deflate slowly after communication with anesthesia and members of resuscitation team	Profound hypotension Loss of desired balloon and wire position	Slow or gradual deflation in communication with resuscitation team being prepared to reinflate the balloon to support central pressure
Sheath removal	Open exposure or cut down on sheath entry site	Proximal and distal control above and below the sheath entry site and closure with 5-0 or 6-0 monofilament following its removal	Loss of arterial control upon removal Ineffective arterial closure	Wide proximal and distal exposure and arterial control to allow safe, hemostatic removal and effective sheath removal and arterial closure

REBOA

Stannard A, et al. Resuscitative Endovascular Balloon Occlusion of the Aorta(REBOA) as an Adjunct for Hemorrhagic Shock J Trauma. 2011 Dec;71(6):1869-72

Examples of Tools

Zone 1 is measured to the xiphoid, Zone 3 is measured to just above the umbilicus. Measure at the proximal portion of the balloon

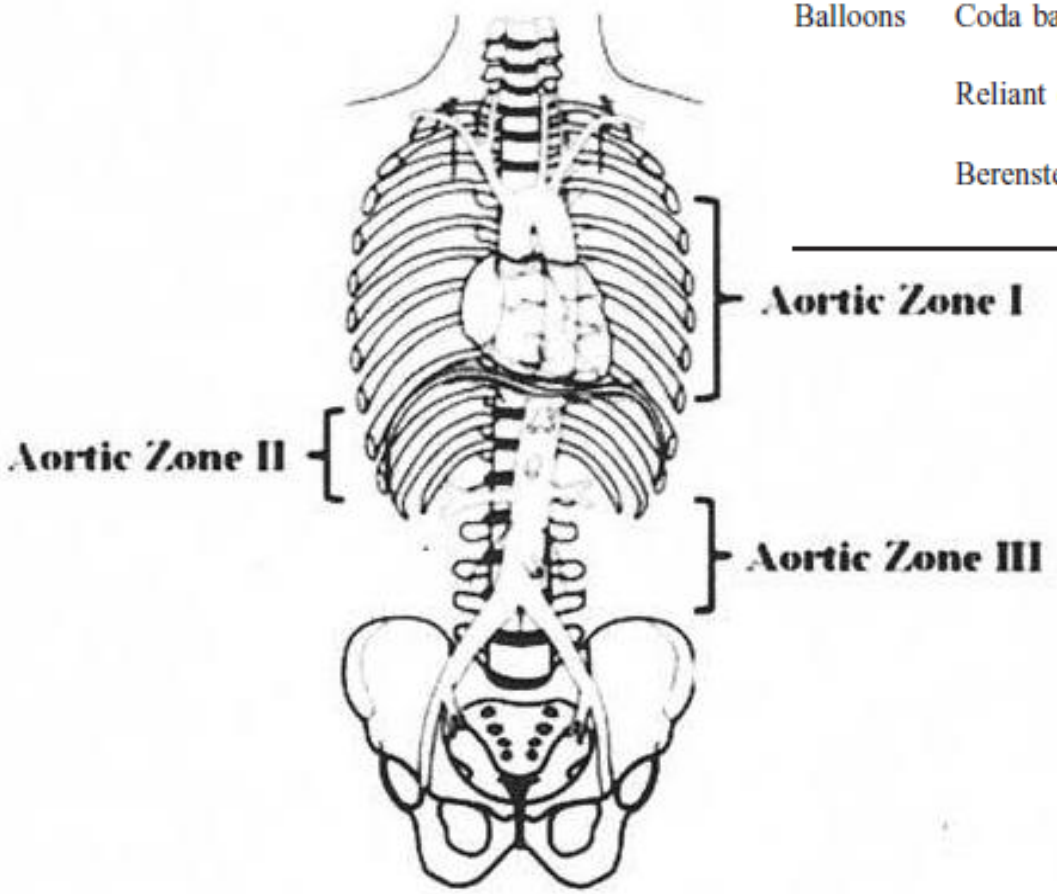


TABLE 2. Examples of Endovascular Tools (Wires, Sheaths, and Balloons) Used To Accomplish REBOA

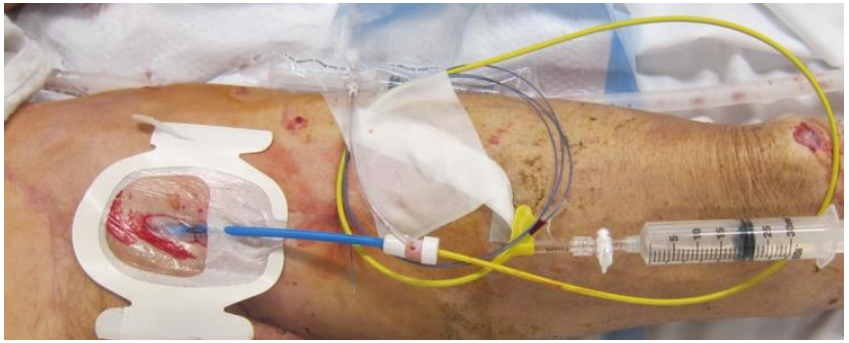
	Description	Size	Length (cm)
Wire	Amplatz Stiff Wire Guide (Cook Medical)	0.035 inch	260
Sheaths	Initial (starter)	5–6 Fr	8–15
	Delivery and support	12–14 Fr	45–60
Balloons	Coda balloon (Cook Medical)	14 Fr (32–40 mm diameter)	120
	Reliant (Medtronic)	12 Fr (10–46 mm diameter)	100
	Berenstein (Boston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

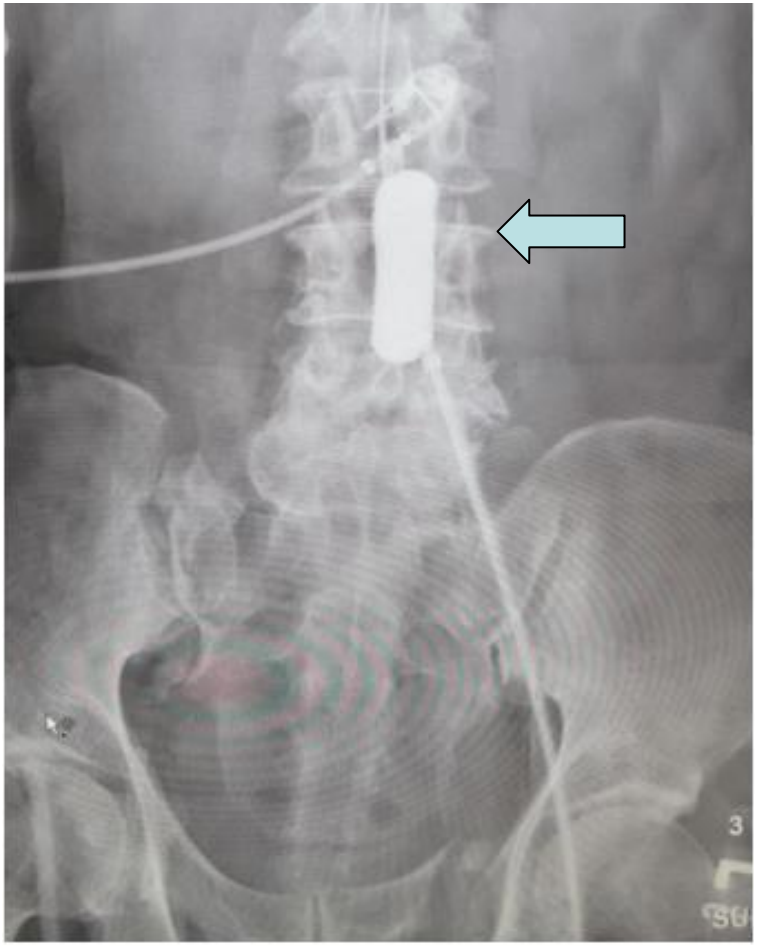
Zone 1 = Origin of left subclavian artery to the celiac artery

Zone III = Lowest renal artery to aortic bifurcation

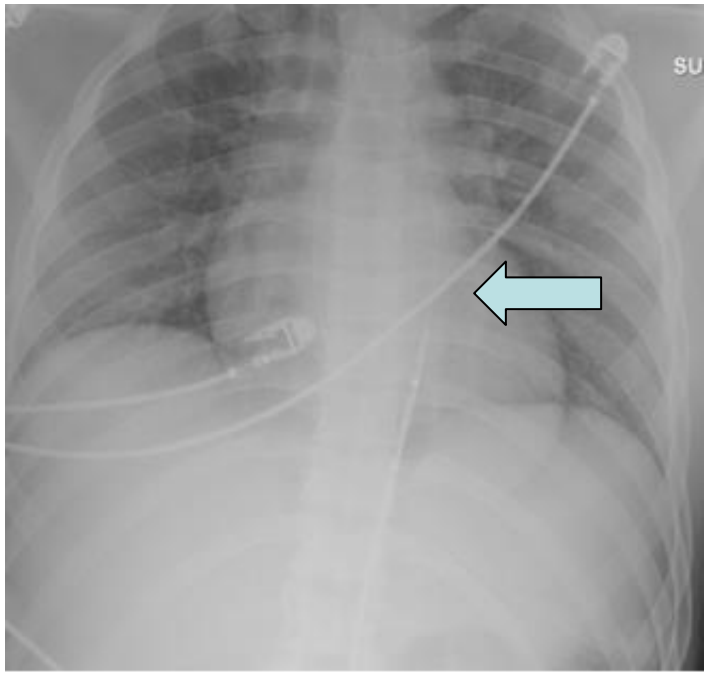
REBOA

Inflation and Securing





Balloon in Zone-3



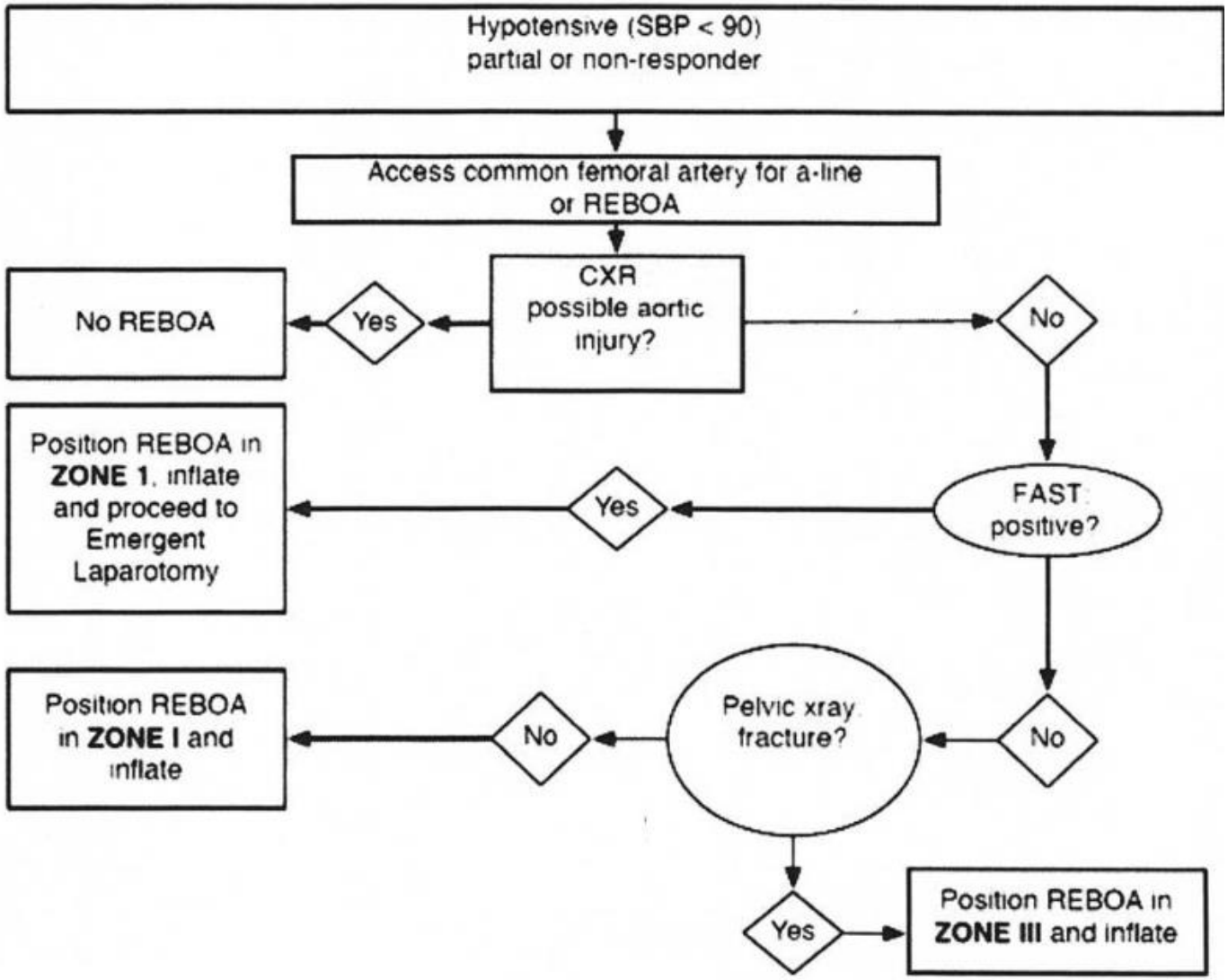
Balloon in Zone-1

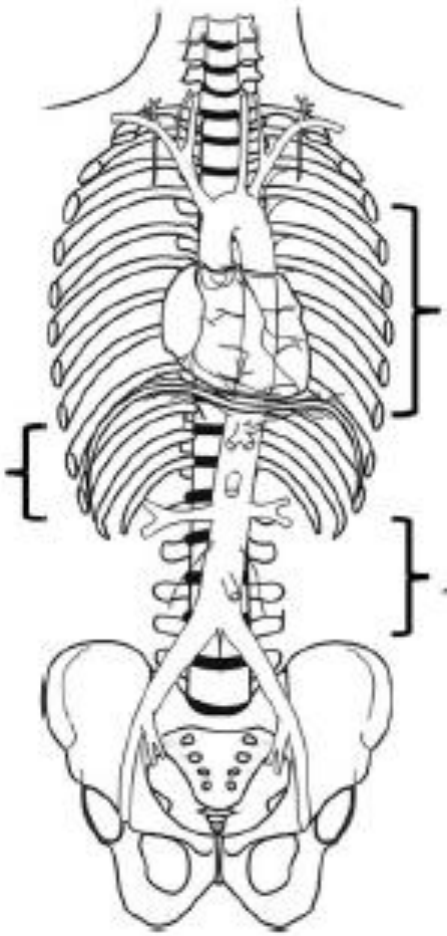
- ✓A large-volume syringe (usually 30–60 mL)
- ✓ Filled with a 1/2 and 1/2 solution of sterile saline and iodinated contrast.
- ✓Use just saline if contrast not available

REBOA

Brenner M et al. Basic Endovascular Skills for Trauma Course: Bridging the Gap between Endovascular Techniques and the Acute Care Surgeon J Trauma and Acute Care Surg. 2014 77(2):286-91

