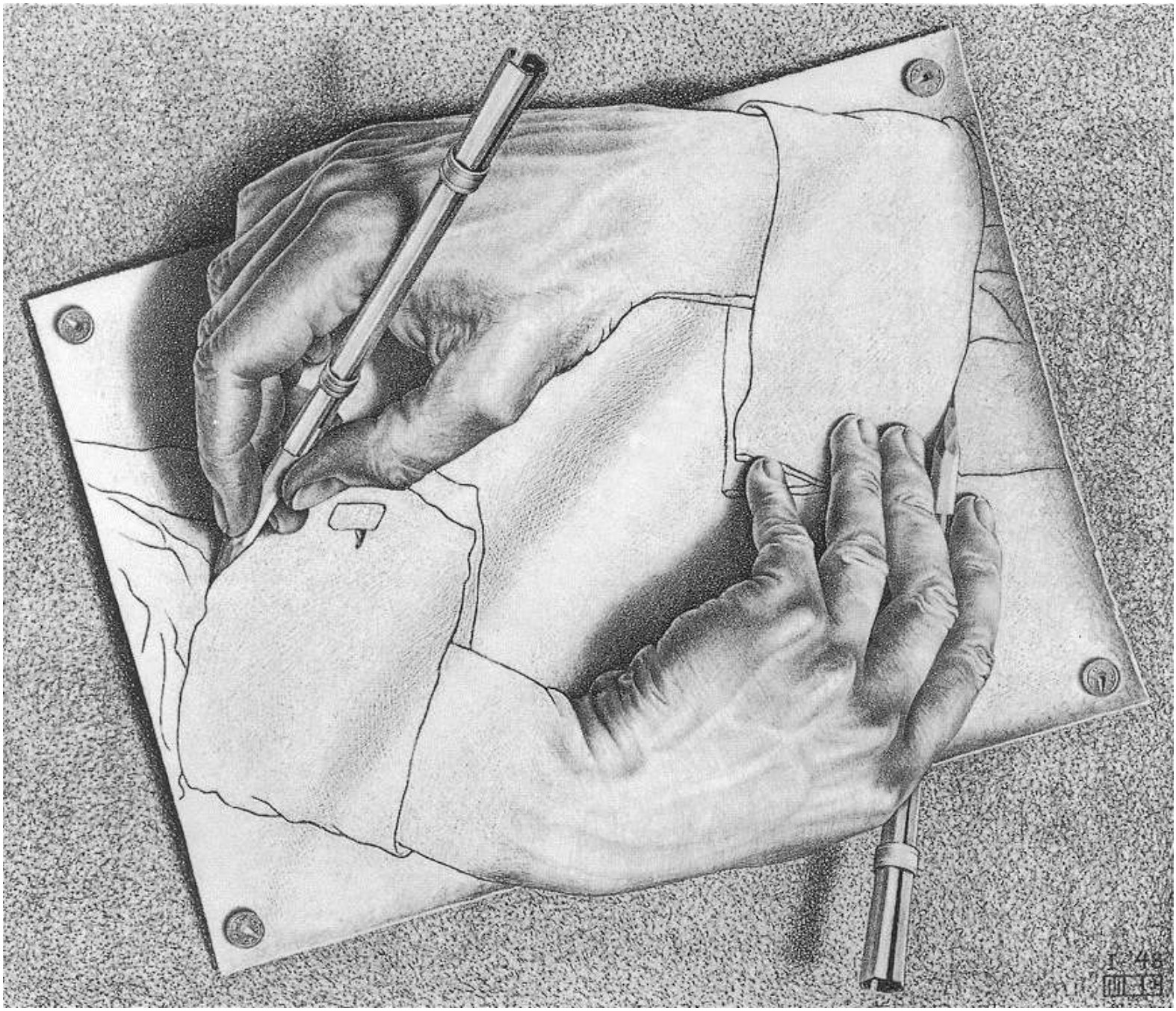
THE NORTHERN HOSPITAL

THORACOLUMBAR SPINE CLEARNANCE



Emergence - "Drawing Hands", Lithograph, January 1948. M.C Escher.

