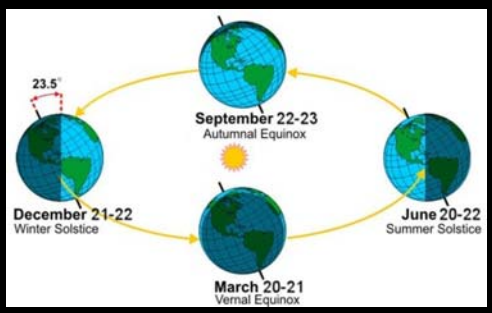
Pediatric Blunt Abdominal Trauma: Solid Organs, Seatbelts, and Sieverts

Tucker Redfern Symposium 2018

Ramin Jamshidi, MD FACS



23 March

1965: Gemini 3 launch

2001: Mir scrapped

The Plan

Solid Organ Injuries
Seat-Belt Trauma
Abdominal Imaging

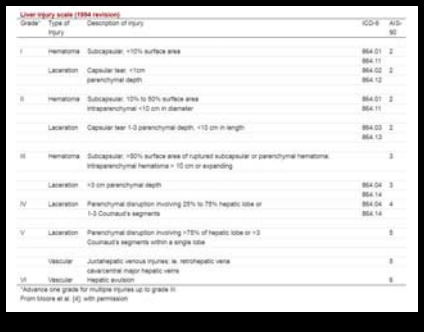
Core principles
Key publications
Discussion

Scope of the Problem

Incidents and Case Fatality Rate by Mechanism of Injury

MECHANISM	NUMBER	PERCENT	DEATHS	CASE FATALITY RATE
Fall	48,106	34.11	704	1.46
Motor Vehicle Traffic	33,434	23.70	1,065	3.19
Struck by, against	13,860	9.84	187	1.35
Transport, other	9,914	7.04	143	1.44
Firearm	6,211	4.40	695	11.19
Pedal cyclist, other	4,478	3.17	48	1.07
Other specified and classifiable	4,987	3.54	230	4.61
Cut/pierce	4,546	3.22	71	1.56
Hot object/substance	4,144	2.94	4	0.10
Natural/environmental, Bites and stings	2,802	1.99	40	1.43
Unspecified	1,451	1.03	46	3.17
Fire/flame	1,286	0.91	39	3.03
Other specified, not elsewhere classifiable	806	0.57	23	2.85
Overexertion	819	0.58	4	0.49
Natural/environmental, Other	566	0.40	3	0.53
Pedestrian, other	709	0.50	29	4.09
Machinery	586	0.42	4	0.68
Poisoning	90	0.06	0	0.00
Suffocation	250	0.15	61	29.05
Drowning/submersion	125	0.09	36	28.80
Adverse effects, medical care	11	0.01	0	0.00
Adverse effects, drugs	5	0.00	0	0.00
Mv/Hit	1,873	1.33	29	1.55
Total	141,051	100.00	3,461	2.45

SOI: Liver



Liver injury scale (1994 revision)

Grade*	Type of Injury	Description of Injury	ICD-9	AIS-90
I	Hematoma	Subcapsular, <10% surface area	864.01	2
			864.11	
	Laceration	Capsular tear, <1cm parenchymal depth	864.02	2
			864.12	
II	Hematoma	Subcapsular, 10% to 50% surface area	864.01	2
		Intraparenchymal <10 cm in diameter	864.11	
	Laceration	Capsular tear 1-3 parenchymal depth, <10 cm in length	864.03	2
			864.13	
III	Hematoma	Subcapsular, >50% surface area of ruptured subcapsular or parenchymal hematoma; Intraparenchymal hematoma > 10 cm or expanding		3
	Laceration	>3 cm parenchymal depth	864.04	3
			864.14	
IV	Laceration	Parenchymal disruption involving 25% to 75% hepatic lobe or 1-3 Couinaud's segments	864.04	4
			864.14	
V	Laceration	Parenchymal disruption involving >75% of hepatic lobe or >3 Couinaud's segments within a single lobe		5
	Vascular	Juxtahepatic venous injuries; ie, retrohepatic vena cava/central major hepatic veins		5
VI	Vascular	Hepatic avulsion		6

*Advance one grade for multiple injuries up to grade III.
From Moore et al. [4], with permission