Shock Trauma Center Protocol





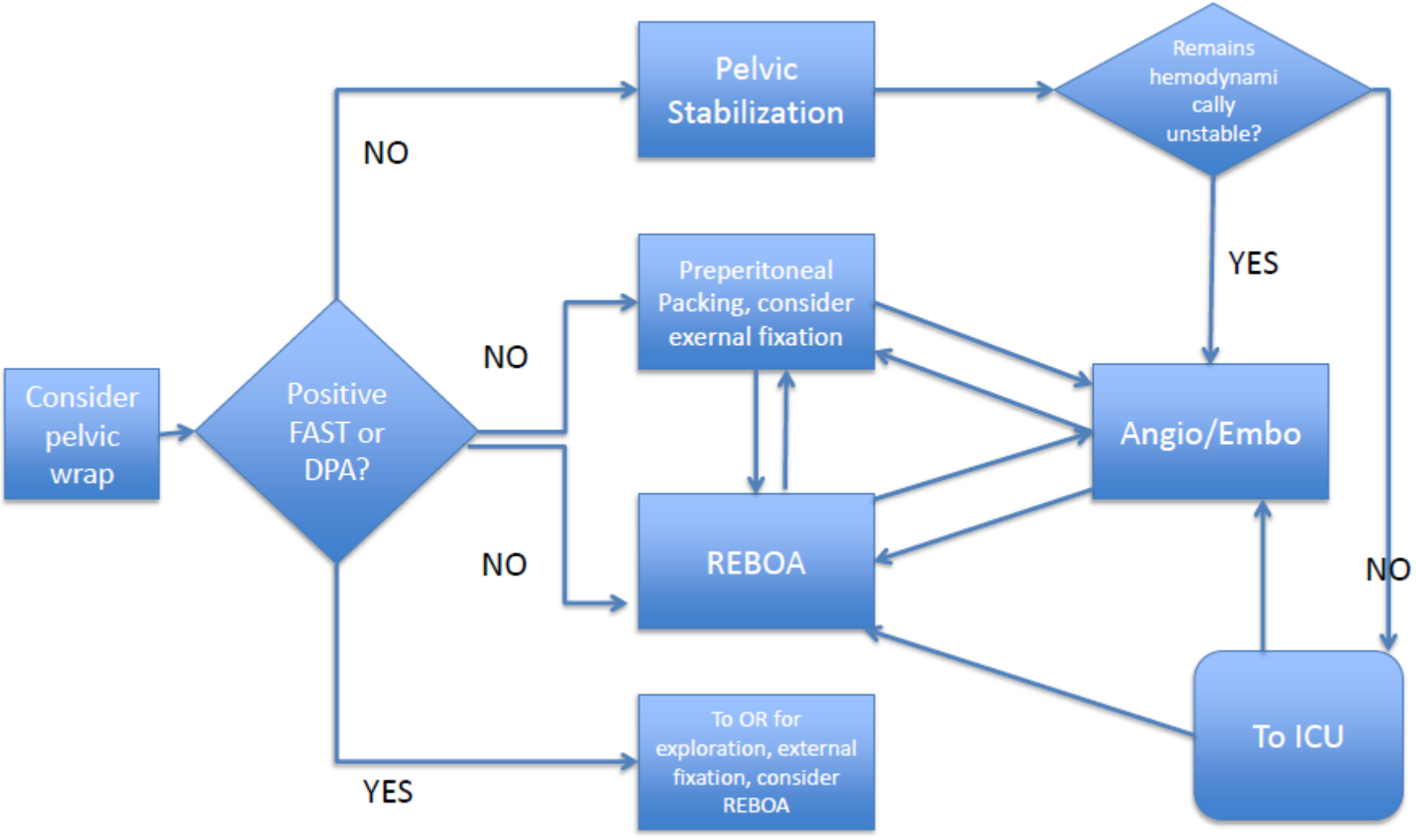
REBOA

Physicians of all specialties committed to improving trauma care

Western Trauma Association

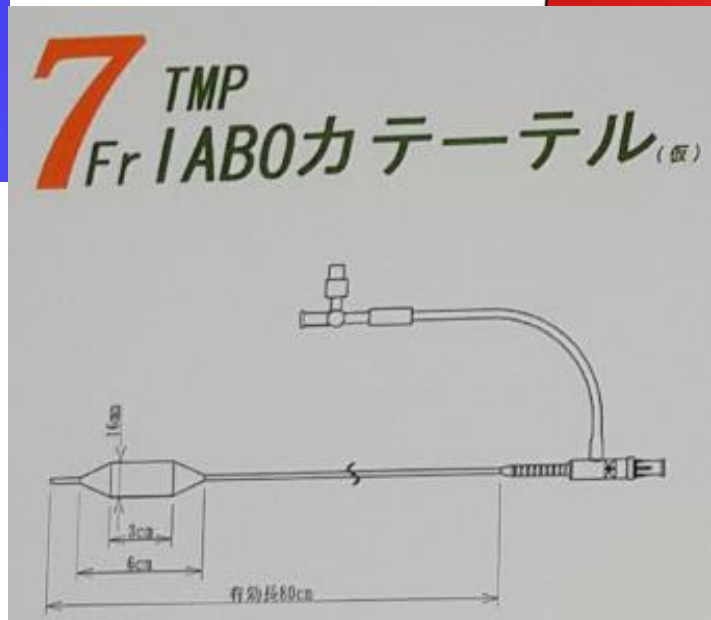
ALGORITHMS TO BE PRESENTED AT THE 2015 WTA MEETING

Expanded from zoomed area of Davis algorithm. Decisions will be based on local resources.



REBOA

Basic Endovascular Skills for Trauma Course



Pre-hospital REBOA

- ✓ Zone III REBOA is indicated
- ✓ Blunt trauma pts with suspected pelvic fracture
- ✓ Penetrating injury to the pelvic or groin area
- ✓ Uncontrolled hemorrhage from lower limb

(any constrictive device)

Pre-hospital REBOA

HEMORRHAGIC SHOCK & MANAGEMENT

How Can I Do That???.

- ✓ Trauma Team Activation, Multidisciplinary approach
- ✓ Transfusion and fluid resuscitation
- ✓ Considering of all therapeutic modalities
- ✓ Indication
- ✓ Early decision
- ✓ Experience
- ✓ Do not hesitate
- ✓ Rapid action to make appropriate therapy possible

ARDS in trauma

울산대학교의과대학

울산대학교병원

김 정 원

ULSAN UNIVERSITY HOSPITAL

Acute Respiratory Distress Syndrome

- A Clinical Syndrome of Severe Dyspnea of
  - Rapid onset
  - Hypoxemia
  - Diffuse Pulmonary Infiltrates

  leading to **Respiratory Failure**

Acute Respiratory Distress Syndrome

- Traumatic wet lung (1945)

  (Burford TH et al.)

- Acute respiratory distress in adults (1967)

  (Ashbaugh DG et al.)

- Adult respiratory distress syndrome (1971)

  (Petty TL & Ashbaugh DG)

- Acute respiratory distress syndrome (1994)

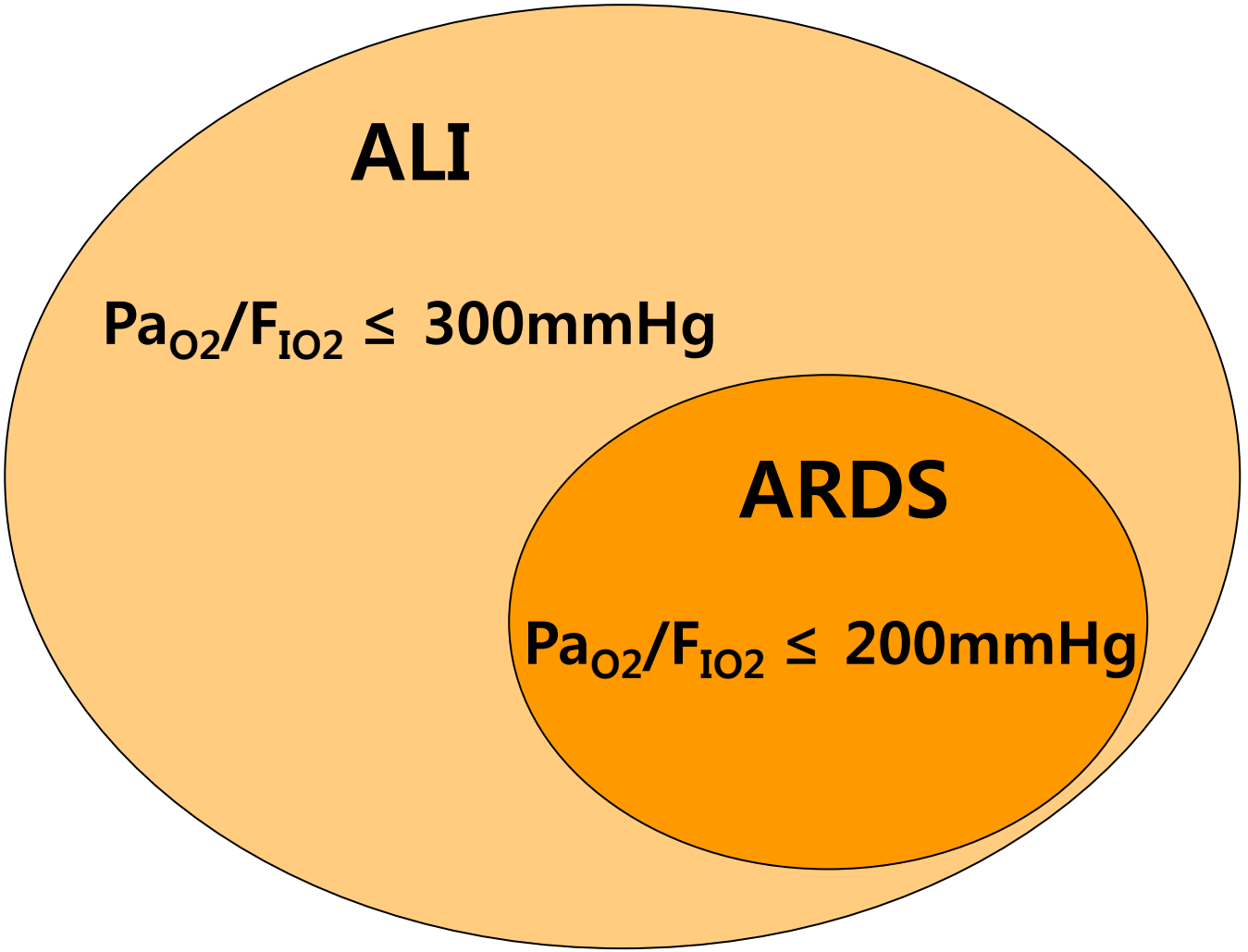
  (The American-European Consensus Conference on ARDS)

Recommended criteria for ARDS and ALI

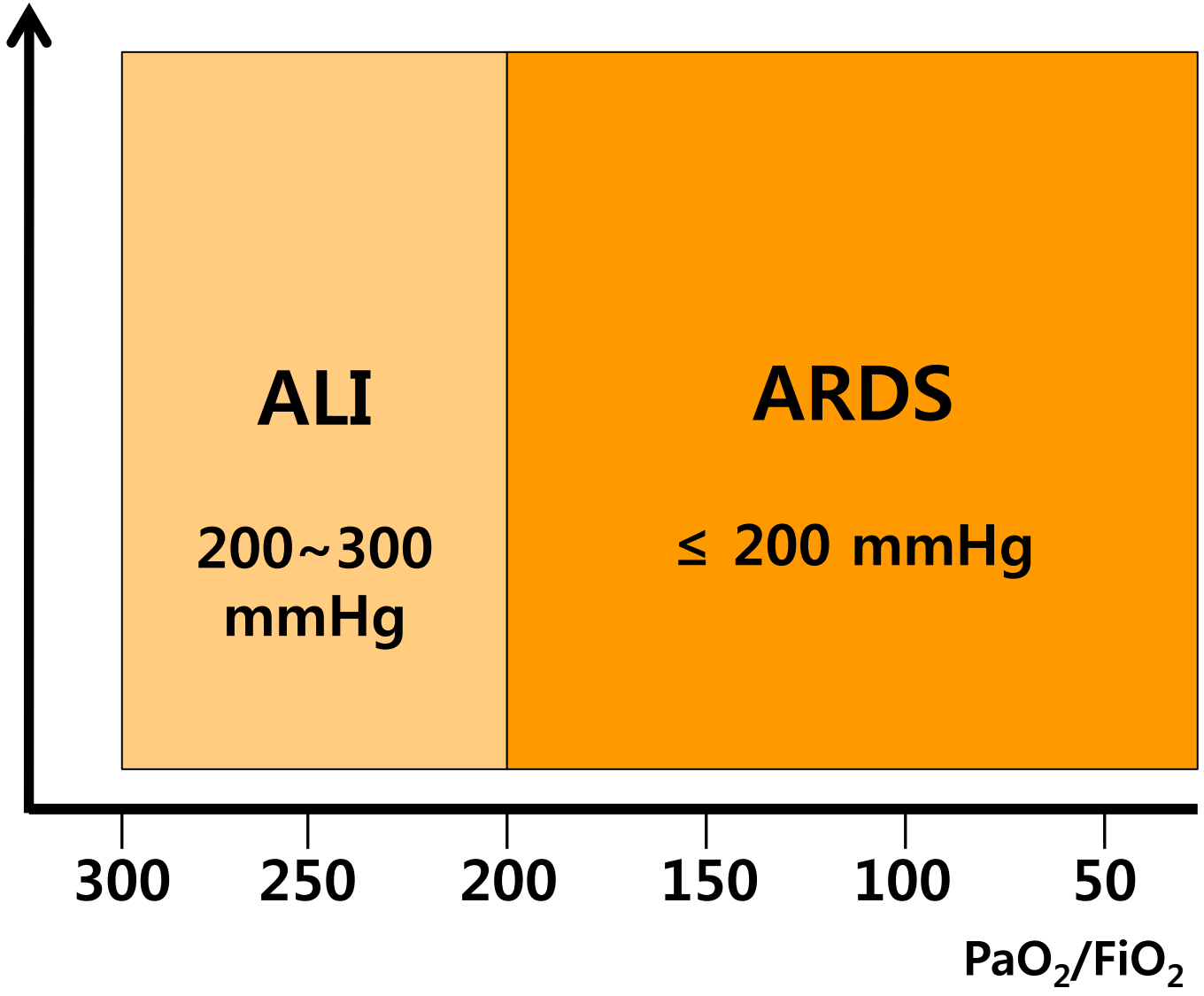
The American- European Consensus Conference on ARDS (AECC definition, 1994)

	Timing	Oxygenation	Chest X-ray	PAOP
ALI Criteria	Acute onset	$Pa_{O2}/F_{IO2} \leq 300$mmHg (regardless of PEEP level)	Bilateral infiltrates	≤18 mmHg (no clinical evidence of left atrial hypertension)
ARDS Criteria	Acute onset	$Pa_{O2}/F_{IO2} \leq 200$mmHg (regardless of PEEP level)	Bilateral infiltrates	≤18 mmHg (no clinical evidence of left atrial hypertension)

ALI and ARDS by AECC definition



ALI and ARDS by AECC definition



Concerns over the ARDS definition

- The defining statements are not specific
- The meaning of "acute" is not clear
- Chest radiograph parameters also are not standardized
- It is difficult to rule out patients who have volume overload

Epidemiology

- 10 ~15 % of pts admitted to an ICU
- ≥ 20 % of mechanically ventilated pts meet criteria for ARDS
- The mortality rate varies with cause : 40 %
- Most patients dying of MOF rather than isolated respiratory insufficiency

Common Risk Factors for ARDS

Direct	Indirect
Pneumonia	Nonpulmonary sepsis
Aspiration of gastric contents	Trauma, nonthoracic
Inhalation injury	Pancreatitis
Pulmonary contusion	Severe burns
Pulmonary vasculitis	Noncardiogenic shock
Near drowning	Drug overdose
	Multiple transfusions or transfusion-associated acute lung injury (TRALI)

Pathogenesis

- Direct insult (Pulmonary ARDS)
  - 1st injured structure : pulmonary epithelium

  → Activation of Alv Macrophage inflammation network

  → Alveolar flooding

  → ↓ Removal of edema fluid (loss of EP cell integrity)

  → ↓ Surfactants (type II cell loss)

  → Fibrosis

Pathogenesis

- Indirect insult (Extra-Pulmonary ARDS)
  - Mediators release from extra-pulmonary foci