"The love of complexity without reductionism makes art; the love of complexity with reductionism makes science."

Edward O. Wilson, Consilience: The Unity of Knowledge

We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of the tiniest atom; for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes.

Pierre Simon Laplace, A Philosophical Essay on Probabilities 1814

One of the most stunningly successful strategies of the scientific method has been that of reductionism, or the process of breaking down complex systems into smaller more easily understood component parts and thus by so doing come to an understanding of the complex system under study as a necessary consequence of the properties and laws governing the more fundamental component parts. In this manner we may understand biology, in terms of chemistry, and in turn we may understand chemistry in terms of physics.

If reductionism can explain systems of higher complexity, then what level of higher complexity might this be taken to? Might a knowledge of the position and momentum of every quark in the Universe, be able to explain not only biology but also human emotion, culture, societies, ethics or even religion? This was a concept explored by the great Edward O. Wilson in his 1998 book "Consilience". Consilience refers to the principle that evidence from different or unrelated disciplines can converge or "jump together" to enable the formulation of a strong conclusion or understanding. Wilson had hopes that scientific methods, such as reductionism, could one day be applied to the humanities and so a great "chain of being" could be established between the sciences and the humanities.

Reductionism may explain scientific complexity but it is a difficult argument to accept that it may also be capable of explaining things such as culture, ethics or religion. Human nature or any human endeavor cannot be reduced to a set of mathematical laws, which underpin the primal level of physics. As the magisterial Stephen Jay Gould wrote, we may praise the charms and colours of particle physics, but we cannot expect these to explain the dismal human "science" of economics! Gould strongly disagreed with Wilson, in his 2003, book "The Hedgehog, the Fox and the Magister's Pox", where he describes the two great stumbling blocks of making predictions about highly complex systems (such as the human brain) based purely on reductionist thinking.

The first is the phenomenon of emergence. This is a property which emerges from the interaction of simpler component parts that cannot be predicted purely on a the basis of an understanding of those component parts. An example often quoted is that of the elements sodium and chloride. A complete understanding of these two elements does not predict that when combined sodium chloride will impart a salty taste. Salty taste is an emergent property. Gould goes on to explain, "…just knowing the properties of each part as a separate entity (and all the laws regulating its form and action as well) won't give you a full explanation of the higher level in terms of these lower level parts because, in

constructing the higher level item, these parts combine and interact. Thus one must also include these interactions as essential aspects of an adequate higher level explanation. How then, can reductionism work if interactions among lower-level parts must figure prominently in any higher level explanation?"

The second stumbling block to reductionism is the phenomenon of contingency. No general principle or no law of nature can foresee the unexpected happenstances within the timeline of history. Perhaps the most famous contingency in the history of evolution of life on Earth, was the impact of an Everest sized meteorite on the current day location of the Yucatan peninsula in Mexico, that resulted in the extinction of the dinosaurs and ended the Cretaceous Period. This event allowed for the rise to dominance of a previously very insignificant group of life forms - the mammals - from which Homo sapiens would eventually arise. The dinosaurs as a group were one of the most successful in the history of life on Earth, and if not for the contingency of a random catastrophic celestial impact they could well still be thriving today. The whole history of life on Earth is laced with contingency, unpredicted by any genome.

The brilliant French mathematician, astronomer, and physicist Pierre-Simon Laplace most famously put the case for reductionism in his "Philosophical Essay on Probabilities" in 1814. In it he explained:

"….We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of the tiniest atom; for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes".

In a religious age this view held a deep resonance with many theologians of the day. Here was a scientific mechanism by which God could be all knowing! Later on, Twentieth century Physicists struggled mightily with the concept that the universal constants of Nature had values that seemed custom made to the Universe we inhabit, even though there did not seem any necessary reason why any of these constants had the values that they did. There seemed to be only two possible explanations - either we fortuitously inhabit one of an infinite number of possible alternate Universes that exist in other unseen dimensions - or the Universe is a "put up job"! Either way each alternative is as equally terrifying as the other. The idea that a being could know "all forces that set nature in motion, and all positions of all items of which nature is composed" in not only one Universe but also in an infinite number of alternative realties raises to a whole new staggeringly incomprehensible level, the concept of an "all knowing" God!