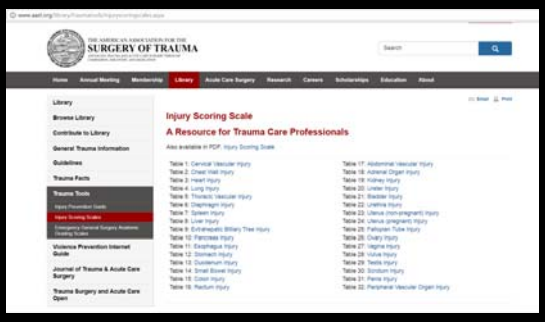
SOI: Spleen

Spleen injury scale (1994 revision)

Grade*	Injury type	Description of injury	ICD-9	AIS-90
I	Hematoma	Subcapsular, <10% surface area	865.01	2
			865.11	
	Laceration	Capsular tear, <1cm parenchymal depth	865.02	2
			865.12	2
II	Hematoma	Subcapsular, 10%-50% surface area	865.01	
		Intraparenchymal, <5 cm in diameter	865.11	
				2
	Laceration	Capsular tear, 1-3cm parenchymal depth that does not involve a trabecular vessel	865.02	
			865.12	
				3
III	Hematoma	Subcapsular, >50% surface area or expanding; ruptured subcapsular or parecymal hematoma; intraparenchymal hematoma ≥ 5 cm or expanding		
	Laceration	>3 cm parenchymal depth or involving trabecular vessels	865.03	3
			865.13	
IV	Laceration	Laceration involving segmental or hilar vessels producing major devascularization (>25% of spleen)		4
V	Laceration	Completely shattered spleen	865.04	5
	Vascular	Hilar vascular injury with devascularizes spleen	865.14	5

*Advance one grade for multiple injuries up to grade III.
From Moore et al. [4] with permission

AAST Grades of Injury

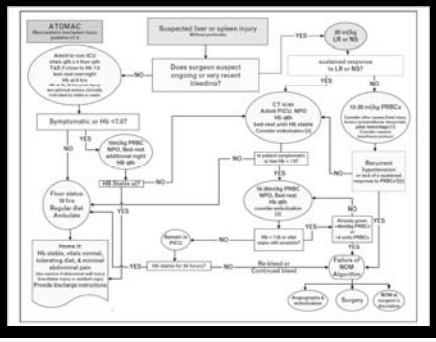


SOI Management

APSA Guidelines (2000)

Clinical parameter	CT grade of injury I	II	III	IV or V
ICU stay (day)	None	None	None	1
Hospital stay (day)	2	3	4	5
Predischarge imaging	None	None	None	None
Postdischarge imaging	None	None	None	None
Activity restriction (weeks)	3	4	5	6

ATOMAC Guidelines



Non-Op Failure

- No/Transient response to 20mL/kg cryst + 20mL/kg PRBC
- Unstable of hgb < 7 after 40mL/kg PRBC
- Splenic blush not predictive

SOI Post-Discharge

- Restricted activity: grade + 2 weeks
- No routine follow-up imaging
- High-impact activities?

Solid Organ Injury

CliffsNotes

- AAST standardized grading
- Non-op management generally successful
- Consider failure at 40mL/kg PRBC
- Uncertainty in f/u imaging & rough activity


Seat Belts Laws

Seat Belt Sign

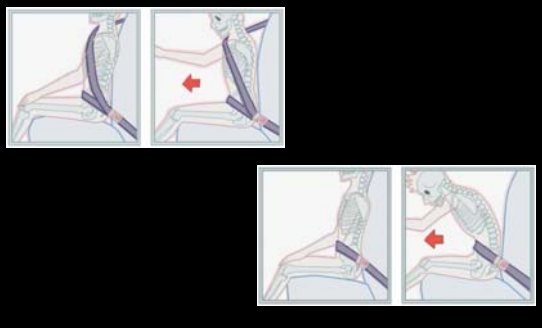
Yes, Wear Them

- Mandatory seat belt laws
  - Fatalities reduced 8%
  - Serious injuries reduced 9%
- Primary laws more effective than Secondary laws

Seat Belts in MO

Seat Belt Sign

Belt Position



"Seat Belt Syndrome"

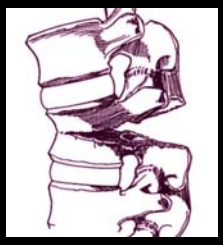
THE SEAT BELT SYNDROME

JOHN W. GARRETT AND PAUL W. BRAUNSTEIN, M.D.