  → Main target damage: pulmonary endothelial cell

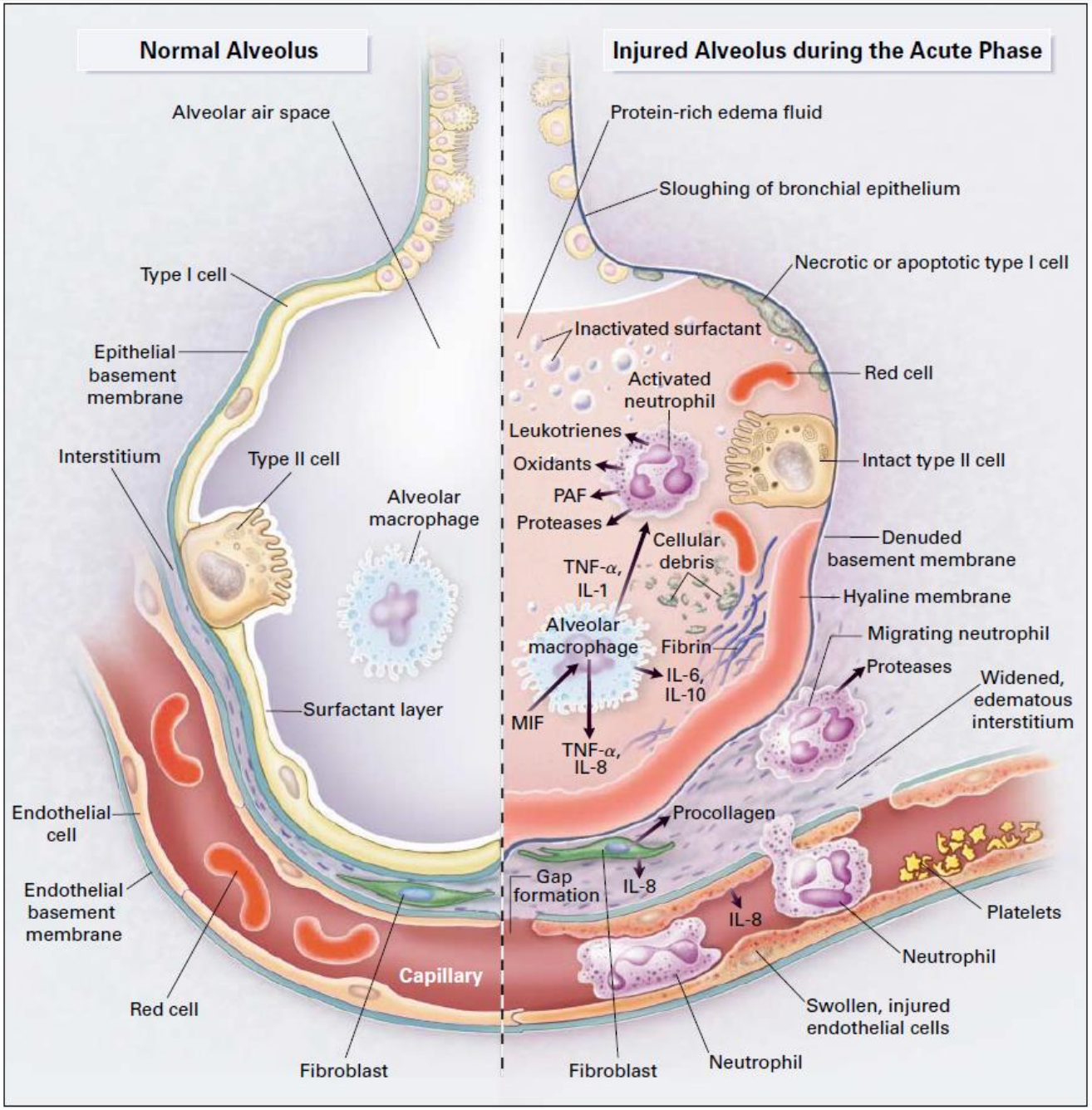
  → ↑ Permeability of endothelial cell barrier

  → Activation of inflammatory network

  → Microvascular congestion, interstitial edema

  → Relative sparing of intra-alveloar spaces
- Direct and Indirect insult can coexist
  - One lung pneumonia

  → The other lung is indirectly injured



N Engl J Med 2000;342:1334-1349

SPECIAL COMMUNICATION

ONLINE FIRST

Acute Respiratory Distress Syndrome
The Berlin Definition

The ARDS Definition Task Force*

JAMA. 2012;307(23):2526-2533
Published online May 21, 2012.

Berlin Definition Draft

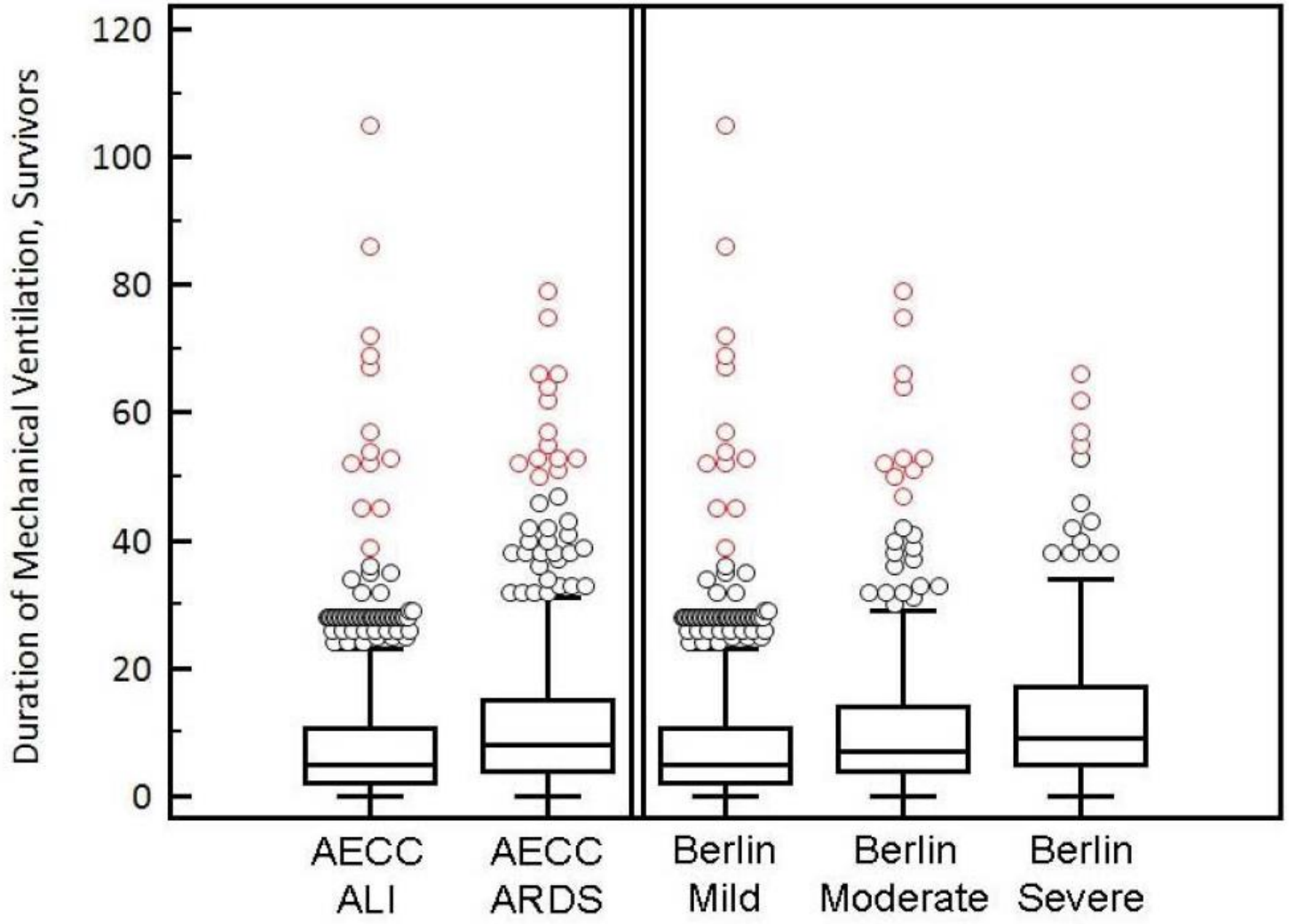
	Mild	Moderate	Severe
Timing	Acute onset within 1 week of a known clinical insult or new/worsening respiratory symptoms		
Hypoxemia	PaO_2/FiO_2: **201-300** with **PEEP/CPAP ≥ 5**	PaO_2/FiO_2 **≤ 200** with **PEEP ≥ 5**	PaO_2/FiO_2 **≤ 100** with **PEEP ≥ 10**
Origin of Edema	Respiratory failure not fully explained by cardiac failure or fluid overload**		
Radiological Abnormalities	Bilateral opacities*	Bilateral opacities*	Opacities involving at least 3 quadrants*
Additional Physiological Derangement	N/A	N/A	$V_{E\ Corr}$ > 10 L/min or C_{RS} < 40ml/cmH_2O

* **Not fully explained by effusions, nodules, masses, or lobar/lung collapse; use training set of CXR_S**

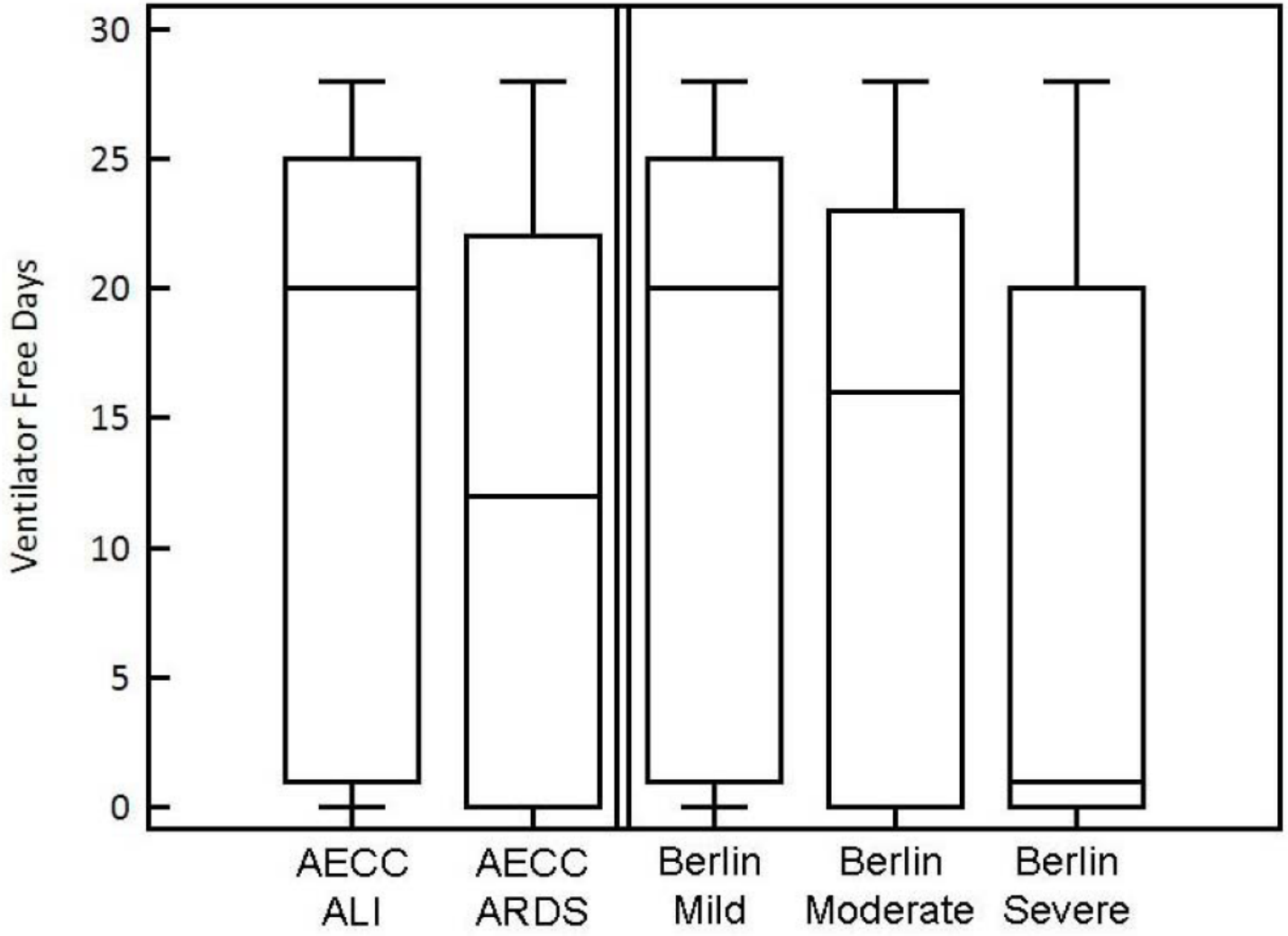
** **Need objective assessment if no risk factor present (See table)**

$V_{E\ Corr}$ = V_E x PaCO2/40 (corrected for Body Surface Area)

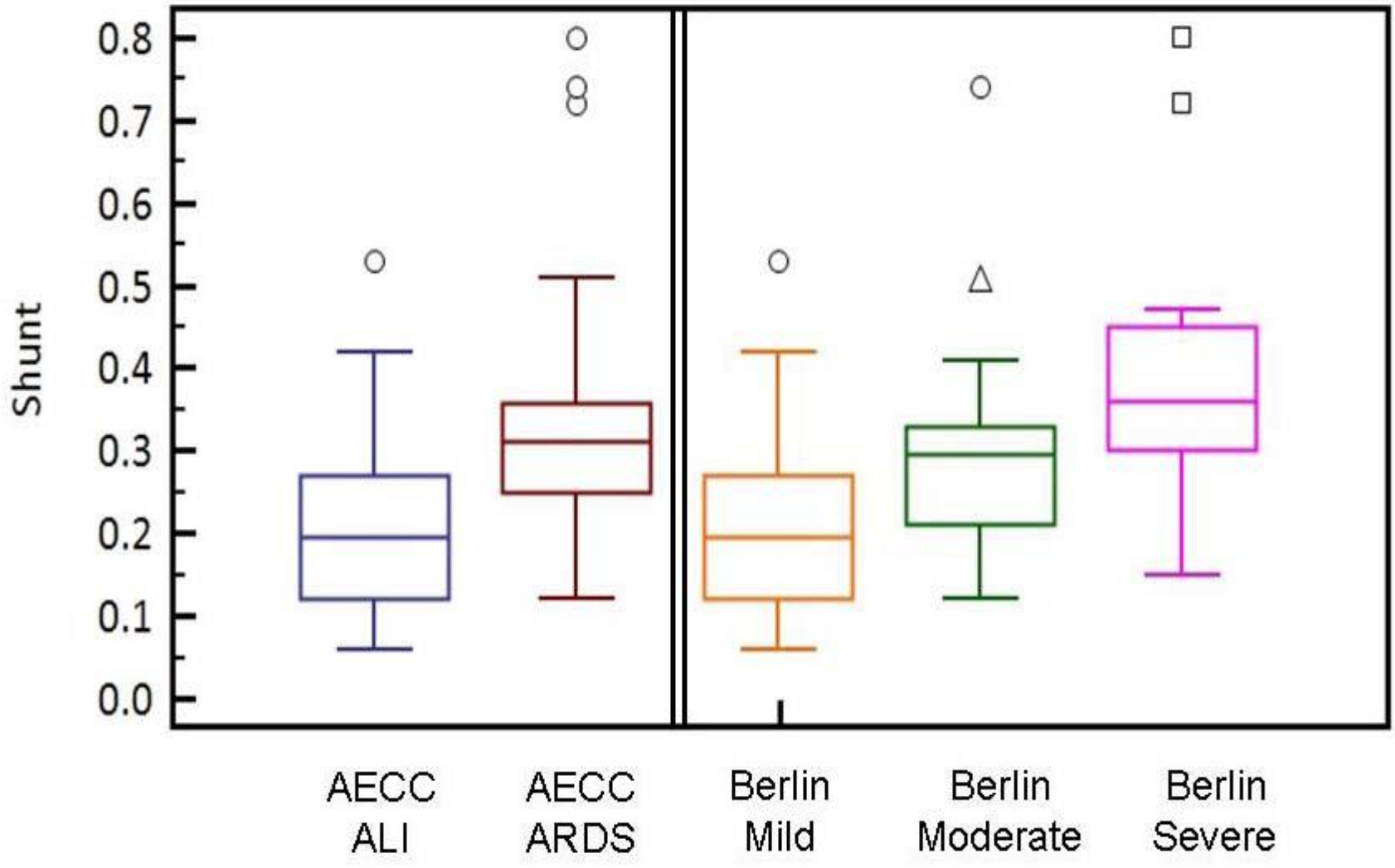
Duration of Mechanical Ventilation in Survivors in AECC and Berlin ARDS Definitions