Ultimately in any case Twentieth century Physics, in the form of the disturbing theories of quantum mechanics - as these relate to the true nature of reality - would shake the very foundational premise of reductionism. Within the oeuvre of quantum mechanics, Heisenberg's uncertainty principle states that the more precisely the position of a particle is determined, the less precisely its momentum can be known, and vice versa. In other words the exact location and velocity of a particle cannot both be known at the

same time - it seems Laplace was wrong - and if Laplace was wrong then ultimately reductionism - even discounting the phenomena of emergence and contingency - will never be able to fully describe the true nature of reality.

In modern science we struggle to understand the nature of the Universe we happen to inhabit. In medical science we struggle to understand the true nature of the human body in both health and disease. We analyse by reductionism the component parts of those who have sustained trauma to their thoracolumbar spine, in order to derive a reliable way of understanding these injuries, and by so doing to formulate a set of "rules" that may be universally applied that may guide us in our decision making regarding the need for CT imaging. By some studies, five component parts are discovered - mechanism, age, ability to communicate, distracting injury and examination findings - which, when combined, should satisfactorily describe this complex assessment. But if applied rigidly then we should CT the spine of the elegantly communicating 61 year old Harvard Professor of Literature, having falling- a fall of 0.9 of a meter - even though he is alert, orientated, in no pain whatsoever, and has no positive examination findings! On the other hand all clinicians, especially who work in high-end volume departments, have been trapped by the patient who - for whatever reason - simply does not convey all the vital facts or even the truth of the history of events - leading us to miss a significant injury.

In the end we are assessing a very complex "system" and total reliance on a reductionist protocol will not always give us a true picture of events in every situation - the contingency for example of the CT scanner "going down" at the critical moment - or the emergent situation of a frustratingly unreliable patient whose history is ever changing and inconsistent!

There is no doubt at all that CT scanning is far superior to traditional radiography when it comes to imaging the thoracolumbar spine - this is not the question however - the question is, ***who*** *to image? We may gain some valuable guidance from reductionist derived protocols - but these can never fully replace what North American clinicians like to call "equipoise" or what German clinicians far more elegantly call "gestalt" ...or what the rest of the "lay" public would simply call....plain common sense!*

Rather than ticking off single items in isolation it is often better to use ***gestalt*** *to assess the* ***emergent*** *properties when of all the basic components are combined, as a final complex entity!*

THORACOLUMBAR SPINE CLEARNANCE

Introduction

Thoracic and **lumbar spinal fractures** are *commonly* encountered in blunt trauma patients.

Delays in diagnosis of **thoracolumbar spine (TLS) fractures** can result in significant increases in neurological deficits, (up to an eightfold increase).

For patients who suffer blunt trauma, the imaging of choice for the radiological clearance of the TLS is multiple detector computed tomography (MD-CT).

MDCT scan should be considered the criterion standard screening modality for TLS injuries in blunt trauma patients.

If MDCT scans are not available, the practitioner should consider transferring the patient to the closest trauma facility with MD-CT scan capabilities.

Advantages of MD-CT over Plain Radiography include:

- MD-CT is superior (more sensitive) than plain radiography
- Shorter time to diagnosis
- Cost savings by the elimination of *multiple* plain radiographs.

It is also important to note that when **truncal CT scans** are used for screening in comparison to **multiple region-specific plain radiographs**, there is **no** excess radiation exposure.

Practitioners who elect to use plain films for TLS screening should fully acknowledge and accept the limitations of plain films in relation to the clinical scenario, the mechanism, and the evidence-based recommendations that have been published by the Eastern Association for the Surgery of Trauma. [1]

As thoracolumbar spine injuries are *frequently associated with soft tissue injuries*, it is now also common to "**Pan-Scan**" patients i.e. CT scan of the chest, abdomen, pelvis (and neck and head as clinically indicated) and from these images "**spinal reconstructions**" of the thoracolumbar spine can be done, (without any additional radiation).

