TRAFFIC ACCIDENTS
INJURIES AND MORTALITY

Traffic accidents occupy an important position in the medico-legal pathology, because of the various juridical problems they raise and the necessity of medical intervention in solving them.

WHO statistics show that every year over 150,000 persons are killed in the world in traffic accidents and that for every death there are 10-15 severely injured and 30-40 lightly injured.

THE MAIN FACTORS INVOLVED IN TRAFFIC ACCIDENTS

A thorough analysis of the injuries discovered in live and dead victims of traffic accidents allows the elaboration of interpretation algorithms for the identification of the implicated traumatic agents.

The factors involved in traffic accidents are:

- ***the conditions of the road***
- ***the technical condition of the vehicle***
- ***the driver (the human factor)***

The condition of the roads

Crossroads, especially those improperly or purely signalized are often involved in traffic accidents, mostly in urban areas and more rarely on open roads. Left turns in intersections seem to have the highest potential for accidents.

Traffic security is influenced by the way traffic network is conceived:

- curves
- inclinations
- visibility distances
- the quality of the roads.

Inclined roads have a higher rate of accidents. Modern highways and cross-country roads correctly built and adapted to the requirements of nowadays traffic is safer for traffic participants.

Twilight can increase the frequency of traffic events.

Roads need to be sufficiently large to ensure a fluent, risk-free traffic. The existence of at least three tracks for each direction on important roads is a rational concept that offers maximum safety.

Traffic signalling is extremely important for traffic safety. The lack of proper signalling or its improper placement significantly increases the risk of accidents.

The technical condition of the vehicle

It is evaluated that this factor is responsible for approximately 12% of all traffic accidents.

The updated technical revision of vehicles is a necessity; is assesses if cars provide the technical standards required by law.

The braking, steering, illumination and signalisation systems need to be in perfect condition and to ensure safety on public roads.

The condition of the tires is easier to appreciate; an exaggerated wear leads to defective breaking and exposes to side-splits on slippery roads, especially during rain.

Passenger and luggage overload can be cause for loosing vehicle stability and it can lead to severe accidents; wind and improper tires are favouring factors.

The driver **(driver-related factors are involved in ¾ of all traffic accidents.)**

1. Individual factors

a. Driving errors

Driving errors are considered responsible for most accidents. They include excessive speeding, right of way disturbances, lack of attention, carelessness before changing direction, pedestrian carelessness etc.

b. Somatic and psychological factors

The driver's age is an important factor. Although young drivers have the ability of fast learning, they lack self-control, prudence and, of course, inexperience.

Both male and female drivers under 50 represent high-risk groups, with an incidence peak between 20 and 39 years old.

The driver's personality, temperament and psycho-affective constitution also need to be taken in consideration.

Even in subjects with optimal aptitudes, experience and training, the physiological state can intervene and has to be taken in consideration.

Safe driving involves the integrity of all sensorial abilities and accommodation reflexes; visual and audditive aptitudes are most important.

A diminished visual acuity can significantly increase the potential risk for accidents; for example myopia over 6 or hypermetropia over 3 are incompatible with driving.

Other visual factors that affect the driving capacity are:

- *monocular vision (influences the appreciation of distances)*
- *narrowed visual field (blurred peripheral details)*
- *decreased lateral vision or alterations of chromatic vision (the impossibility of distinguishing the colour red of traffic lights).*

Fatigue, regardless of its aetiology, decreases attention and vigilance.

c. Driver's illnesses and accidents

The identification of certain illnesses in case of traffic accidents is very important because it can play an important role in determining the accident, causing death or preventing a future incident.

Cardio-vascular diseases, especially ischemic disorders, are most frequently associated with traffic accidents.

Epilepsy is also known as an important risk factor for accidents by loss of vehicle control. Such drivers have to be identified and denied the right to get a driving license.

Diabetics can also cause accidents during hypoglycaemia. Moderate hypoglycaemia (2.6 mmol/l) can severely deteriorate driving skills but only a part of these drivers is aware of this fact.

2. Exogenous factors

Alcohol and traffic accidents

Driving on public roads under the influence of alcohol is a potential risk for traffic accidents, so alcoholism is considered a major triggering factor for traffic accidents.

This is why laws in all countries incriminate driving under the influence of alcohol, with different superior limits of blood alcohol levels, regardless wetter a traffic incident took place or not. (RO limit: 0.8 g‰).

The highest risk age group for drunk driving is 20-29, for both genders.

Most deadly accidents associated with alcohol consumption take place between 22:00 and 04:00.

Pedestrians represent the higher percentage of victims.

The metabolism of alcohol

After ingestion, alcohol is absorbed first through the bucal mucous membrane. Absorption continues in the stomach and is maximal in the small intestine.

Alcohol metabolism is performed in the liver, by alcohol-dehydrogenase. The remaining alcohol is metabolized by the mycrosomial enzymatic oxidative system (MEOS). MEOS activity can be increased by some drugs and by chronic alcohol consumption. This explains the high tolerance to alcohol in chronic consumers. An enzyme called catalase mediates a third, normally insignificant metabolic path.