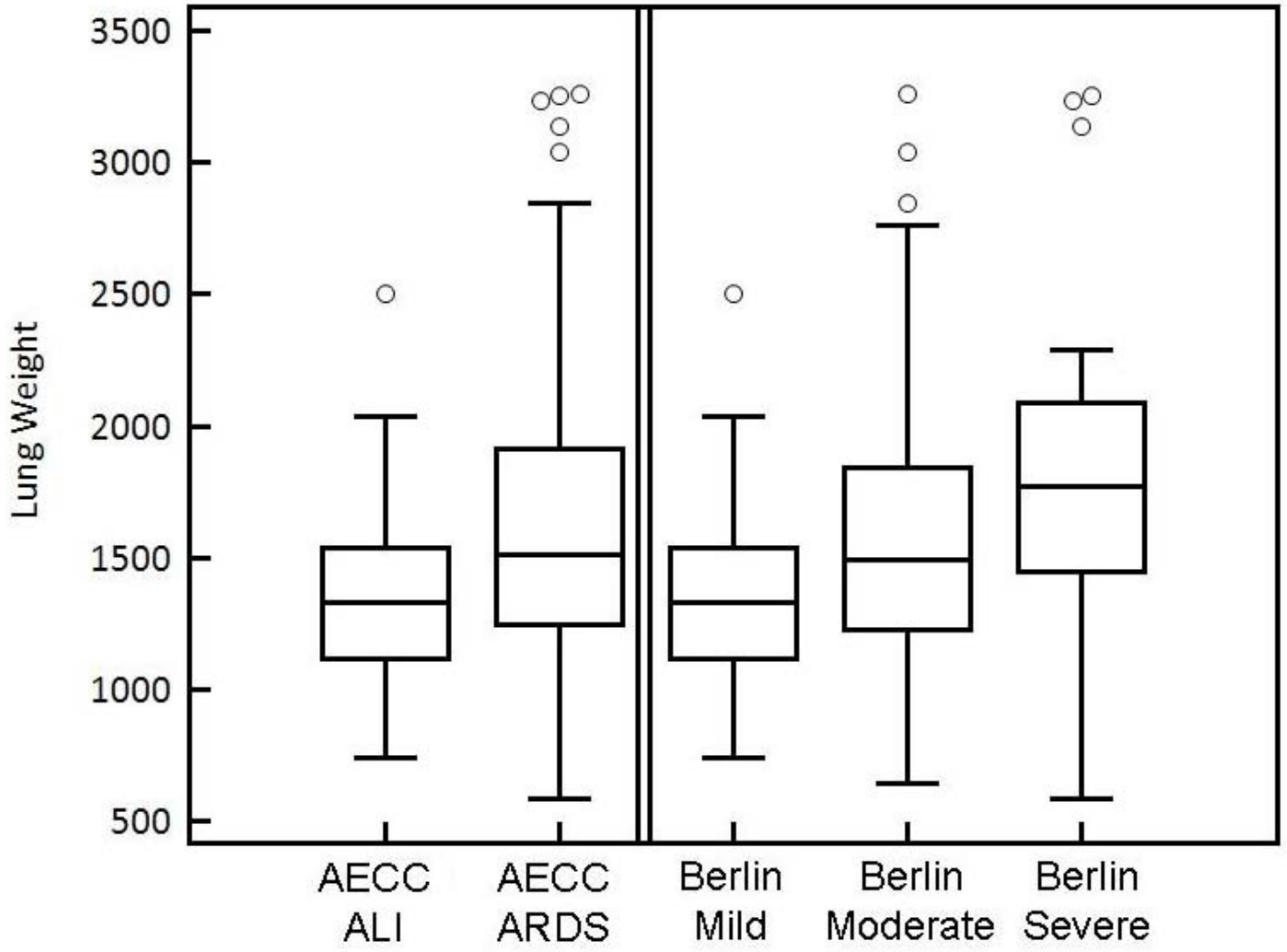
Ventilator Free Days in AECC and Berlin ARDS Definitions



Shunt in AECC and Berlin ARDS Definitions



Lung Weight in AECC and Berlin ARDS Definitions



Management of ARDS

Pharmacotherapy

Therapy	Outcomes
Surfactant	No significant mortality benefit (adult populations)
NO	NO Improves oxygenation but no mortality benefit
Corticosteroids (preventative)	Not effective in preventing ALI/ARDS
Corticosteroids (therapeutic)	No mortality benefit; may increase risk in patients with ARDS of 14 d duration
Antifungal agents (-azoles)	No mortality benefit in treating ARDS; may help prevent development of ARDS
Phosphodiesterase inhibitors (eg, lisofylline and pentoxifylline)	No mortality benefit in ALI/ARDS

Chest 2007;131:913–920

General Principle of Treatment

- Recognition and Tx of the underlying disorders (sepsis, aspiration, **trauma**)
- Minimizing procedures and their complications
- Prophylaxis against DVT, G-I bleeding, cath inf.
- Prompt recognition of nosocomial infections
- Provision of adequate nutrition
- Avoiding continuous infusion of sedatives, NMB
- Control of blood glucose
- Lung Protective ventilation

ARDSnet Ventilator Management

Assist control mode—volume ventilation

Reduce tidal volume to 6 mL/kg lean body weight

Keep plateau pressure < 30 cm H_2O

–Reduce tidal volume as low as 4 mL/kg predicted body weight to limit plateau pressure

Maintain Sao_2/Spo_2 between 88% and 95%

Anticipated PEEP settings at various Fio_2 requirements

Fio_2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	5	5	8	8	10	10	10	12	14	14	14	16	18	20-24

Predicted Body Weight Calculation

Male— 50 + 2.3 [height (inches) – 60] or 50 + 0.91 [height (cm) – 152.4]

Female—45.5 + 2.3 [height (inches) – 60] or 45.5 + 0.91 [height (cm) – 152.4]

Sao_2 = arterial oxygen saturation, PEEP = positive end-expiratory pressure, Spo_2 = oxygen saturation on pulse oximetry. Adapted from Acute Respiratory Distress Syndrome Network. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome.
N Engl J Med 2000; 342:1301–1308.

Summary of Ventilator Procedures
in the Higher PEEP Groups of the ALVEOLI Trial

Procedure	Value
Ventilator mode	Volume assist/control
Tidal volume goal	6 mL/kg of predicted body weight
Plateau pressure goal	≤ 30 cm H_2O
Ventilator rate and pH goal	6–35, adjusted to achieve arterial pH ≥ 7.30 if possible
Inspiration expiration time	1:1—1:3
Oxygenation goal	
Pao_2	55—80 mm Hg
Spo_2	88%—95%
Weaning	Weaning attempted by means of pressure support when level of arterial oxygenation acceptable with PEEP < 8 cm H_2O and FIo_2 < 0.40

Allowable combinations of PEEP and FIo_2[a]

Higher PEEP group (after protocol changed to use higher levels of PEEP)

FIo_2	0.3	0.3	0.4	0.4	0.5	0.5	0.5–0.8	0.8	0.9	1
PEEP	12	14	14	16	16	18	20	22	22	22–24

Note: Complete ventilator procedures and eligibility criteria can be found at www.ardsnet.org.

Spo_2 = oxyhemoglobin saturation as measured by pulse oximetry, FIo_2 = fraction of inspired oxygen, PEEP = positive end-expiratory pressure.

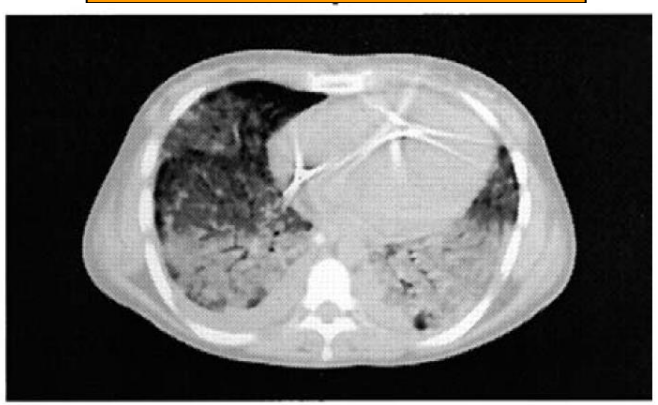
[a]In both study groups (lower and higher PEEP), additional increases in PEEP to 34 cm H_2O were allowed but not required after FIo_2 had been increased to 1.0, according to the protocol.

Adapted from Brower RG, Lanken PN, MacIntyre N, et al: Higher vs. lower positive end-expiratory pressures in patients with the acute respiratory distress syndrome.
N Engl J Med. 2004; 351(4):327–336.

Prone Position

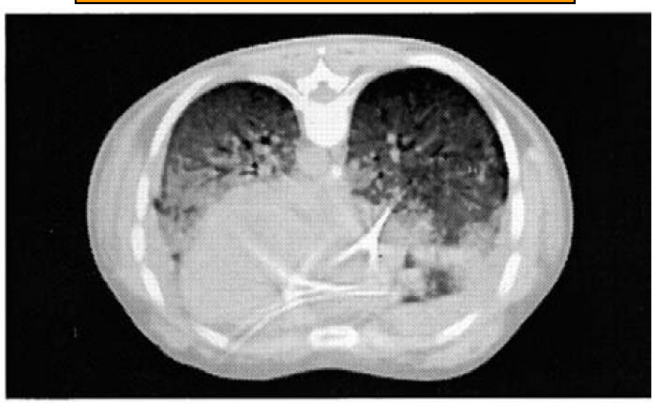
Shunt
Q without V

Redistribute
Q to area of V



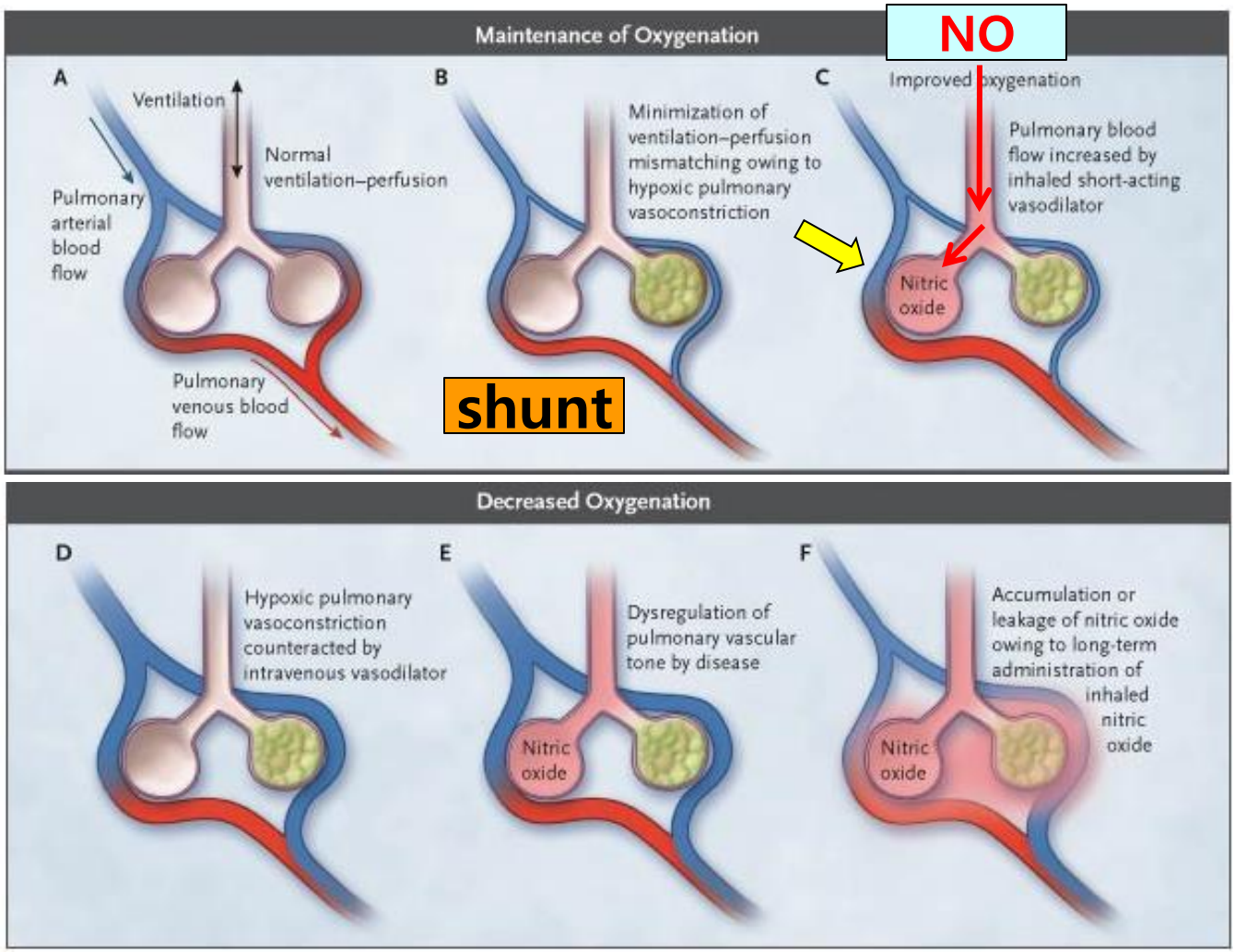
* Dependent Lung
  - More edema
  - More Q

Redistribute
V to area of Q

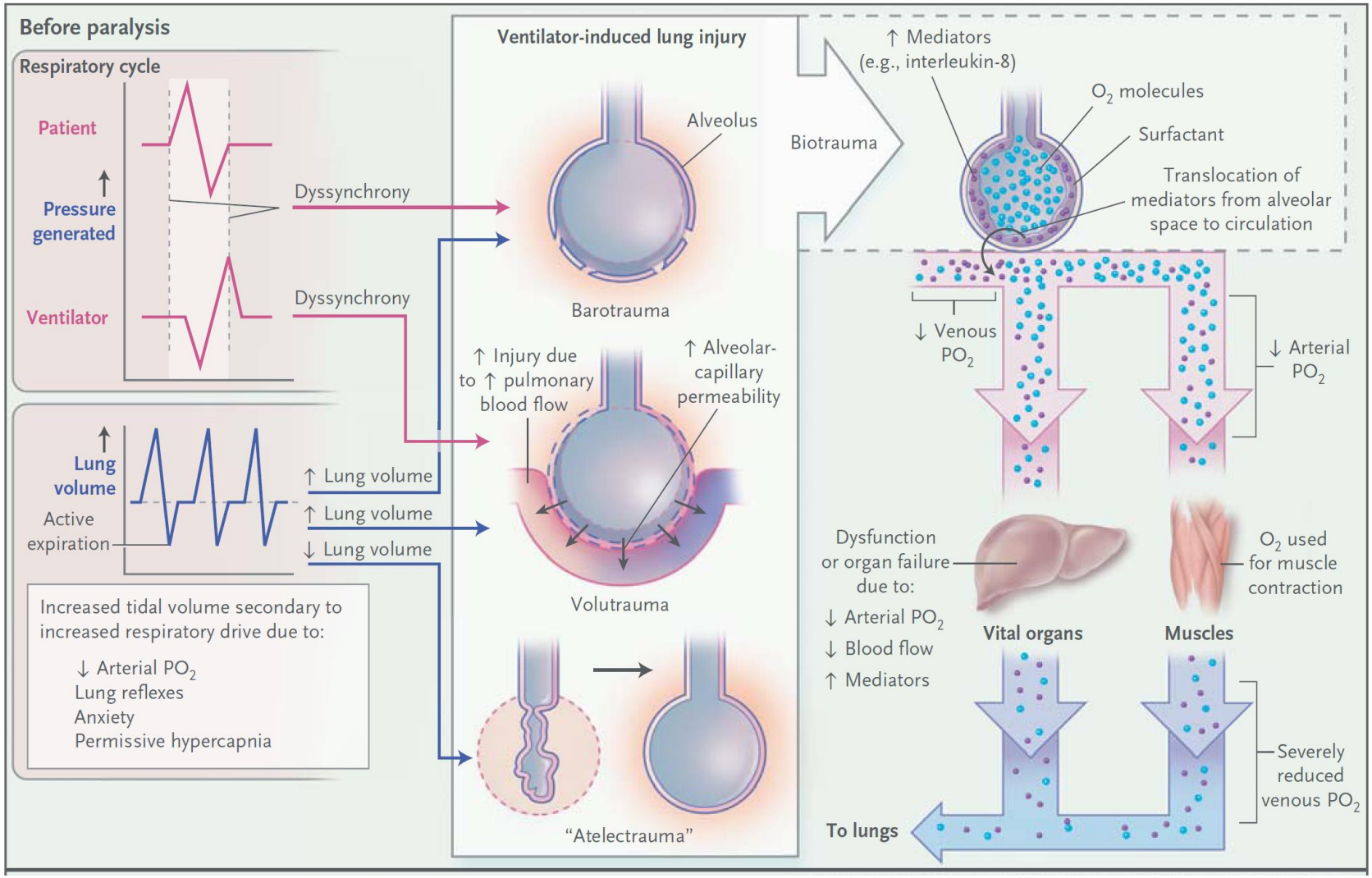


* Prone Positioning
  redistribute Q to Ventral lung

Mechanism of Action & Inaction of inhaled Nitric Oxide(iNO)