MRI should be considered in patients with:

1. Neurological signs
2. Abnormalities detected on MDCT

3. Suspected significant soft tissue injuries:

- Spinal Epidural Hematoma
- Ligamentous injuries

CT Angiography or **MRA** is performed if an associated vascular injury is suspected or needs to be ruled out.

Epidemiology

Thoracic and lumbar spinal fractures are commonly encountered in blunt trauma patients.

Approximately 50% of all vertebral fractures occur in the thoracolumbar spine (TLS).

The incidence of TLS fractures in trauma patients presenting to Level 1 trauma centres is 4 - 5%.

Neurologic injury to the spinal cord occurs in 19% - 50% of these patients.

Clinical assessment

Screening for **TLS injuries** is critical owing to the potentially devastating consequences that unrecognized fractures and resultant spinal cord injuries can have on patient outcomes.

Indications for MDCT of the TLS are essentially similar to those for cervical spine imaging and so include the following **5 groups**:

1. Impaired Ability to Communicate:

   Examples include:

   - Altered conscious state (i.e. GCS < 15)
   - Intubated patients
   - Drug / alcohol affected.
   - Intellectual impairment (consider).
   - Language barrier (consider).
   - Psychiatric disorder (consider).
   - Opioid analgesia has been given, (within previous 4 hours)

2. Positive Physical Exam:

- Pain
- Tenderness
- Deformity
- Neurological deficit

3. High risk Mechanism:

Examples include:

- Fall > 1 meter (or 5 steps).
- Axial load to the head (e.g. diving).
- Motor vehicle mechanisms, involving:
  - ♥ High speed MCA (> 60 km/hr)
  - ♥ Ejection
  - ♥ Rollover
  - ♥ Any motorized unenclosed vehicle; (e.g. motor cycle).
  - ♥ A bicycle collision
- Crush injuries
- Pedestrian struck by motor vehicle.
- Significant damage to vehicle.
- Death of another person

4. Distracting Injuries:

No *precise* definition for distracting injury is possible, and so experienced clinician judgment will be required.

It may include any condition thought by the clinician to be producing pain that is sufficient to distract the patient from a coexisting spinal injury.

Examples may include, but are not limited to, the following:

- Any long bone fracture.

- Visceral injury requiring surgical consultation.
- Extensive laceration, degloving injury, or crush injury.
- Significant burns.
- Any injury producing acute functional impairment.

Physicians may also classify *any other* injury as distracting if it is thought to have the potential to impair the patient's ability to appreciate other injuries.