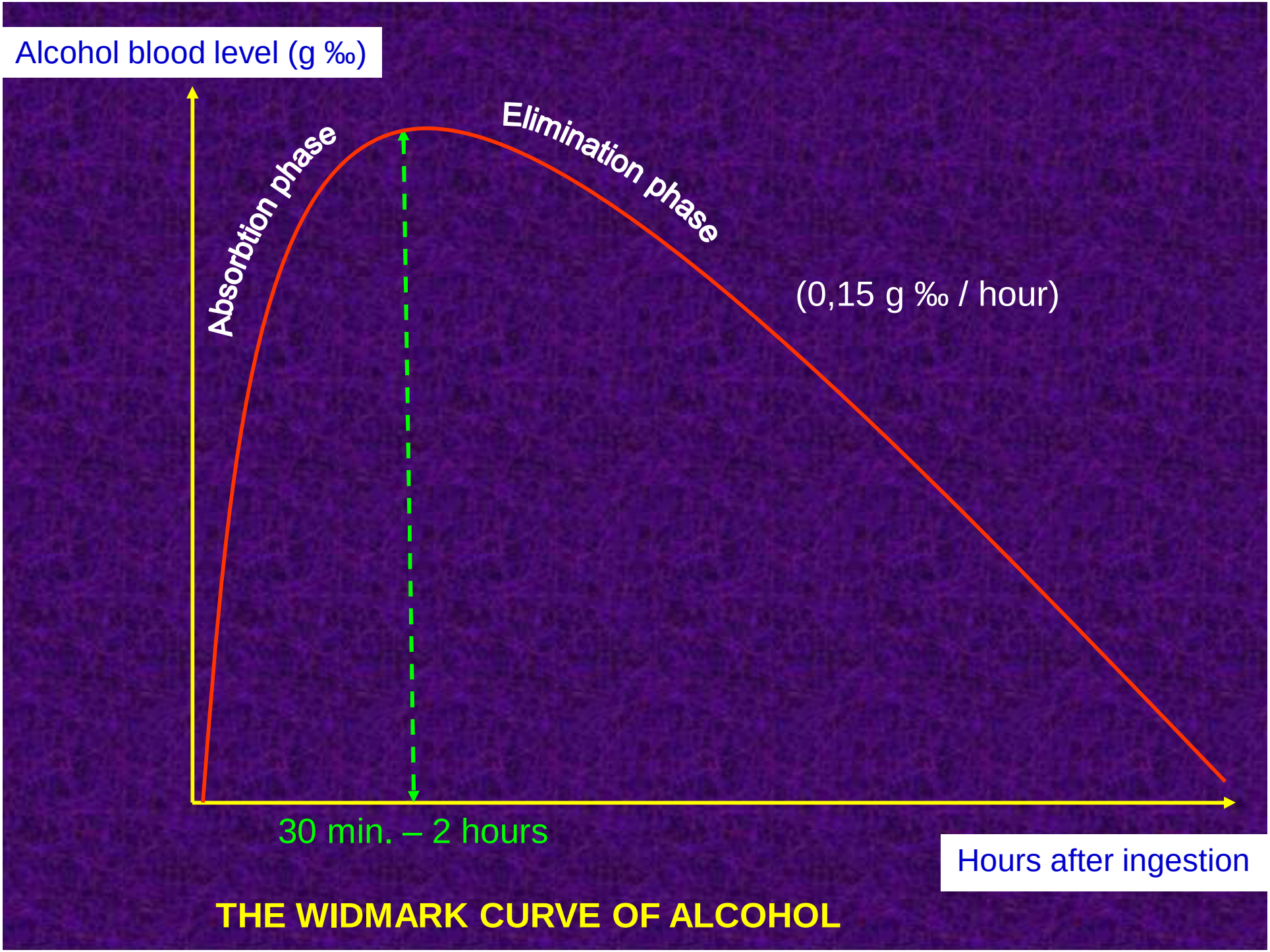
Alcohol metabolism is non-linear and this fact has implications in calculating the blood alcohol level at a certain moment after sampling.

The maximum blood alcohol level is reached 20-30 minutes after ingestion, on an empty stomach, and after 1-2 hours on a full stomach; the food content delays the absorption.

The Widmark curve represents the alcohol metabolism by hepatic alcohol dehydrogenase. In healthy subjects, approximately 90% of the ingested alcohol is eliminated from the blood stream by hepatic metabolism, with a rate of 0.15 g‰.

The relation between the blood alcohol level (alcoholemy) and the urine alcohol concentration (alcoholury) is very important from the medico-legal standpoint. An alcoholury higher then the alcoholemy in the moment of sample collecting is an indication that the subject is in the alcohol elimination phase; if the alcoholemy is higher and alcoholury is zero the subject can be in the absorption phase.

The repeated alcohol consumption determine the cumulative effect of the alcohol showed on the blood alcohol level curve.


Alcohol blood level (g ‰)
Absorbtion phase
Elimination phase
(0,15 g ‰ / hour)
30 min. – 2 hours
Hours after ingestion
THE WIDMARK CURVE OF ALCOHOL

The effects of alcohol on the driving skills

Alterations of the cognitive functions, motor coordination and sensorial perception appear at values over 0.5 g‰ blood alcohol level.

Alcohol blood level (g ‰)	Stages	Effects
under 0.50	Sobriety	No visible effects. Possibly logorrhoea and well-being sensation
0.50 - 1	Euphoria	Unclear speech, bravery, decreased concentration and sensorial perception
1 - 1.50	Excitation	Emotional instability. Significant decrease of concentration. Weak sensorial perception.
1.50 - 2	Drunkenness	Disorientation, mental confusion and dizziness. Decreased pain perception, balance disorders and incoherent speech
2 - 3	Stupor	Generalized inertia, apathy, indifference, lack of sensitivity. Severe lack of response at stimuli. Vomiting, faecal and urine incontinence.
3 - 4.5	Coma	Coma and anaesthesia diminished or abolished impulses.
over 4.5	Death	Possible death due to respiratory paralysis.

THE EFFECTS OF ALCOHOL

Increased blood alcohol levels are associated with various effects on the central nervous system:

- ✓ ***unclear speech;***
- ✓ ***balance disorders;***
- ✓ ***sleepiness;***
- ✓ ***memory disorders and unclear reasoning;***
- ✓ ***diminished perception;***
- ✓ ***low concentration.***

Although alcohol induces a state of well being, in fact it depresses the cerebral functions, decreases muscle control and coordination and prolongs the reaction time.