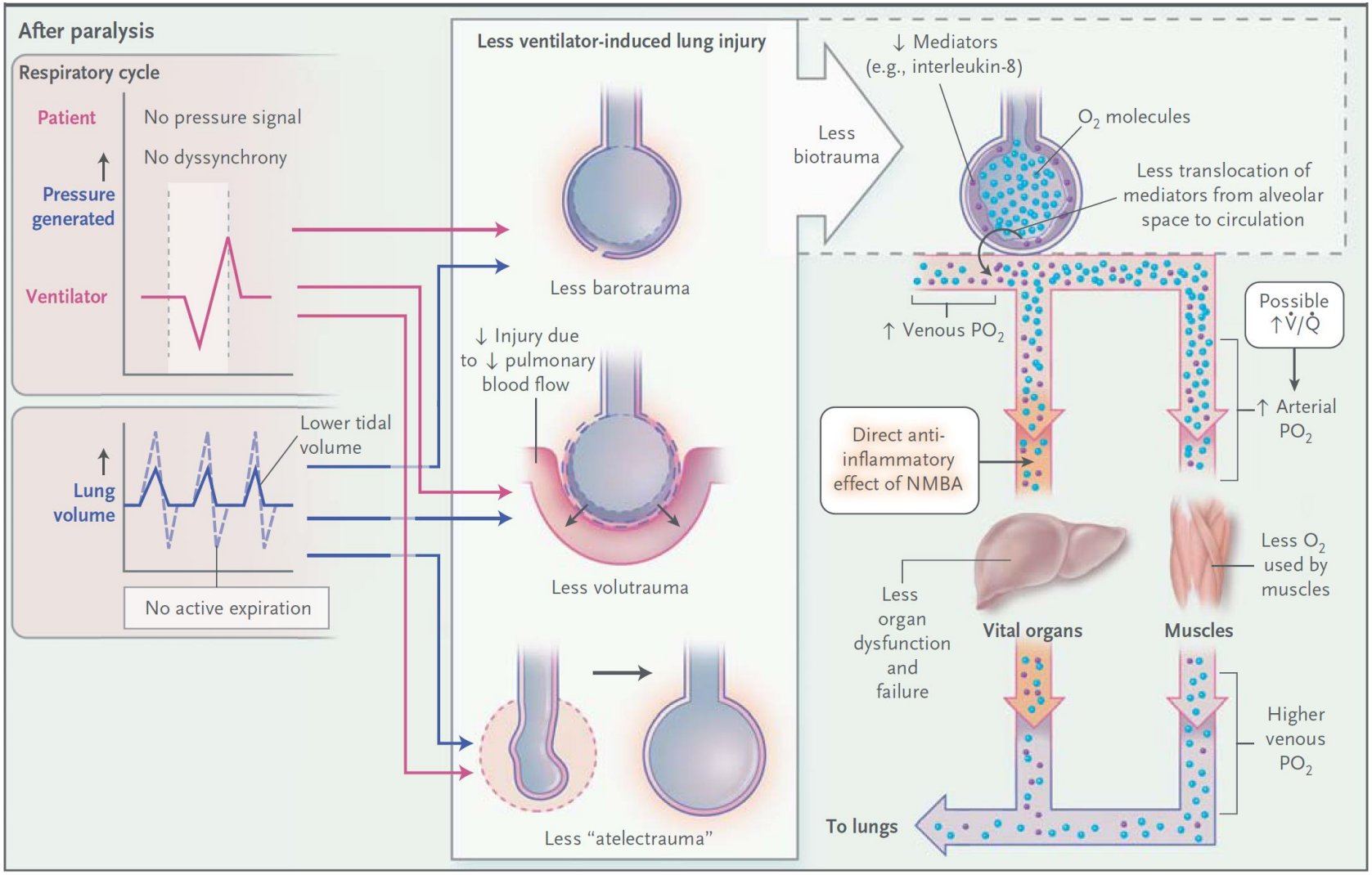


Possible Mechanism of NMBAs



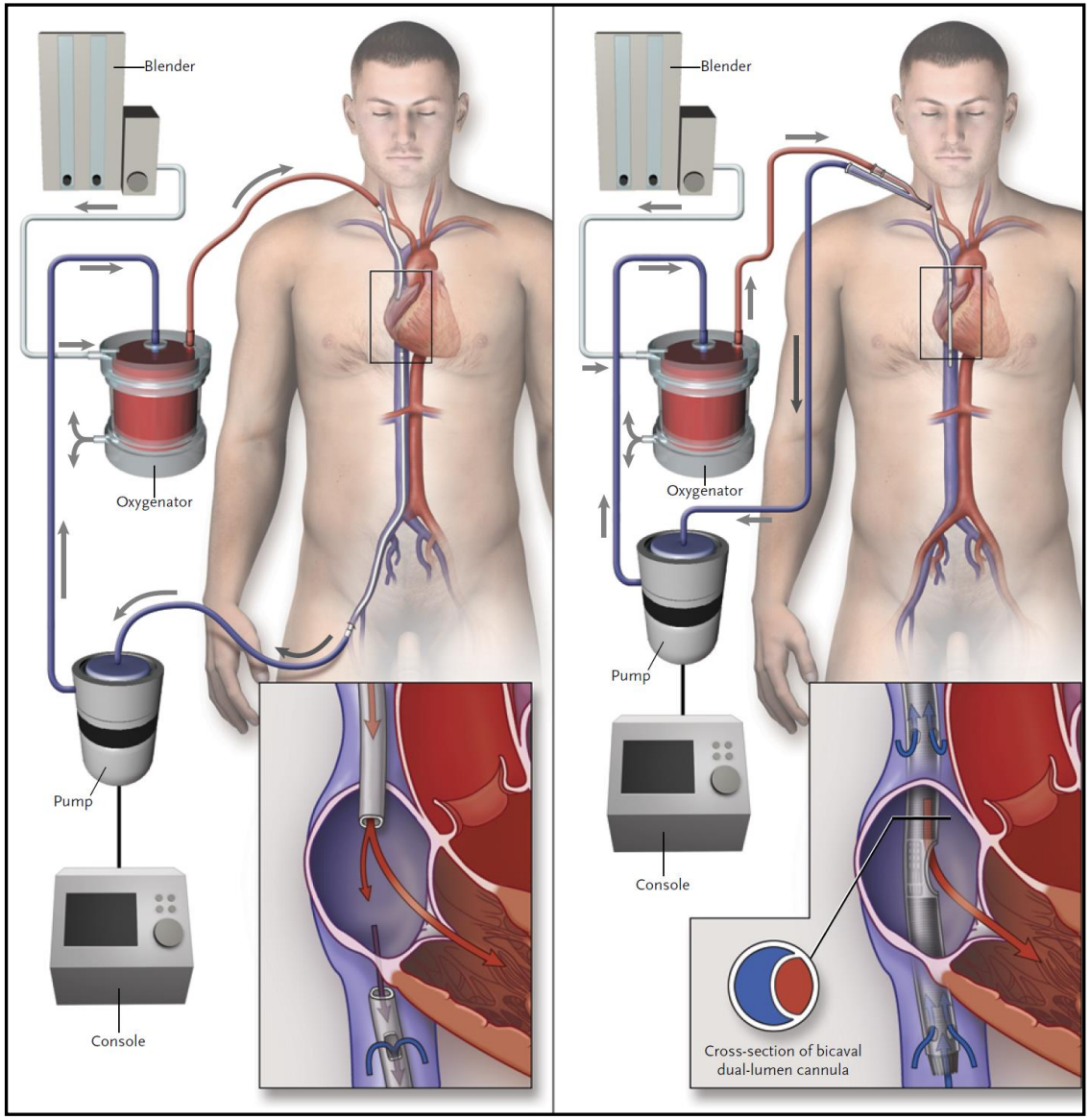
NEJM 2010;363:1176

Possible Mechanism of NMBAs



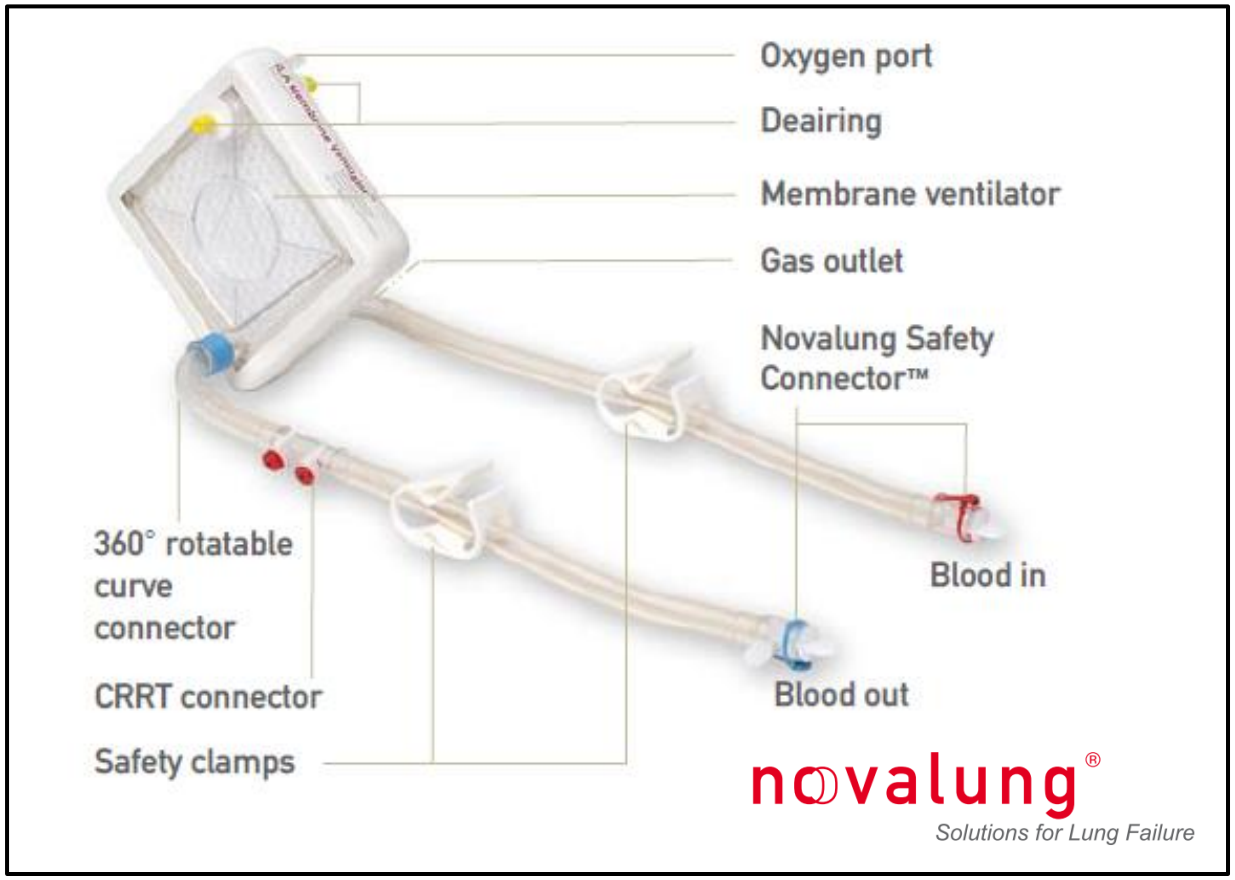
NEJM 2010;363:1176

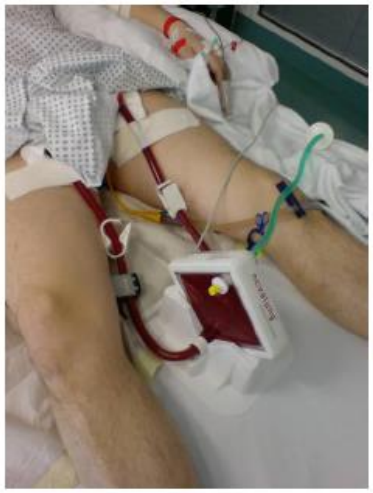
Extracorporeal Membrane Oxygenation



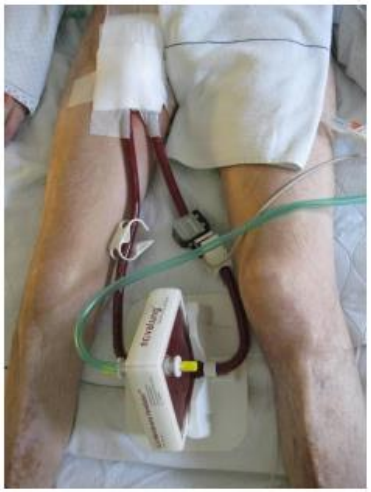
NEJM 2011;365:1905

Interventional Lung Assist (iLA) device





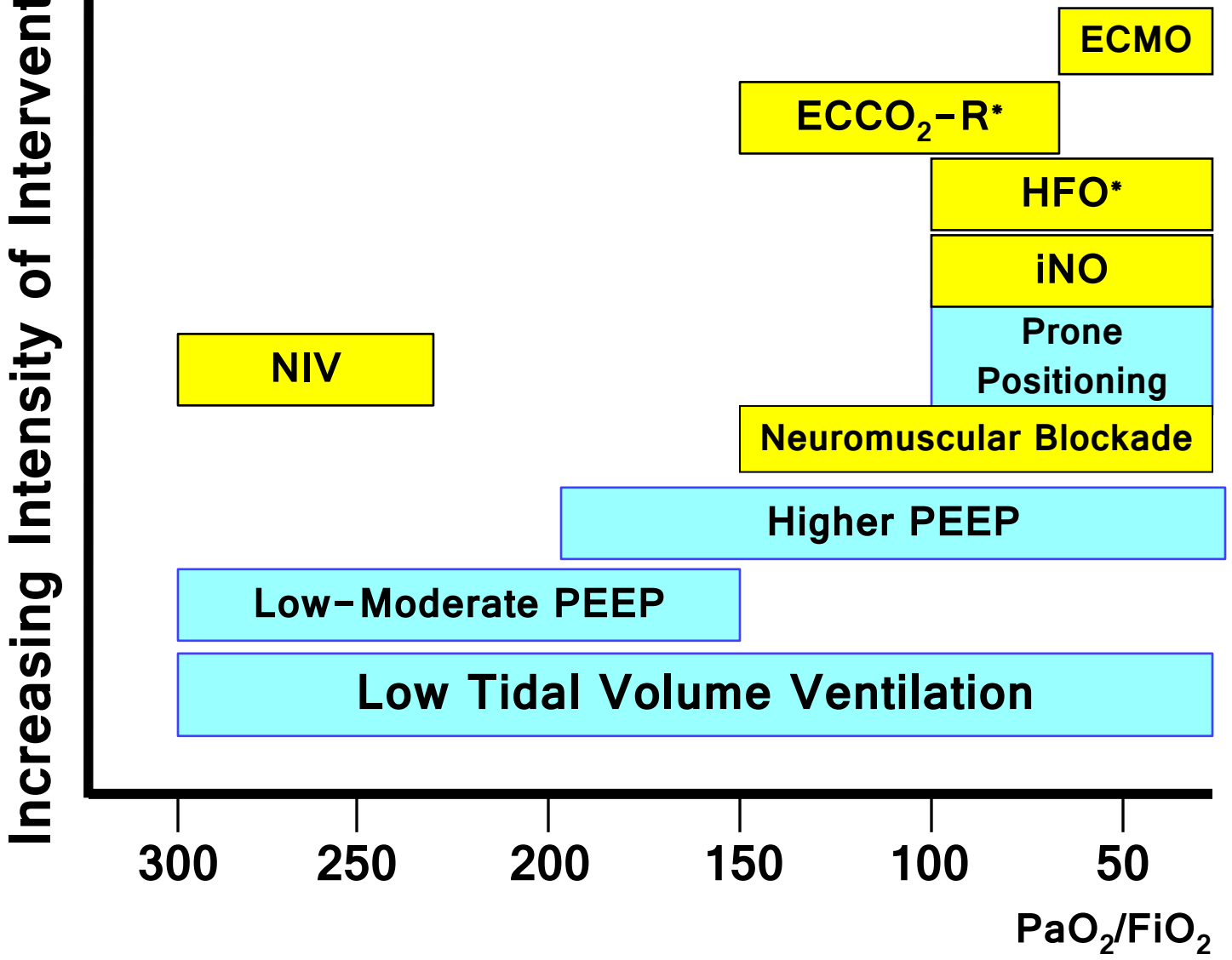
Bilateral use preferred



Unilateral use possible

중증 급성 호흡부전 환자 중 고평부압을 35cmH_2O이하로 유지시키면서, 일회호흡량을 최대한 증가시켜도, 고이산화탄소혈증(70mmHg 이상)으로 인한 호흡성 산증 (pH 7.2 미만)이 교정되지 않고, 혈역학적으로 안정되어 있는 경우

Management of ARDS



ARDS in Trauma ?