INTRODUCTION

During the past few years, automobile seat belts have received wider public acceptance than ever before. Whether this acceptance reflects the efforts of the nationwide educational campaign sponsored jointly by the American Medical Association, the United States Department of Health, Education and Welfare, and the National Safety Council, the Fort Wayne seat belt program, the study of seat belt effectiveness (7) by Automotive Crash Injury Research of Cornell University, etc., or whether it reflects a growing public awareness of the fact that certain preventive measures can be taken to protect our occupants in case of an accident is difficult to determine. Whatever the reason, the public is more receptive; seat belts are better publicized and more readily obtainable and, as a result, more belts are purchased and installed in automobiles than ever before. It is probable that the presence of seat belt attachment points in the 1962 models of American automobiles and the continuation of educational programs will further accelerate this trend.

Abd wall bruising, intra-abd injury, spinal fracture (J Trauma 1962)



SBS / Intra-Abd Injury

ORIGINAL CONTRIBUTION

Association Between the Seat Belt Sign and Intra-abdominal Injuries in Children With Blunt Torso Trauma in Motor Vehicle Collisions

- 585 pts w/ sbs: 14.4% IAI (6.8% to OR)
  - 5.2% IAI w/o sbs (1.5% op'n)
- Of 249 IAI, 71% SOI, 25% GI, 6% panc

SBS / Intra-Abd Injury

- 120 pts, 38 w/ abnormal CT
  - 13% HVI
- 1/5 of HVI identified delayed
  - CT 3.6% false negative

Identification of S/B Injuries

- CT imaging important consideration
- Observation may be required despite CT

Seatbelt Syndrome

CliffsNotes

- Seatbelts are good
- Injuries are not rare
- CT may be indicated
- May need more than CT to exclude injury

BAT Evaluation Options

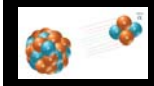
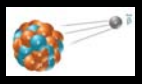
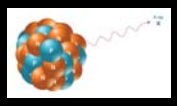
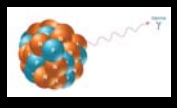
- Labs
- Imaging
  - CT
  - MRI
  - U/S
- Observation
- Diagnostic Laparoscopy

Radiation Measures

- Grey (Gy) = 1 Joule / kg
  1 Gy = 100 rads
  Physical quantity
- 1 Sv = biological effect of 1 Gy absorbed
  1 Sv = 100 rem
  Measure of effect

Radiation

- Beta and gamma equivalent, alpha worse
  - 1 Gy alpha 20x worse than 1 Gy gamma
  - 1 Gy gamma = 1 Sv
  - 1 Gy alpha = 20 Sv

Radiation Exposure

Median Effective Radiation Dose for Each Type of CT Study

Anatomic Area, Study Type	Median (mSv)	Range (mSv)	Dose equivalent (No. of chest x-rays)
Head and neck			
Routine head	2	0.3–6	10
Routine neck	4	0.7–9	55
Suspected stroke	14	4–64	199
Chest			
Chest, no contrast	8	2–24	117
Chest, with contrast	8	2–19	119
Suspected pulmonary embolus	10	2–30	137
Coronary angiogram	22	7–39	309
Abdomen-pelvis			
Routine abdomen-pelvis, no contrast	15	3–43	220
Routine abdomen-pelvis, with contrast	16	4–45	234
Multiphase abdomen-pelvis	31	6–90	442
Suspected aneurysm or dissection	24	4–60	347

Food and Drug Administration Public Health Notification. Reducing radiation risk from computed tomography for pediatric and small adult patients. Available at: http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/PublicHealthNotifications/ucm080185.htm Accessed March 19, 2018.

Radiation Risk

Background Radiation

- US average: 3 mSv / year
- Denver: 6 mSv / year
- Flight crews: + 2.2 mSv / year

Attributable Incidence

Risk prediction models from Japanese atomic explosion survivors

- Sum 50-60 mGy head: 3x brain tumor *f*
- Sum 50-60 mGy marrow: 3x leukemia *f*
- 40yo woman coronary CTA: 1/270
- 40yo woman head CT: 1/8100
- 29k future CA related to US CTs in 2007
  - A/P 14k, C 4k, H 4k

Rads

- **Sensitivity: Lung > liver > muscle or skin**
- **Leukemia <= 10 years**
- **Exposure @ 50: 1/3 risk of 30 yo**
- **10 yo ~ 2 times risk of 30 yo**