5. Age:

- If age is **≥ 60 years,** then examination becomes much less reliable

Clinical Clearance for TLS Injury in Adults

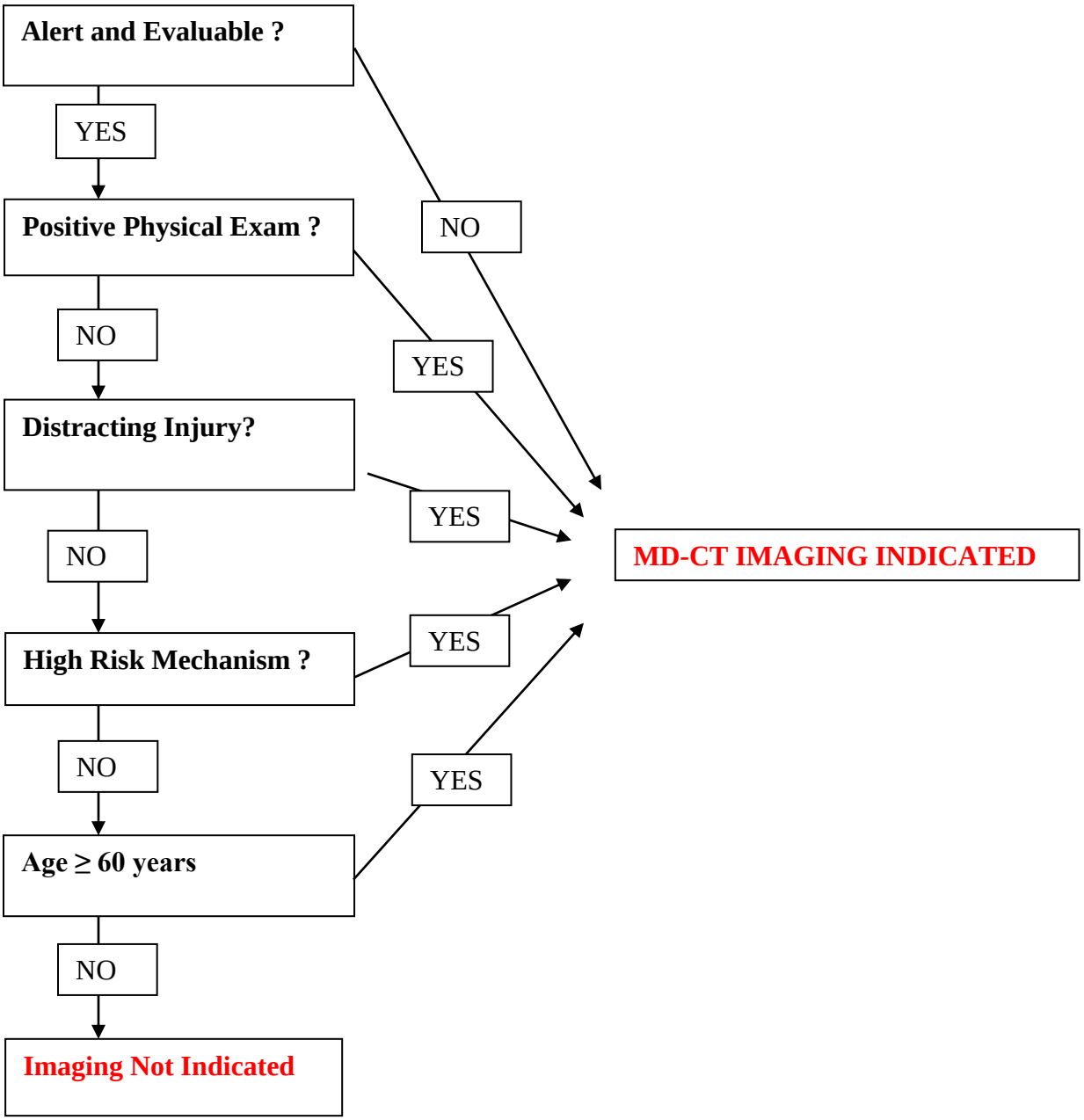
Adults with blunt trauma, may be clinically cleared of a TLS injury, providing:

1. They are alert and evaluable
2. There are no abnormalities on physical exam
3. There has not been a high-risk mechanism
4. There is no significant distracting injury.
5. Age is < 60 years.

See Appendix 1 below for a summary clinical pathway

Appendix 1

Suggested Thoracolumbar Spine Imaging Pathway for Blunt Trauma: [2]



References

1. Sherry Sixta, Forrest O. Moore et al. Screening for thoracolumbar spinal injuries in blunt trauma: An Eastern Association for the Surgery of Trauma practice management guideline. J Trauma Acute Care Surg. 2012;73: S326YS332.

2. Inaba K, Nosanov L, Menaker J, et al. Prospective derivation of a clinical decision rule for thoracolumbar spine evaluation after blunt trauma. J Trauma Acute Care Surg. 2015; 78: 459 - 467.

3. Jeff Riddell at al. A Clinical Decision Rule for Thoracolumbar Spine Imaging in Blunt Trauma? Ann Emerg Med. 2016;68:781-783.

    - doi.org/10.1016/j.annemergmed.2016.10.018

Dr J. Hayes
March 2018