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

The Decreasing Incidence of Late Posttraumatic Acute Respiratory Distress Syndrome: the Potential Role of Lung Protective Ventilation and Conservative Transfusion Practice

David Plurad, MD, Mathew Martin, MD, Donald Green, MD, Ali Salim, MD, Kenji Inaba, MD, Howard Belzberg, MD, Demetrios Demetriades, MD, PhD, and Peter Rhee, MD, MPH

J Trauma. 2007;63:1–8.

- All trauma patients were admitted to the ICU between January 1, 2000 and December 31, 2005 and intubated within the first 48 hours were included.
- There were 2,346 patients entered into the study.

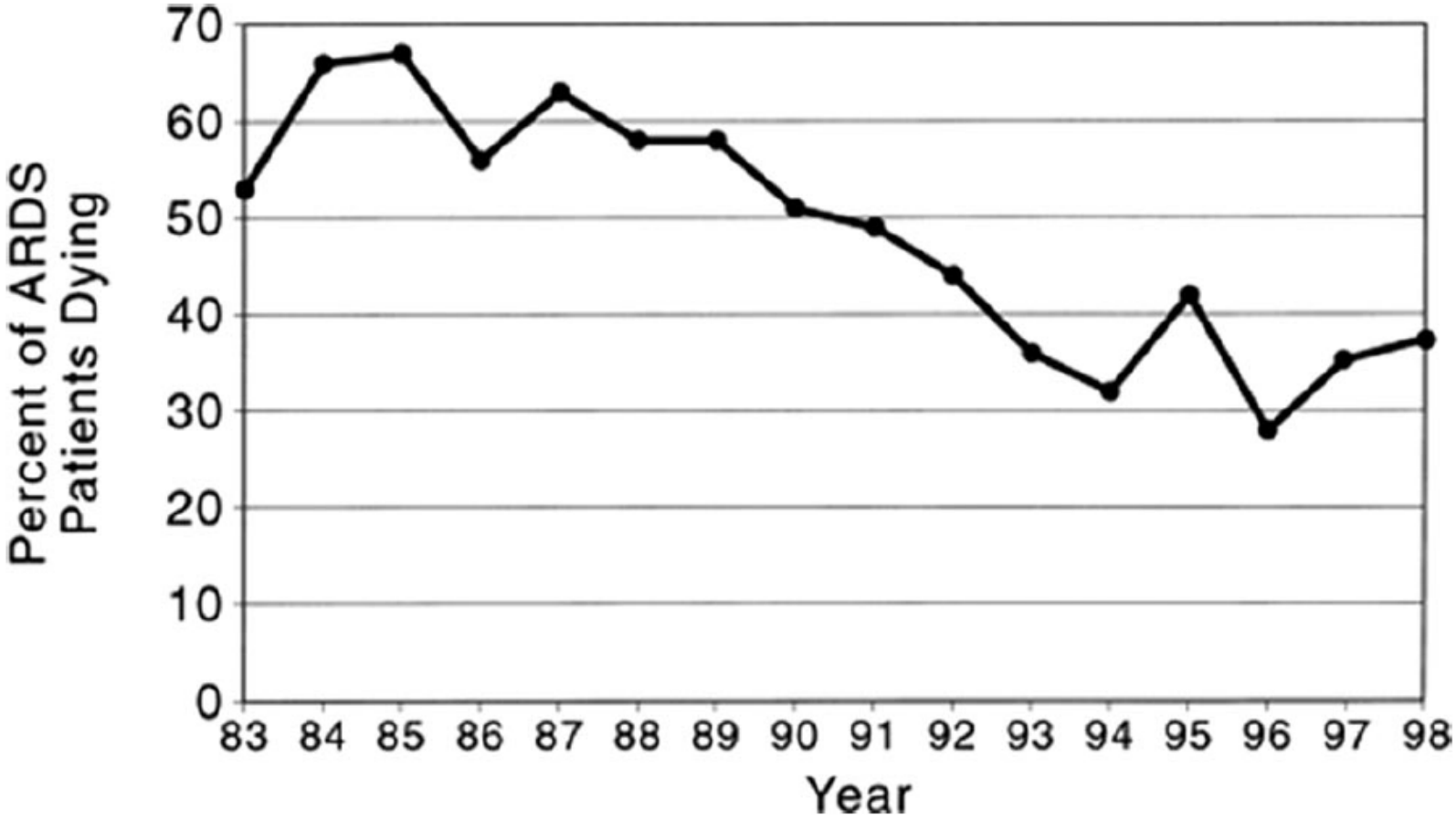


Fig. 1. *Mortality in patients with ARDS prospectively identified at Harborview Medical Center is shown over time. Data were adjusted for age, gender, and risk factor. The same definition for ARDS was used during this entire time.*[1]

J Trauma 2007;63:1-8.

Table 1 Comparison of Trauma Patients With and Without Late-Onset ARDS

Variable	ARDS (+) (192)	ARDS (–) (2,154)	*p* Value
Age (years)	41 ± 17.1	37 ± 18.2	0.004
Gender (male)	150 (78.1%)	1,775 (82.4%)	0.139
Mechanism (blunt)	129 (67.2%)	1,411 (65.5%)	0.639
ED hypotension (SBP <90 mm Hg)	27 (14.1%)	176 (8.2%)	0.005
Glasgow Coma Score	11.5 ± 4.3	10.4 ± 4.8	0.002
Injury Severity Score	27.3 ± 12.7	21.8 ± 13.1	<0.001
Body mass index (kg/m^2)	28.9 ± 6.9	26.7 ± 5.9	<0.001
Fluid balance, 48 h (ml)	3,671.2 ± 3,821.7	1,670 ± 3,298.6	<0.001
Transfused (y/n)	135 (70.3%)	918 (42.6%)	<0.001
Blood volume PRBC transfused, 48 h (ml)	970.4 ± 1,305.3	529.1 ± 940.5	<0.001
Total units PRBC transfused, 48 h (units)	2 ± 3	1.6 ± 3.1	0.003
Tidal volume (ml/kg)	8.6 ± 1.7	8.8 ± 2.3	0.383
Peak inspiratory pressure (mm Hg)	33.7 ± 9.8	30.4 ± 30.4	<0.001

ED, emergency department.

J Trauma 2007;63:1-8.

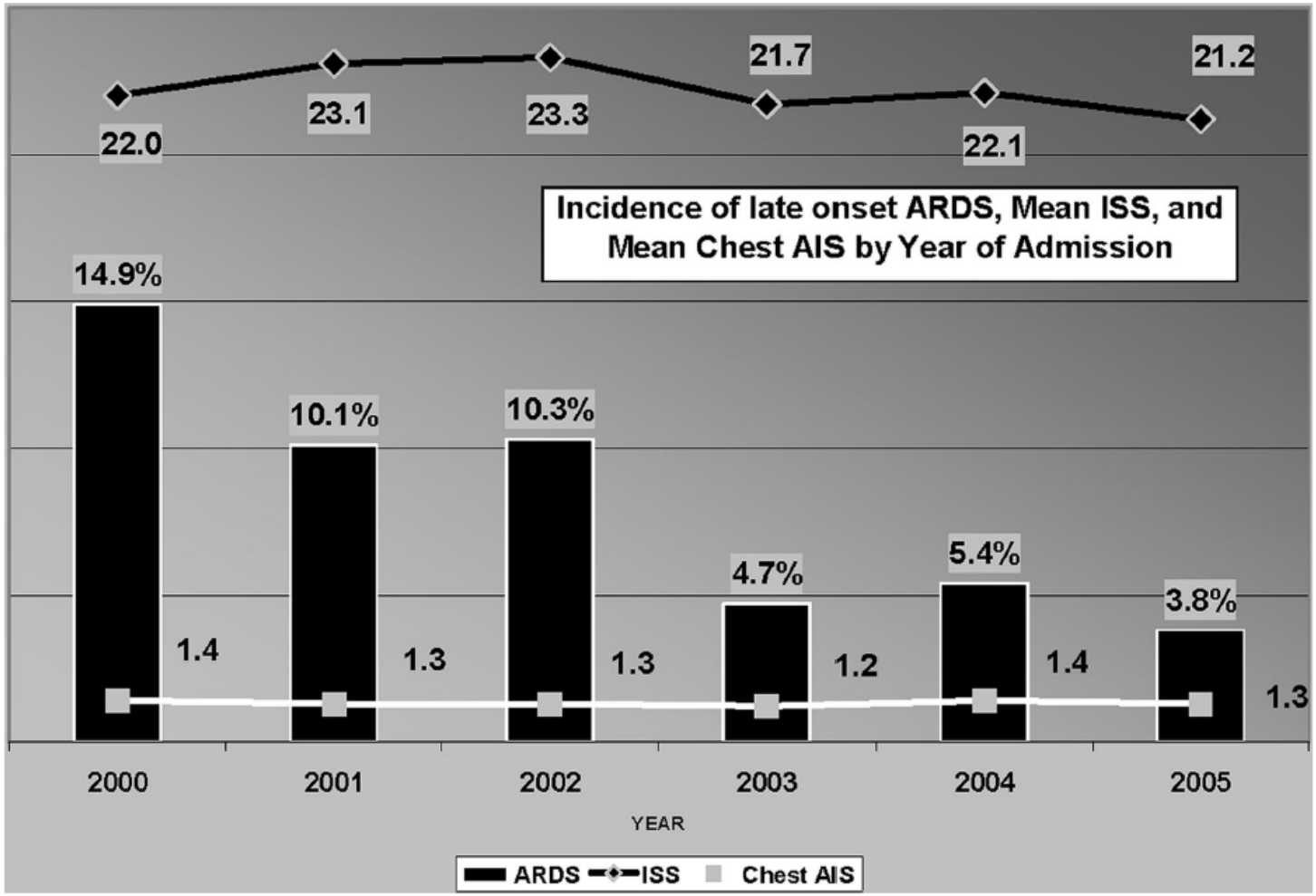


Fig. 1. *Incidence of late posttraumatic ARDS (diagnosed after 48 hours of admission) by year of admission. Decrease in incidence was statistically significant ($p \leq 0.001$ by χ^2), whereas change in ISS and chest AIS was not significant ($p = 0.2$ and 0.595 by ANOVA).*

J Trauma 2007;63:1-8.

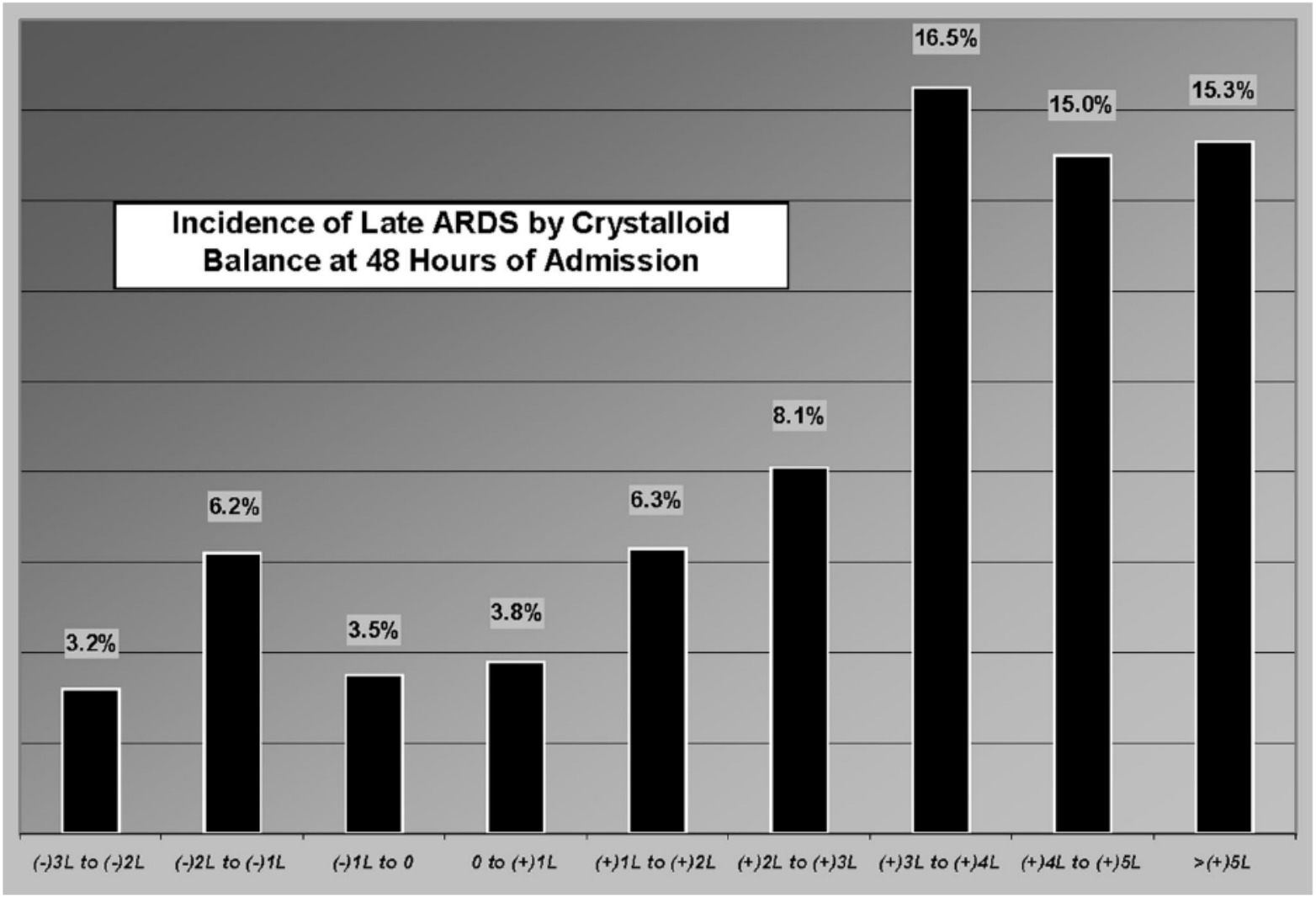


Fig. 2. *The incidence of late posttraumatic ARDS increased significantly with increasing fluid (L) balance at 48 hours* ($p \leq 0.001$ *by* χ^2).

J Trauma 2007;63:1-8.