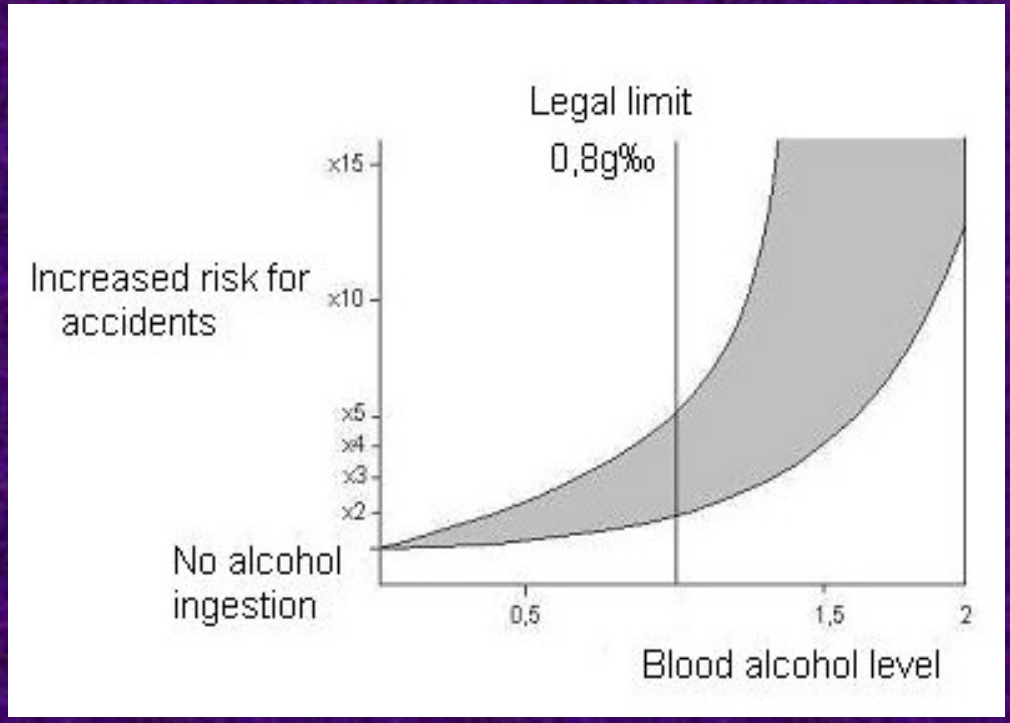
Another consequence is the blurred vision and diminished perception, especially in the dark.

The ability to appreciate speed and distance are also affected, and so is the capacity to face/overcome unpredictable situations.

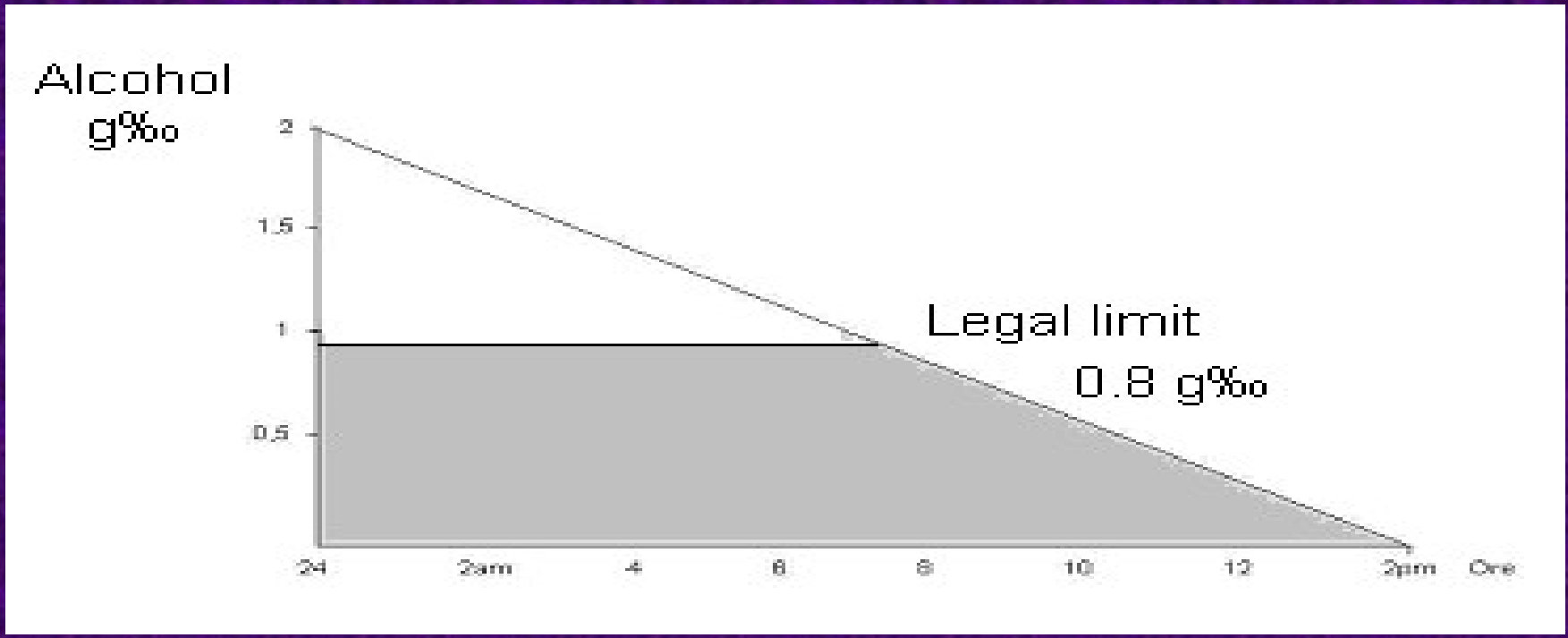
The correlation between the blood alcohol level and the accident risk leaded to the introduction of various legal limits for alcoholemy.