Pediatric Sensitivity

- Under age 10 ~ 3 times as sensitive
- Effective doses 50% higher
- Inherent sensitivity
- Longer lifetime

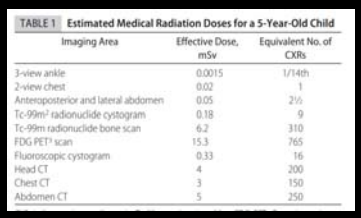


TABLE 1 Estimated Medical Radiation Doses for a 5-Year-Old Child

Imaging Area	Effective Dose, mSv	Equivalent No. of CXRs
3-view ankle	0.0015	1/14th
2-view chest	0.02	1
Anteroposterior and lateral abdomen	0.05	2½
Tc-99m[2] radionuclide cystogram	0.18	9
Tc-99m radionuclide bone scan	6.2	310
FDG PET[3] scan	15.3	765
Fluoroscopic cystogram	0.33	16
Head CT	4	200
Chest CT	3	150
Abdomen CT	5	250

Pediatric Radiation Risk

Examination	Effective dose (mSv)	Lifetime risk of fatal cancer
Limbs	<0.005	1/a few million
Chest (PA)	0.01	1/million
Spine (AP, PA, Lat)	0.07	1/150000
Pelvis	0.08	1/120000
AXR	0.10	1/100000
MCU	1.0	1/10000
CT Head	2	1/5000
CT Body	10	1/1000

Exposure Reduction

- Scan only when necessary
- Adjust exposure for size
  - Reduce tube current
  - Increase pitch
- Scan only areas of particular interest
- Limit resolution (ALARA)

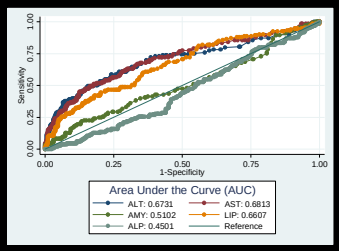
BAT Evaluation Options

- Labs
- Imaging
  - CT
  - MRI
  - U/S
- Observation
- Diagnostic Laparoscopy

Labs

- Used as a ‘screening test’ to decide on CT
- Unknown pathophysiology (AST/ALT with spleen)
- Inconsistent threshold use

Labs: ROC for any IAI



Ultrasound (FAST)

- Free fluid not specific
- Free fluid not indication for operation
- Weight/size-based variation in fluid

Ultrasound (FAST)

- Helpful IF
  - Hemorrhage with hypotension
  - Refractory to transfusion
  - No other source of hemorrhage

    …might operate on basis of FAST
- Must maintain practice if considering use

Choosing to Image


Identifying Children at Very Low Risk for Blunt Intra-Abdominal Injury in Whom CT of the Abdomen Can Be Avoided Safely

Christian J Streck, MD, FACS, Adam M Vogel, MD, FACS, Jingwen Zhang, MS, Eunice Y Huang, MD, FACS, Matthew T Sammut, MD, FACS, Kuojen Tsao, MD, FACS, Richard A Falcone, MD, FACS, Melvin S Dassinger, MD, FACS, Robert T Russell, MD, FACS, Martin L Blakely, MD, MS, FACS, for the Pediatric Surgery Research Collaborative

- Abd pain
- Abd TTP, distension
- Abnl CXR
- AST > 200
- Abnl Amy or Lip

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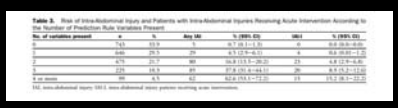

- Abd pain
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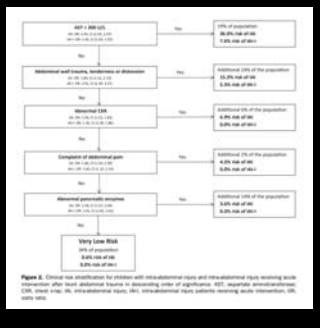

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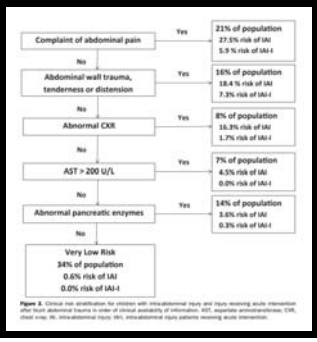

Abd Trauma CT

CliffsNotes

- FAST & labs have limitations
- CT is ideal mode – use when necessary
- Recognize rad risks & inform families
- Consider observation / laparoscopy

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THANK YOU

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