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RESEARCH ARTICLE

BIOMECHANICS OF CAR CRASH RELATIONSHIP BETWEEN THE VEHICLE OCCUPANT AND THE VEHICLE' S RESTRAINT SYSTEM IN TIME OF A CRASH: SEAT BELT SYNDROME CASE REPORT

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Abstract

The purpose of this article is to help surgeons understand and anticipate the pattern of injury, and biomechanics of the seat belt syndrome (SBS), better assess trauma patient and identify a patient who is more likely to have an underlying issue, caused by improper use of the seatbelt.We present a case of SBS occurring in a patient with a high BMI and an improper relaxed position, in context by a frontal car impact. The purpose is to use an example to describe the dynamic between the car occupant and the vehicle in case of a high-speed collision and what type of injury to expect.

Introduction:-

The invention of the automobile revolutionized everyday life, both a jewel of technology and innovation, considered by many as one of the greatest and most important inventions in human history, its everyday use became a social game changer. According to a study done by Harvard Health Watch, we spend on average 101 minutes per day driving.

As many advantages automobile use provides, a risk remains. Road traffic collisions (RTC) are responsible for 3,700 deaths daily, up to 1,2 million yearly deaths worldwide. Most of them are Adults between the ages of 14-45 years old. 1,8 trillion dollars is the estimated cost to the world economy of fatal and non-fatal crash injuries from 2015-2030[1] .

Low-and Middle-Income Countries (LMICs) are most affected.

In Morocco for instance, 75% of RTC involve young adults between the age of 15-64 years, with a ratio of 5:1 male to female with up to 1,143 life years. Affected due to disability from road crash injuries per 100,000

The science of road traffic collision and its impact on the driver deserves a chapter on its own. What makes RTC [2]complex to manage are the multiple variables interacting. Predicting the severity of the lesions starts by predicting how the vehicle and the body will react in a high-speed collision. Specific characteristics range from the vehicle size, shape, impact speed effectiveness of absorbing impact energy, to the driver or passenger age, gender, BMI, biomechanical tolerance, and seatbelt wearing … without forgetting the circumstance of the accident and the effectiveness of the medical treatment. For vehicle-to-vehicle impact whether it be frontal, or side impacts the change of velocity or Delta-V is the most accurate predictor of injury severity, considering the characteristics of the vehicle, such as weight and stiffness, in addition to the initial speeds of the vehicle involved. The use of the seatbelt

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has alone prevented 50-80% of all deaths of RTC[2]. Meanwhile, the restrained occupants who survived were shown to have more incidence of vertebral and intra-abdominal injuries compared with unbelted occupants. Are those Injuries caused by a seatbelt or detected more in those who survived?

The aim of this article:
1-is to understand how severe injuries occur at high-speed velocity
2-review the seatbelt development, Understand the mechanism of seat belt protection at high velocity, and the type of injury that might occur mechanism of action and effects
3-How to evaluate this type of patient and understand the importance of early diagnosis through a case study

Seat Belt Syndrome
A 44-year-old male, with no previous medical or surgical history, presented to the emergency after sustaining a road traffic accident. Context of the accident: Two cars enter a frontalCollision, the second car driver and the passenger were not wearing a seatbelt both dead. The patient and the passenger in the second car were both wearing their seatbelt, the patient was the driver and had a front impact and the airbag was deployed.

On presentation, he was conscious Glasgow Coma Scale 15, Breathing spontaneously Respiratory rate of 15 Oxygen saturation 95% , vitals stable cardiac frequency 78. There were multiple abrasions on the face, arms, and abdomen.

Computed tomography (CT) Abdomen showed no significant abdominal or pelvic findings Patient asked to be released against doctors will 6 days later, Patient returned to the emergency, upon admission with an important abdominal distention, associated with vomiting, fever, tachycardia and tenderness with guarding in the abdomen. CT's abdomen showed an important inflammatory bowel obstruction with no visible obstacle. There were no signs of intra-abdominal injuries. Meanwhile, the abdominal pain increased. He was tachycardic (heart rate 120/min). He was admitted to the OR for an exploratory laparotomy which revealed a mesenteric injury with devascularization of the terminal ileum a resection and anastomosis of the segment involved is performed. Postoperative day 2, The patient developed signs of acute abdomen, tachycardia 128, CRP reactive protein 475 Lactate800, and was taken for exploratory laparotomy which showed anastomotic leak. An ileocolic resection was done with double stomia. Post-operative the patient developed a wound infection which prolonged his hospital stay. The patient was discharged on day 20 with rehospitalization 3 months later for restoration of digestive continuity.

Figure 1:- Intra-operatives image of a mesenteric tear in a case of seat belt syndrome.