There is no standard "secure" limit or a standard legal limit. Each country established different rules and values. Most scientific opinions are in favour of legal limits around 50 mg% (0.5 g‰), because over this level, the risk for traffic accident increases significantly for all drivers.

The risk of involvement in a traffic accident increases dramatically after the legal limit of alcoholemy is passed, and the probability of a potentially severe accident increases with the alcoholemy.



THE RISK OF TRAFFIC ACCIDENTS REPORTED TO ALCOHOL



ALCOHOL ELIMINATION

Based on the rule that the alcohol consisted in 2.1 litters of air is equivalent with the alcohol in 1 ml of blood, devices have been built that determine the blood alcohol level at the scene.

The most precise methods of determining the blood alcohol level are biochemical, using toxicological analyses (Nicloux method and especially gas-chromatographic method), that give real alcoholemy values.

The effects of medication on driving skills

Numerically speaking, accidents that involve alcohol consumption are much more than those involving medication/drugs.

Many prescription drugs influence the driving skills; these influences are more accentuated at the beginning of treatment, so patients are advised to respect the prescribed doses, to try the medicine first in the evening, at home, not to drive in the first day of treatment and not to combine the prescribed drugs with any other self-medication.

Drugs that have the most powerful negative effects on the driving skills are:

- psychotropes
- tranquilizers
- antidepresives;

They alter attention, diminish reflexes and movements.

Sleep and traffic accidents

Falling asleep while driving is a well-known cause of accidents; most of them occur by driving of road, with or without secondary collision.

These incidents have two time-related peaks: around 6 a.m. and in the middle of the afternoon (siesta time) – periods of maximum vulnerability for the driver to fall asleep behind the wheel.

Mobile phones and driving

The use of cell phones while driving is reason for concern.

A recent Canadian study showed an increase by 4 times of accidents favoured by the use of cell phones. The study shows that 24% of the drivers involved in accidents have used their cell phones in the ten minutes preceding an accident.

It is interesting to notice that the use of "hands-free" mode does not offer the desired safety.

Therefore, forbidding the use of cell phones while driving and reservations regarding the "hands-free" mode are just.

Carbon monoxide

Carbon monoxide intoxication can constitute cause of violent death, of toxic nature, while driving.

Suicide behind the steering wheel

In rare cases, suicide can be the cause of apparent accidents.

Usually in such situations there are no evidence referring to suicidal intentions so the cases can be labelled accidents.

Possible indications of a driving suicide can be: single occupant of the vehicle, seatbelt not used, suicide note.

INJURY MECHANISMS AT VEHICLE OCCUPANTS

The type and severity of an accident are determined by:

I. The kinetics of impact:

- speed and impact force

- the position of the person in the vehicle

- the direction of impact

II. The vehicle design, the presence and usage of safety systems

III. The effects of secondary impact represented by ejection, rotation and other risk factors (vehicle burning)

The major determinant factor for the severity of the accident is the deceleration degree – the speed gradient and the intensity of the deceleration. Most injuries are produced in the first 0.05 seconds after impact. An accident can be considered serious when:

a. Speed higher then 40 km/h, unsecured victim, or speed higher then 55 km/h and secured victim (safety belt);

b. an intrusion from the engine compartment or from the lateral side in the car interior, deeper then 1 meter;

c. the victim is ejected.

Safety inside vehicles can be ensured in 2 main ways:

- ***by controlling peak deceleration forces and stretching them on longer time frames,***
- ***or isolating the occupants from the hostile surroundings.***

The use of safety belts substantially reduces the number of severe and lethal injuries in comparison with uninsured occupants, ejected or not.

Still, severe lesions and deaths occur also in restricted occupants, but mostly at high speeds and at lateral impacts; in these situations the restrictive systems are tested to their limit.

Regarding the position in the vehicle, most deaths involve the driver, followed by the front seat passenger and back seat passengers.

Ejection from the vehicle is much more probable in high-speed collisions and if the vehicle rolls over; it is much reduced, although not completely eliminated, by the use of safety belts.

Most ejections take place through the lateral windows and through the windscreen.

The injuries are much more severe if the victim neither is not restricted (by use of safety belt) inside the vehicle.

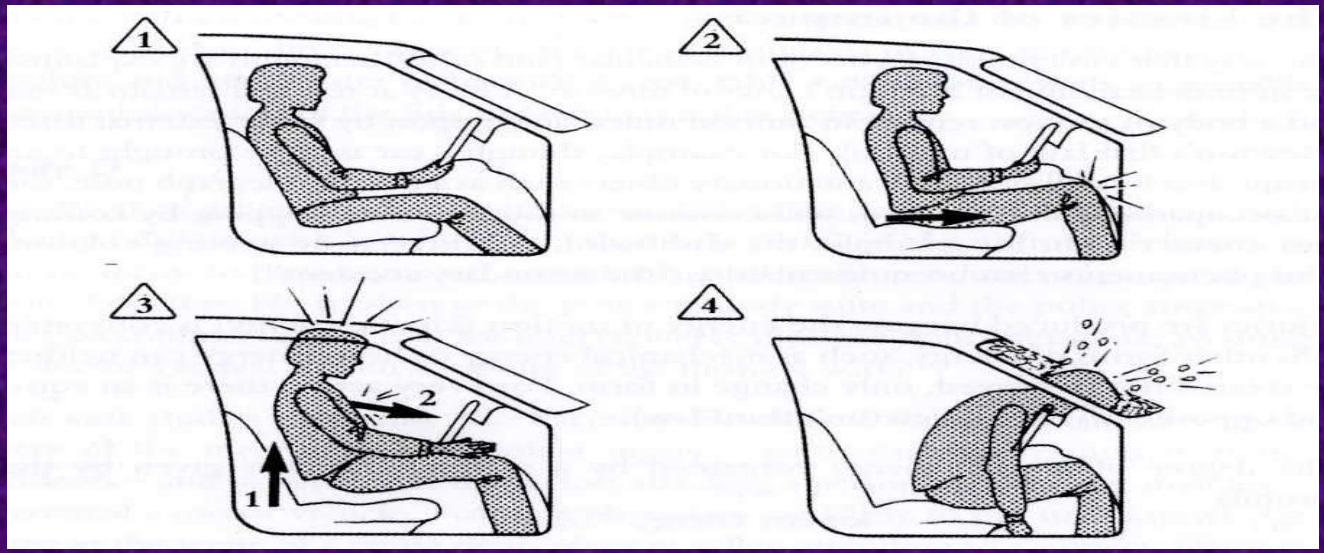
Traffic accident injuries are classified in three main groups:

Mild injuries **– abrasions, wounds or sprained joints, or a mild state of shock that requires medical care at the scene.**

Severe injuries **– which require hospitalization: fractures, large or profound concussions, internal lesions, crushes, profound wounds, severe shock. In some cases, these injuries can present a progressively severe evolution or potentially lethal complications can develop.**

Lethal injuries **– injuries followed by death after a longer or shorter survival interval, depending on their severity and/or evolution.**

The injuries are the result of impact with hard surfaces represented by various profiles from the car interior like the steering wheel, the board or the shield.



INJURIES MECHANISMS IN DRIVER

A predictable sequence of events takes place during frontal impact; it mostly interests the unrestricted occupants and the following movements represent it:

The driver is thrown in forwards and upwards; his lower limbs make contact with the board, the thorax and the superior part of the abdomen with the steering wheel. The driver's body then plunges over the steering wheel so the head bends and hits the shield or the corner pillar.

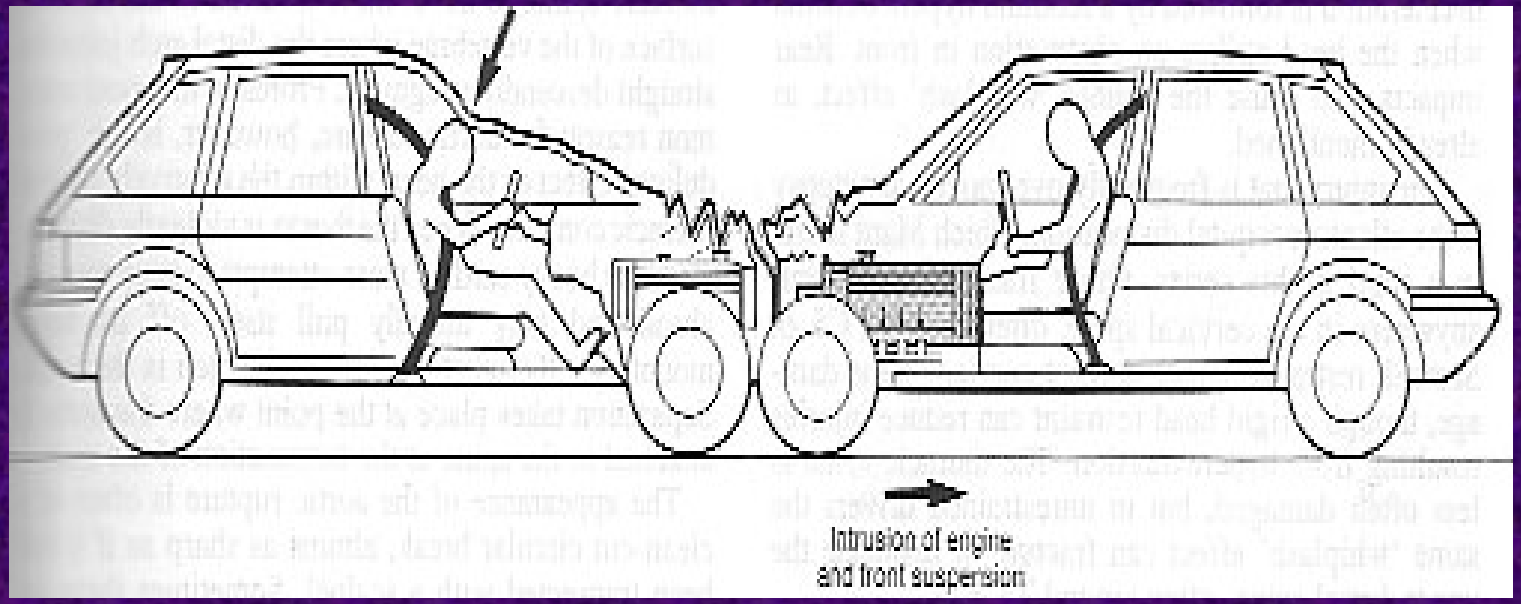
These movements result in injuries to the head, trunk and lower limbs.