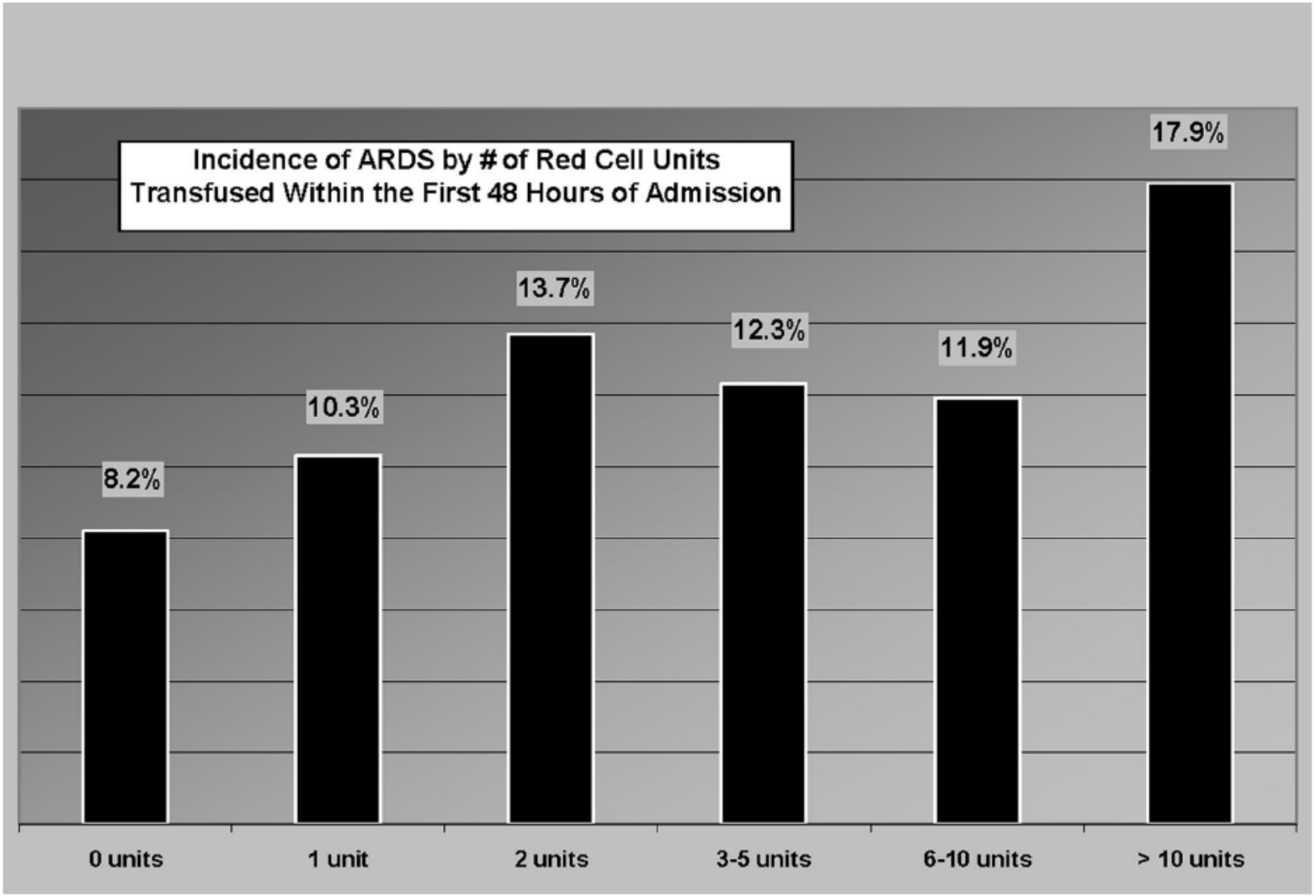


Fig. 3. *The incidence of late posttraumatic ARDS increased significantly with increasing number of PRBC transfused* ($p \leq 0.001$ *by* χ^2).

J Trauma 2007;63:1-8.

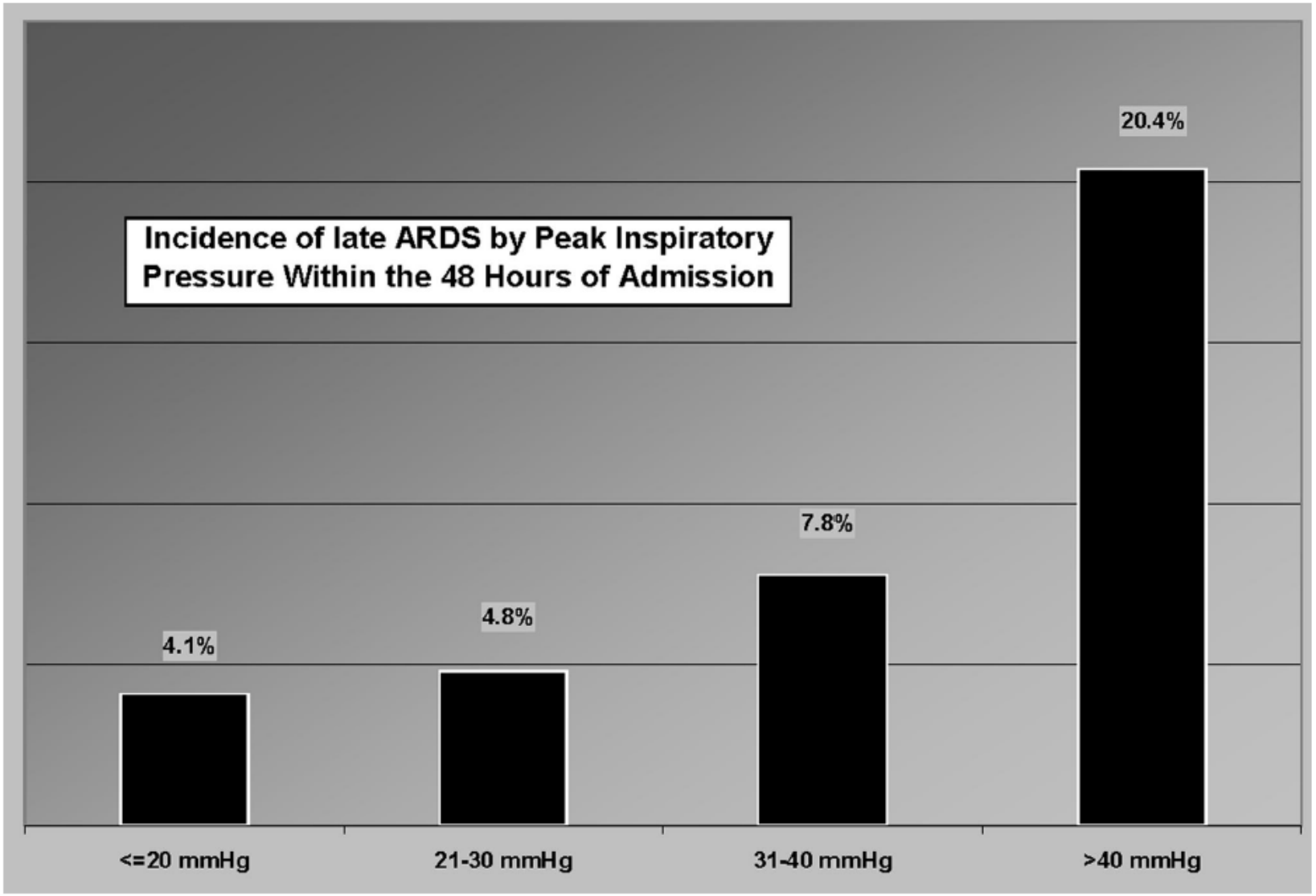


Fig. 4. *The incidence of late posttraumatic ARDS increased significantly* ($p \leq 0.001$ *by* χ^2) *with increasing PIP (mm Hg).*

J Trauma 2007;63:1-8.

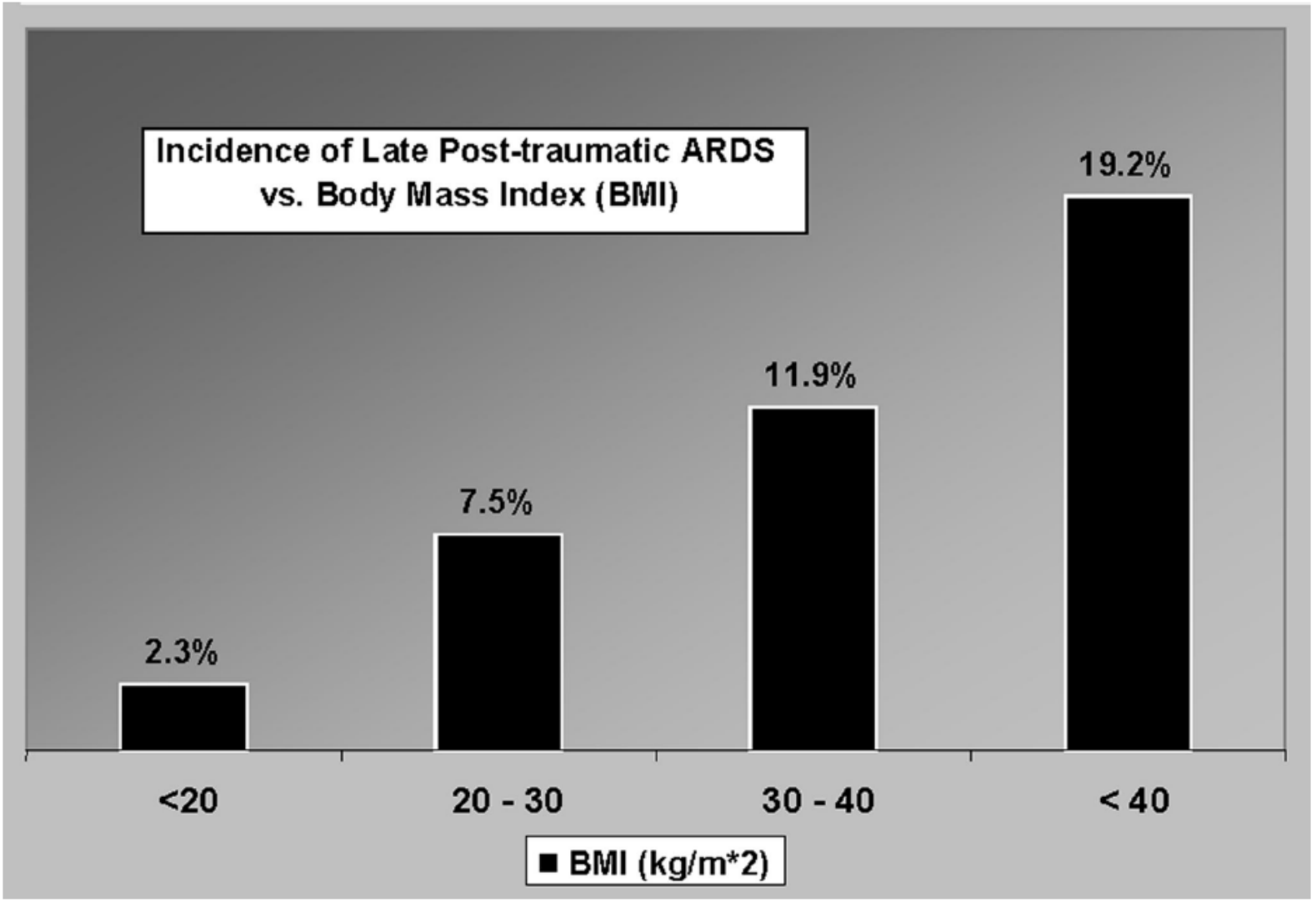


Fig. 6. *The incidence of posttraumatic ARDS increased significantly with increasing BMI* ($p \leq 0.001$ *by* χ^2).

J Trauma 2007;63:1-8.

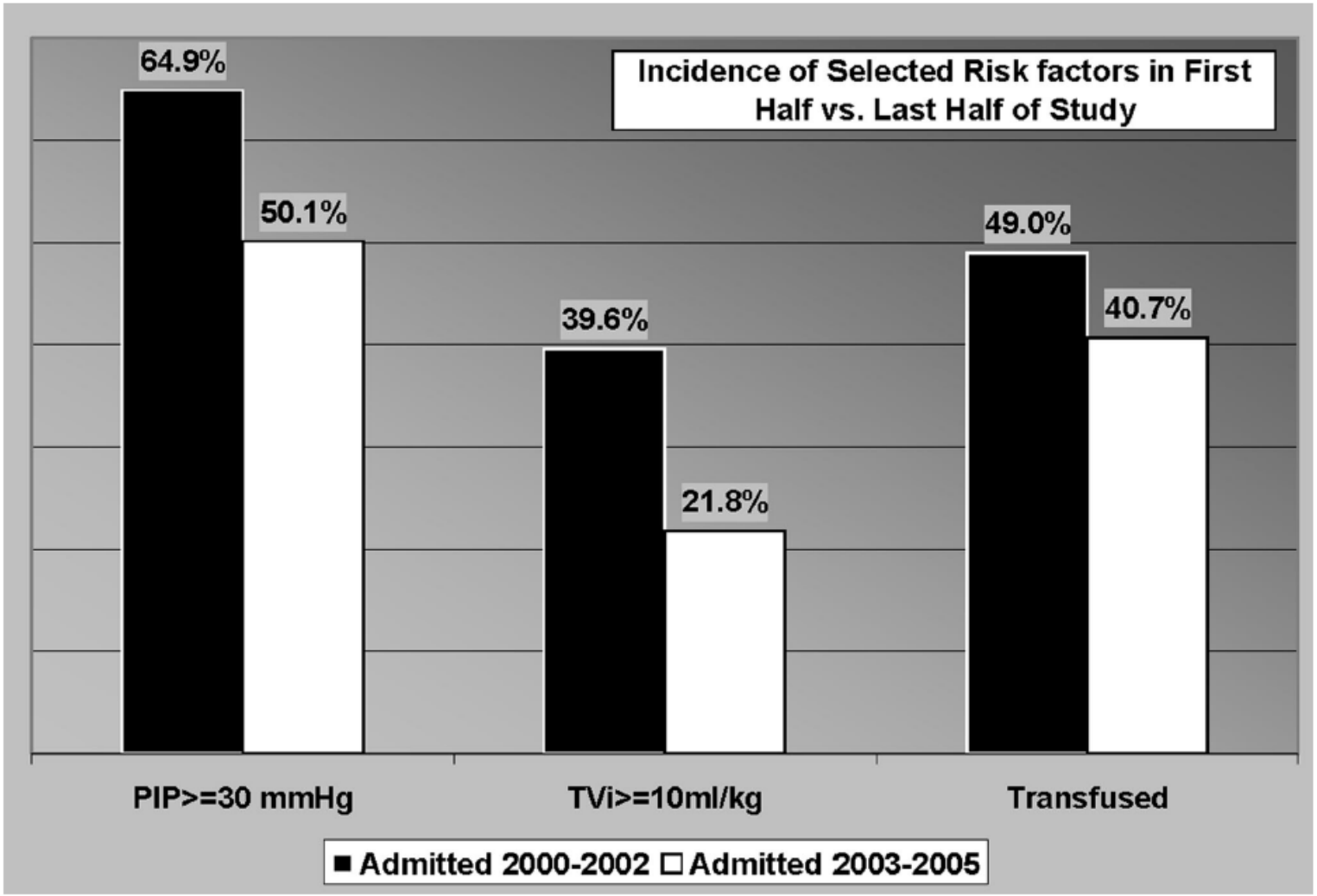


Fig. 7. *When comparing the last half versus the first half of the study, there were significantly less patients with a PIP > 30 mm Hg, a TVi >10 ml/kg, and that were transfused* ($p \leq 0.001$ *by* χ^2 *for all).*

J Trauma 2007;63:1-8.

The Decreasing Incidence of Late Posttraumatic Acute Respiratory Distress Syndrome: the Potential Role of Lung Protective Ventilation and Conservative Transfusion Practice

David Plurad, MD, Mathew Martin, MD, Donald Green, MD, Ali Salim, MD, Kenji Inaba, MD, Howard Belzberg, MD, Demetrios Demetriades, MD, PhD, and Peter Rhee, MD, MPH

- Conclusions: The increasing use of restrictive transfusion policies and ventilation strategies that potentially limit elevations in early peak inspiratory pressures are associated with a decreased incidence of late posttraumatic ARDS.

J Trauma 2007;63:1-8.

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Trauma-associated lung injury differs clinically and biologically from acute lung injury due to other clinical disorders*

Carolyn S. Calfee, MD, **Mark D. Eisner, MD, MPH**, **Lorraine B. Ware, MD**, **B. Taylor Thompson, MD**, **Polly E. Parsons, MD**, **Arthur P. Wheeler, MD**, **Anna Korpak, BA**, **Michael A. Matthay, MD**, and **National Heart, Lung, and Blood Institute Acute Respiratory Distress Syndrome Network**

- **Objective** - Patients with trauma-associated acute lung injury have better outcomes than patients with other clinical risks for lung injury, but the mechanisms behind these improved outcomes are unclear.