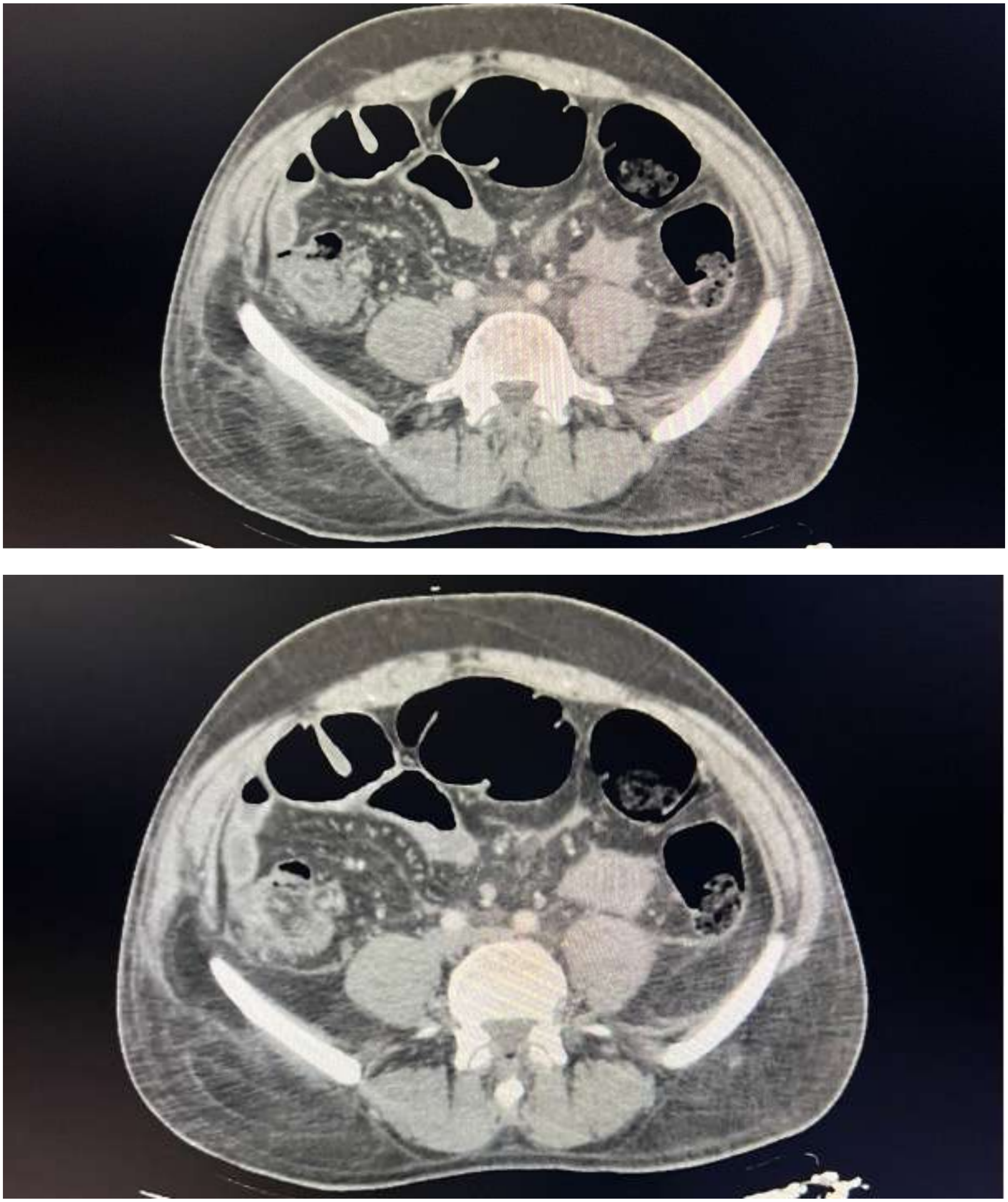

Figure 2:- CT images 6 days after the car crash.

Discussion:-

What happens to a car in frontal high-speed impact?

When a car is at rest it remains at rest. When a car is in motion it remains in motion, at a constant speed and in the same direction unless it is deviated from its trajectory by an unbalanced force. This is what is commonly known as the Newton law of motion.

Whenever a car is involved in a crash, whether it be a frontal impact, side impact, roll over … an important number of kinetic forces is displayed. An acceleration corresponds to the force based on the speed and the mass of the car and the speed and the mass of whatever it hits. In case of a crash there is a rapid change of speed over a very short period, this is what is commonly referred to as a deceleration (negative acceleration).

FORCE= Mass*Accélération

Based on this equation we understand that in order to reduce the forces applied on the vehicle during a crash one must reduce the deceleration.