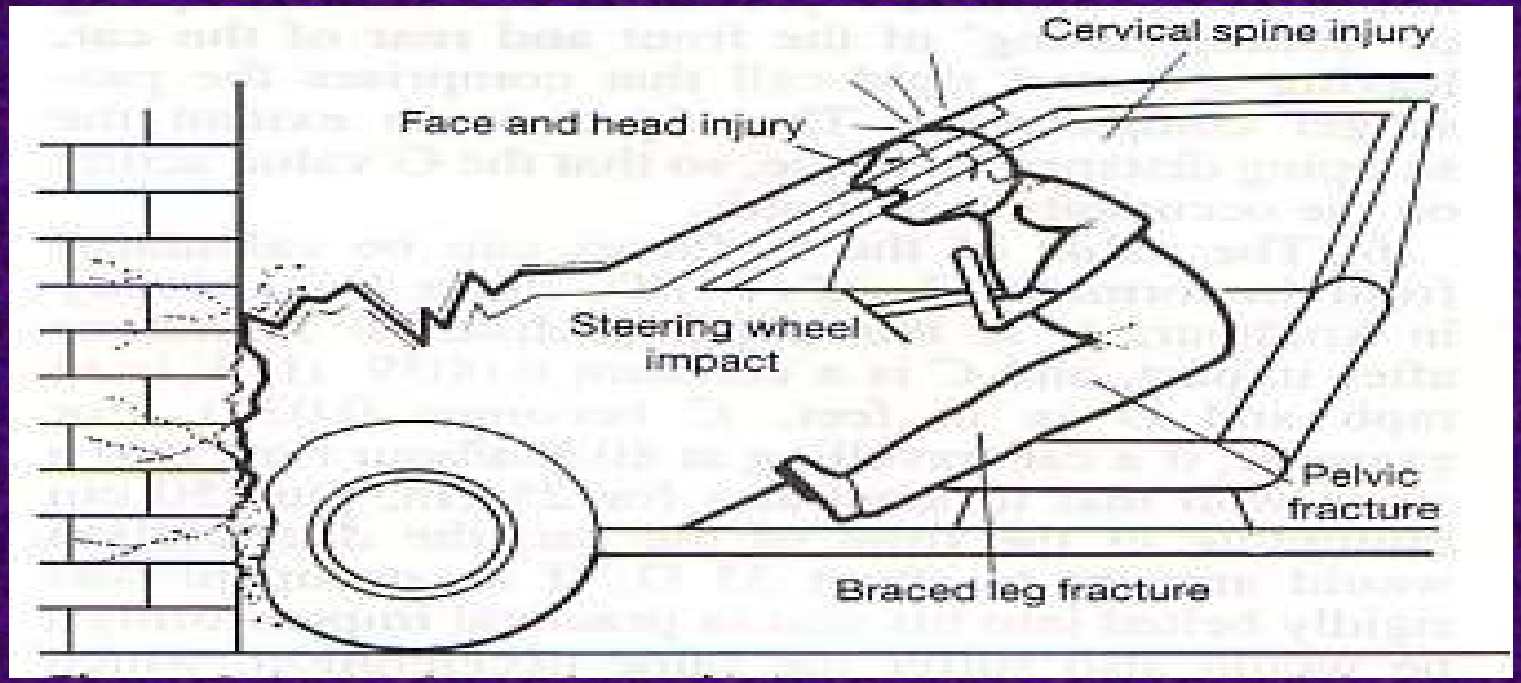
For the front seat passenger, there is no steering wheel to break the forward movement, so the main contact points will be between the lower limbs and the board and between the head and the shield or any other surrounding profiles.

Back seat passengers are thrown forward and will hit the front seats, with lesions to the head, thorax and abdomen.

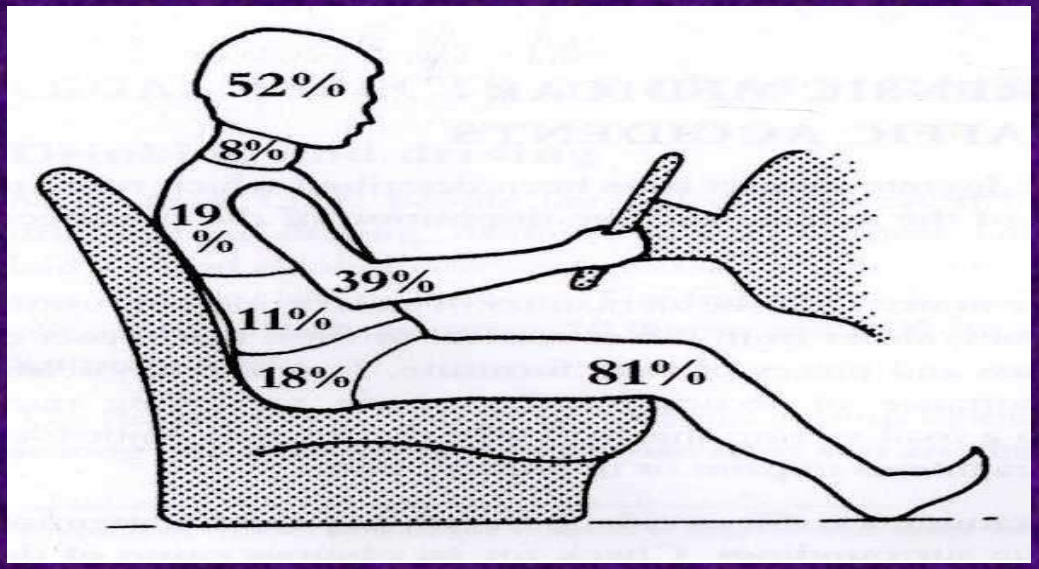
The seat belt alters the above-described dynamics, by substantially reducing forward and upward movements, thus proving its substantial protective role/function.

In frontal impacts, restricted drivers suffer mostly injuries to the head and limbs; most injuries to the upper limbs are due to contact with the steering wheel.


Intrusion of engine
and front suspension


Cervical spine injury
Face and head injury
Steering wheel
impact
Pelvic
fracture
Braced leg fracture

Most frequently injuries areas in frontal collisions:



The most frequently traumatised regions of the front seats occupants

Additional rotation forces and the inside intrusion of the ceiling or doors appear in lateral impacts; they induce direct injuries to the occupants of the respective side – driver or passengers.

When a vehicle is hit laterally, the impact energy is concentrated on the lateral thoracic wall; it determines lateral volets, pulmonary concussions, liver or spleen ruptures, shoulder and pelvic joints injuries.

Rear impact is frequent – a stationary vehicle or a vehicle with low speed is hit from behind. After impact, the vehicle moves forward and in the absence of efficient head protection, the soft tissues of the neck are frequently luxated.

When the car suffers a second crash with another vehicle stationed in front of it, there is the possibility of "secondary impact" injuries, caused by deceleration.

Patterns of injuries in occupants

1. Injuries of the head and neck

Superficial injuries are present in almost 90% of the victims, with or without internal component. Most of them are bruises or irregular abrasions and contusive or crushed wounds, caused by the impact with the structures of the car interior, with structures that penetrate in the car interior, or with the road, in case the victim is ejected from the vehicle.