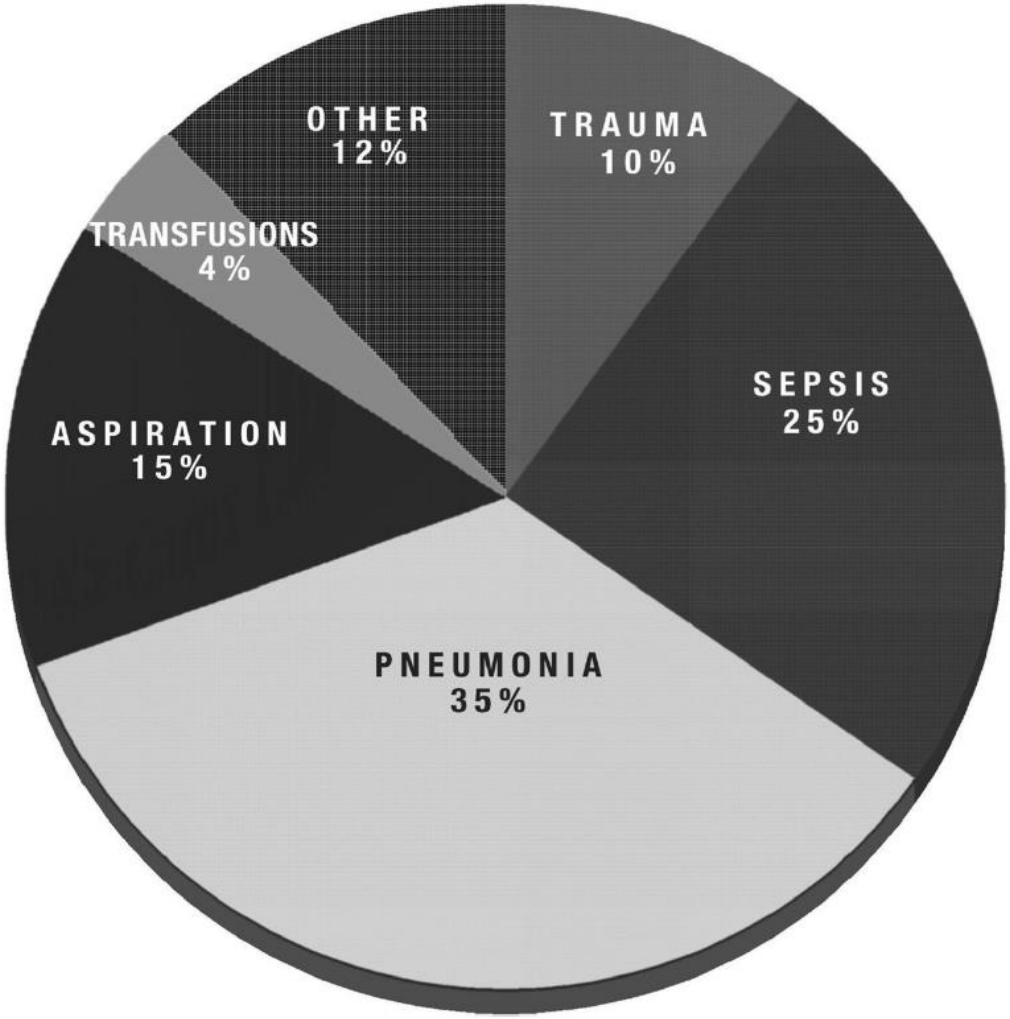

Figure 1.
Primary etiology of acute lung injury in patients in the low tidal volume (n = 902) and Assessment of Low Tidal Volume and Increased End-Expiratory Volume to Obviate Lung Injury (n = 549) trials. Patients with trauma-associated lung injury comprised approximately 10% (n = 141) of the overall study population.

Crit Care Med. 2007;35:2243-50.

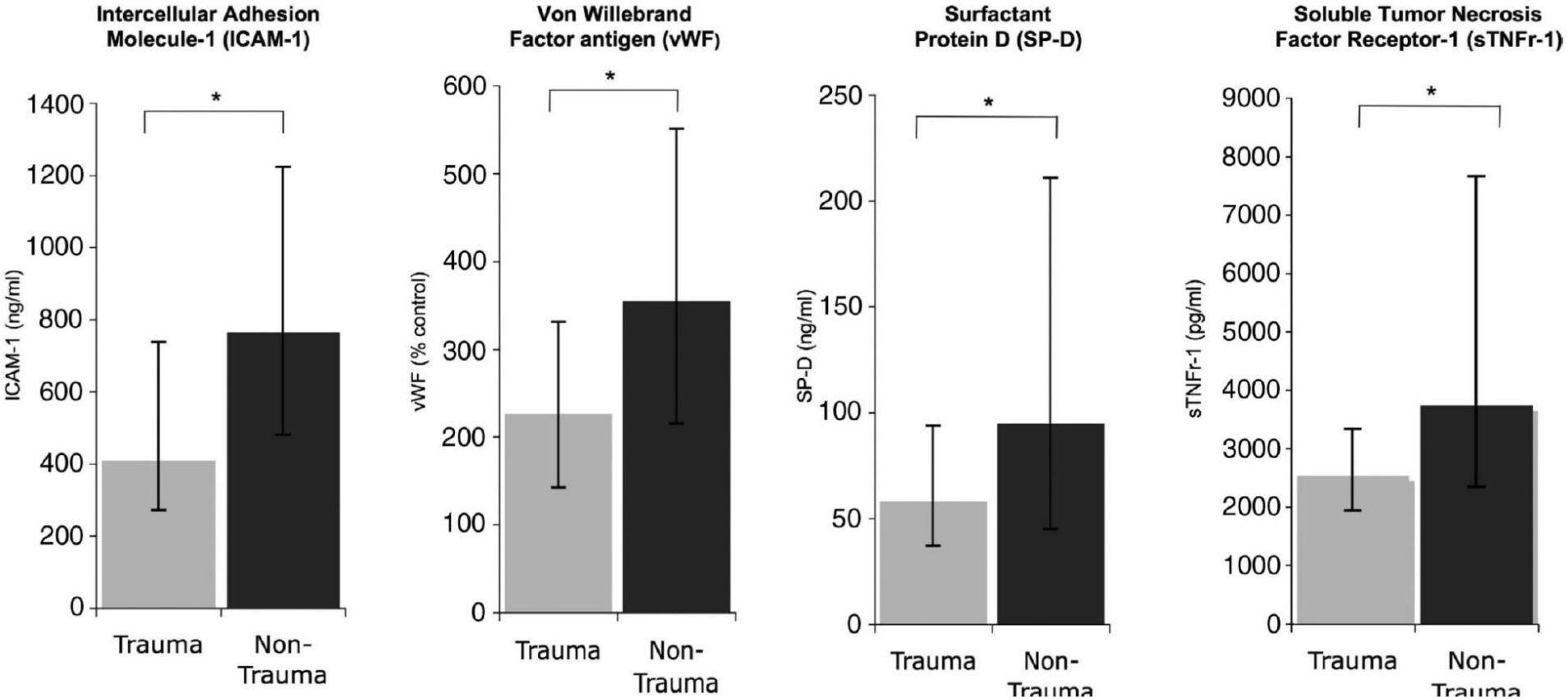

Figure 2.

Trauma-associated acute lung injury patients have lower levels of plasma biomarkers of endothelial and epithelial injury than patients with other clinical risk factors for acute lung injury. *$p < .001$ for all comparisons in unadjusted model; $p \leq .001$ for all comparisons in multivariable model using natural log-transformed biomarkers that adjusts for age, gender, race and ethnicity, comorbidities, severity of illness, and Pa_{O_2}/F_{IO_2} ratio. Median values are depicted; *error bars* represent 25% to 75% interquartile range.

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Trauma-associated lung injury differs clinically and biologically from acute lung injury due to other clinical disorders*

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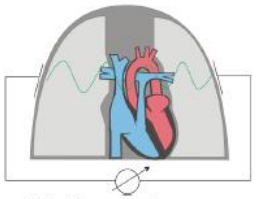
- **Conclusions -** Patients with trauma-associated lung injury are less acutely and chronically ill than other lung injury patients; however, these baseline clinical differences do not adequately explain their improved outcomes.
- Instead, the better outcomes of the trauma population may be explained, in part, by less severe lung epithelial and endothelial injury.

Crit Care Med. 2007;35:2243-50.

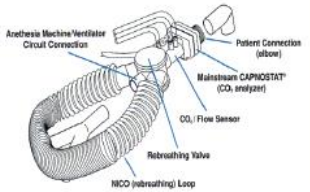
Monitoring & Outcome

Monitoring device → Goal-directed therapy → Outcome

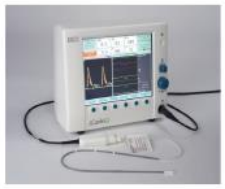


Bioimpedance
Bioreactance

Pulse Wave Analysis



Applied Fick
CO_2-rebreathing



Esophageal Doppler

Anesth Analg 2011;112: 1392–402

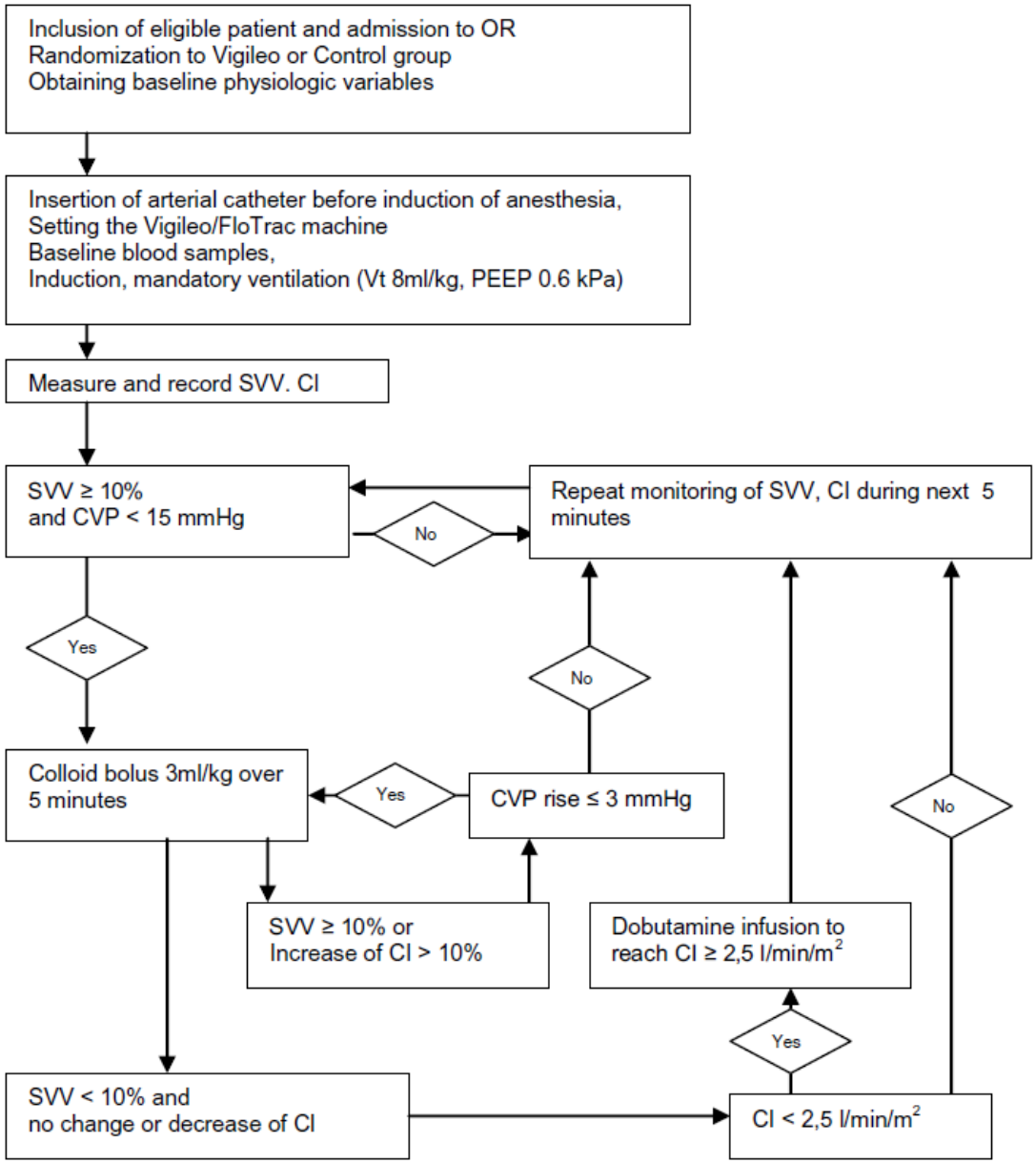


Figure 2 Fluid management in Vigileo group. CI, cardiac index; CVP, central venous pressure; SVV, stroke volume variation; PEEP, positive end-expiratory pressure; Vt, tidal volume; OR, operation room.

Wen et al. World Journal of Emergency Surgery (2015) 10:15
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WJES WORLD JOURNAL OF EMERGENCY SURGERY

REVIEW Open Access

Non-heparinized ECMO serves a rescue method in a multitrauma patient combining pulmonary contusion and nonoperative internal bleeding: a case report and literature review

Pei-Hung Wen[1,2,5*], Wai Hung Chan[1,2*], Ying-Cheng Chen[3], Yao-Li Chen[1,4], Chien-Pin Chan[1,2] and Ping-Yi Lin[4]

- ECMO is still considered contraindicated in polytramatic patients combining pulmonary contusion and other organ hemorrhage because of systemic anticoagulation during the treatment.
- We report a **heparin-free**, vv-ECMO method for patients combining acute pulmonary failure and nonoperative liver laceration, which may extend the feasibility of ECMO in polytraumatic patients.

Table 2 ECMO in polytraumatic patients combining acute pulmonary failure and other vital organ damage: literature review

References	Case no.	Combined injury besides pulmonary failure	Intervention	ECMO	Heparin	ECMO duration	Outcome
Madershahian et al. [2]	1, 19/F	Spleen, Liver	Laparotomy	v-a[5]	(+)	138 hours	Survived
		Right main bronchus	Thoracotomy				
	2, 48/M	Vertebra and long bone Fracture	Osteosynthesis	v-a	(+)	120 hours	Survived
	3, 26/M	Spleen	Splenectomy	v-va[6]	(+)	84 hours	Survived
		Brain					
Yuan et al. [5]	4, 18/M	Liver, Gr. III	Conservative	v-v	(+)	10 days	Survived
		Endobronchial hemorrhage					
	5, 38/M	Brain SDH[1]	Conservative	v-v	(+)	5 days	Survived
Campione et al. [4]	6, 14/M	Bronchial Disruption	Right bilobectomy of lung	v-v	(+)	3 days	Survived
Yen et al. [7]	7, 21/M	Brain EDH[2]	Decompressive craniotomy	v-a	(+)	49 hours	Survived
Friesenecker, et al. [8]	8, 34/M	Liver, Spleen	Laparotomy	v-v	(+)	17 days	Survived
		Brain ICH[3] with edema	Decompressive craniotomy				
Muellenbach et al. [9]	9, 53/M	Liver	Laparotomy	v-v	(–)	8 days	Survived
		Traumatic brain injury	ICP[4] Monitoring				
	10, 16/M	Traumatic brain injury		v-v	(–)	3 days	Survived
	11, 28/M	Spleen	Splenectomy	v-v	(–)	2 days	Survived
		Traumatic brain injury					
Arlt et al. [6]	10 Cases	Bleeding shock	-	7 v-v	All (–)	Mean 5 days	6/10 Survived
				3 v-a			

[1]SDH: Subdural hemorrhage; [2]EDH: Epidural hemorrhage; [3]ICH: Intracerebral hemorrhage; [4]ICP: Intracerebral pressure; [5]V-a: Venoarterial ; [6]V-va: veno-venoarterial.

Take Home Message