In case of a frontal impact involving two moving objects, the force is equally applied to both cars, bending parts of the frame, smashing body panels, shattering glass. all these actions require energy. In1952, an engineer named "Bayenri" reflected on how this energy can be absorbed during an impact, preventing it from being transmitted to the occupant therefore causing severe injury, he came up with the concept of crumpling zones.Crush zones are areas of the vehicle that are designed to deform and crumple in a collision.
two safety goals:
1- reduce the initial force of crash
2 -redistribute the force before it reaches the vehicle's occupants

Many factors to consider in designing safer cars vehicle size, weight, frame stiffness and the stresses the car is likely to be subjected to in a crash, different type of material

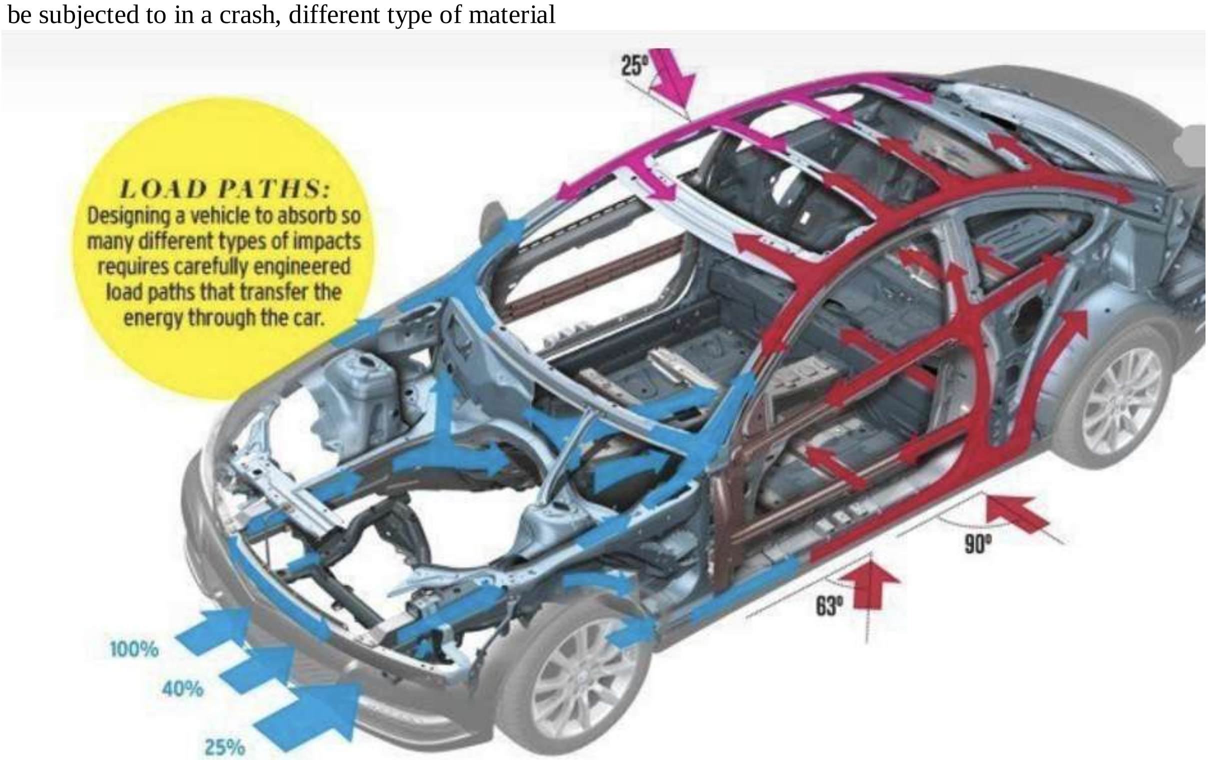

Figure 3:- Crumbles zones distribution examples in cars from Car and driver journal 2013 January issue.

What happens to the body inside the vehicle?
Imagine a vehicle going at a high speed collision vehicle to vehicle frontal impact the driver and the passenger are the first one to receive the blast wave and a powerful deceleration causing the body to move forward , the seatbelt constraints it applying a force to the thoracic and abdominal regions , the lap belt is not anymore on the iliac crest impacting the pression in the abdominal cavity the abdomen support 4 time less force than the pelvic regions[1] thus impacting the movement of the intestines , the liver and spleen by their anatomical position under the ribs are fixed and therefore more exposed to serious injuries this is commonly known as the submarine effect. During a frontal impact the driver is the safest passenger during the crash of the vehicle the downward force of the deceleration is blocked by the backward movement of the dashboard limiting the movement of the pelvic region, the lap belt can't

not go back up over the iliac crests limiting the possibility of a serious abdominal injury, the driver benefits also of more front and knee airbags, a double pretension, anti-slide hump…

The front passenger on the other hand is more exposed to the submarine effect due to the distance between the body and the dashboard and a position more free/relaxed than the driver

The rear passengers are 4,1 more time exposed than the driver due to the placement of seat belt buckles they are also often not equipped with pretension system and load limiter which can decrease the thoracic pressure when present, the deceleration unlock the seat belt movement thus impacting the placement of the belt on the iliac crest in addition to the lighter structure of the rear seat and the absence of anti-slide hump making the passenger feel the deceleration more[3][3,4].