Most characteristic lesions are caused by impact with the wind screen or the lateral windows. They appear as groups of angular abrasions and superficial wounds, situated on the face or in other areas, often containing fragments of glass.

Facial fractures appear in more than 25% of the victims, particularly in front seats occupants. For them the steering wheel and the board are potential impact structures, even with the seat belt on.

Skull fractures are present in over 50% of deaths. Their nature and topography depend on the impact points. Transversal "articular fractures" that cross over to the opposite side of the skull base are typical. They can be associated with comminuted areas at one or both ends.

In frontal collisions, most fractures prove an impact speed of over 48 km/h; they can also appear in case of lower speed and in lateral impacts, frequently associated with protrusions.

Cerebral lesions frequently appear in association with skull fractures, although they can also appear in their absence.

The types of cerebral lesions vary from thin layer sub-arachnoidian haemorrhages and superficial contusions to massive dilacerations.

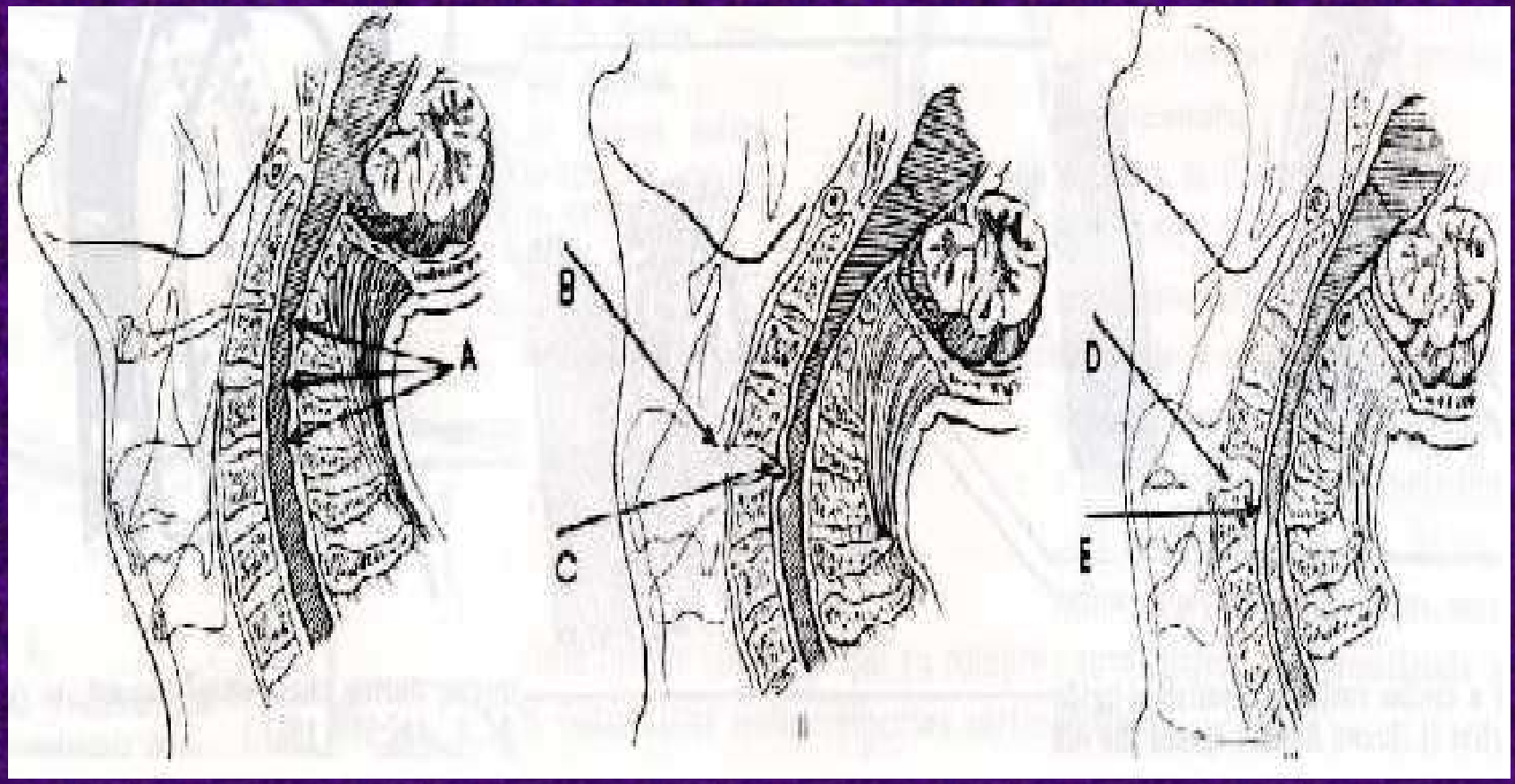
Cervical vertebral column injuries appear in approximately 10% of all traffic accidents. The involvement of the victims varies with the occupied position.

The atlanto-occipital interruption seems to be the most frequent type of injury and it always results in instant death. It can appear in association with skull and/or facial fractures, but it usually is isolated.

Most atlanto-occipital dislocations are more probably the consequence of combined, extension-rotation, backwards movements of the head, rather then of acute flexion, as the clinicians use to consider.

The head (loaded with the own weight) moves forward during the deceleration phase and can provoke cervical and thoracic hyper-flexion injuries.

When the head hits a solid object, the recoil can provoke hyperextension injuries, if the seat is not provided with a headpiece.