Figure 4:- Car crash Dummies Tests from the united states department of transportation NHTSA.

The Abbreviated Injury Scale (AIS) is a score assessing the severity of injuries following an impact and classifying it according to a body region on a 6 point scale

Anatomy of a seatbelt

The seatbelt offers a better distribution of the stopping force throughout the body to minimize the damage, preventing ejection from the vehicle. The energy transfer is the best predictor of abdominal injury, it also appears that the higher the BMI, the smaller the lap belt angle the seatbelt sign position might be higher in obese individuals which may increase the risk of the seat belt syndrome. The presence of the SBS 4-time likelihood of chest injury and 8 time likelihood of abdominal injury than without this sign.

The seatbelt syndrome represents a triad from abdominal wall ecchymosis (AWE), visceral injuries and Musculo skeletal injuries. `

AWE commonly seen in the key placement of the 3 points belts, they present as avulsion, laceration, bruising, in some impact they can be so severe they've caused the decapitation of occupants or impact.

3 types of injuries can occur: crushing injury, viscous injury (blunt force injury) , blast injury the severity depends on the magnitude and direction of the force, body orientation, time duration , seat pitch.

Abdominal injuries are mainly observed in frontal impacts 52%, the most injured just after the thorax the most frequently injured organs are the small bowel 17% at a high velocity the "moving " organs follows the speed of the vehicle the sudden deceleration combined with the stopping force of the seatbelt causes the crushing of the terminal ileum on the right iliac crest of the pelvis by the lap belt the shearing forces cause a mesenteric tears and severe bleeding.

The liver 13% The liver can sustain up to 340 N without injury, a force of 500 N is required to produce AIS 3 injuries and a force of 650 N is required to produce AIS 5 injuries, the reported injuries are seen at a high velocity sub scapular, hemorrhaging, tears and fracture. The spleen 16% is less stiffer than the spleen making it more prone to AIS 3 injuries.

Upper jejunum and colon perforation are due to sudden change of pressure and compression between the seat belt buckle and the vertebral column.

The duodenum and the pancreas are damaged by the force produced by the pression driving wheel and the body flexion [1][5][3,4].

So how can we learn from this data?

Polytrauma response is not standard, it depends on the hemodynamic state of the patient, as well as the injured organ. It can be conservative or surgical, uni-disciplinary or multidisciplinary, involving a wide range of specialties interacting, thus implying symptoms that interact and can be misinterpreted. The multiple variables interacting in the biomechanics of abdominal lesions during a car crash and the complexity of lesions.

We propose the implementation of a checklist, details of the accident, the state in which the body was found… available to both first respondent and physician upon admission of any trauma patient which will allow a fast, easy and efficient assessment of trauma patients, considering the full spectrum of injuries possible for each case.

Identify pattern of injury based on the collision circumstances (frontal impact…)

Plan of action in case of an early discharge to detect early signs of peritonitis or hemorrhage (visit every week, CT scan control…)

Understand the mechanism of injury to better detect it.

The checklist is currently being implemented in IBN SINA Hospital Rabat, for a trial period the results will be published later this year.

Références:-

[1] Yamagata H, Nishida N, Izumiyama T, Asahi R, Koike M, Mihara A, et al. A radiographic and physical analysis of factors affecting seat belt position in sitting car seat. Scientific Reports 2022;12.

https://doi.org/10.1038/s41598-022-14607-x.
[2] Clement EOO, Kelechukwu O. The biomechanics and pathogenesis of seat belt syndrome: Literature review. Nigerian Journal of Medicine 2019;28:323. https://doi.org/10.4103/1115-2613.278605.
[3] Xiao S, Yang J, Crandall JR. Investigation of chest injury mechanism caused by different seatbelt loads in frontal impact. Acta BioengBiomech2017;19:53–62.
[4] Torba M, Hijazi S, Gjata A, Buci S, Madani R, Subashi K. Seat belt syndrome, a new pattern of injury in developing countries. Case report and review of literature*. G Chir2014;35:177–80.
[5] Al-Ozaibi L, Adnan J, Hassan B, Al-Mazroui A, Al-Badri F. Seat belt syndrome: Delayed or missed intestinal injuries, a case report and review of literature. Int J Surg Case Rep 2016;20:74–6.