FRACTURE MECHANISMS OF THE CERVICAL VERTEBRAL COLUMN

2. Thoracic injuries

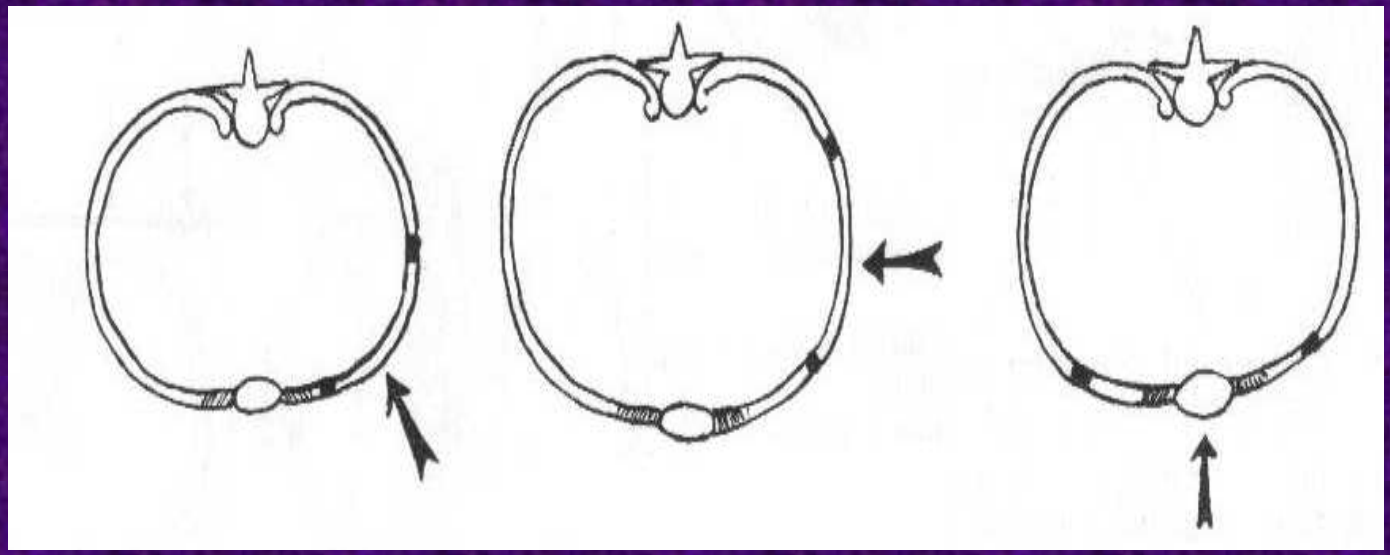
Thoracic injuries are even more frequent then head injuries; they appear in 70% of all accidents and in 80% of the drivers involved in accidents. They include fractures of the thoracic wall, lung and heart contusions due to blunt objects, pleural injuries and pneumothorax.

Superficial lesions are often abrasions and bruises produced in contact with various surfaces inside or outside the vehicle. They can be scares or absent, even in subjects with severe internal damage.

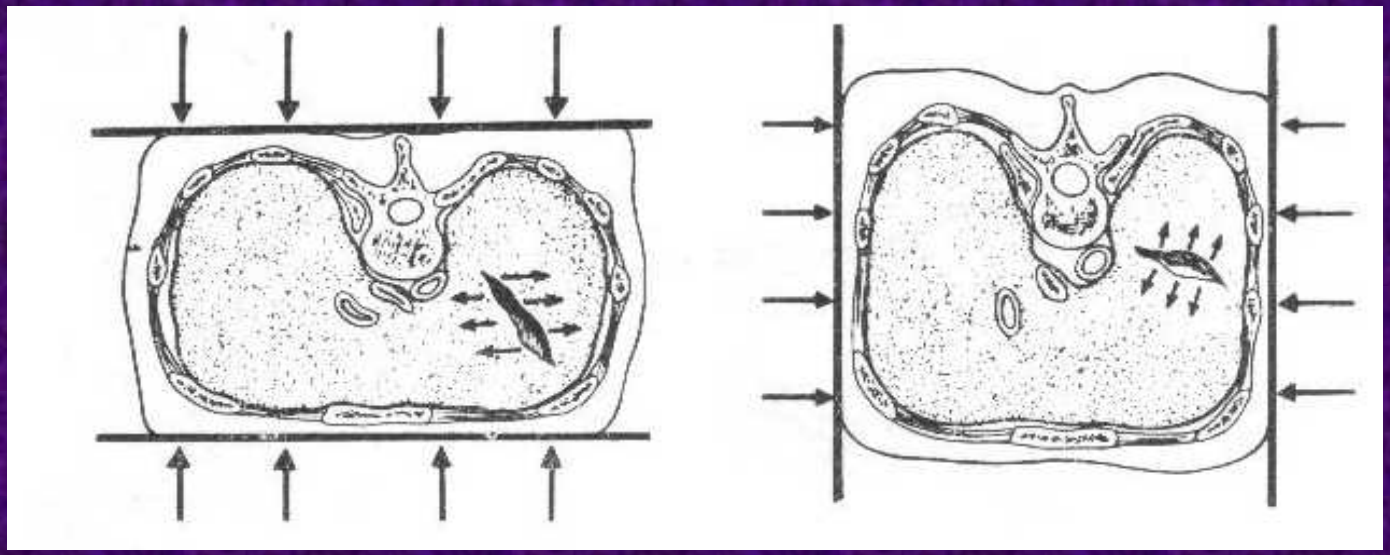
Costal fractures appear in over 70% of the occupants; they are the most frequent injury encountered in traffic accidents. The prevalence of costal fractures on one side can give indications regarding the impact direction. Fractures can occur at any level, and the bone fragments can penetrate the lungs or the heart, determining consecutive, often fatal, ruptures and haemorrhages.

While internal lesions cause most traumatic deaths, occasionally rib fractures can be considered lethal, because of the consecutive acute respiratory failure, particularly in elderly subjects with pre-existent respiratory illnesses.

The pulmonary contusion is the most frequent unique visceral lesion involved in the death of vehicle occupants. It is the result of the impact between the lungs and the thoracic cage, including the vertebral column.

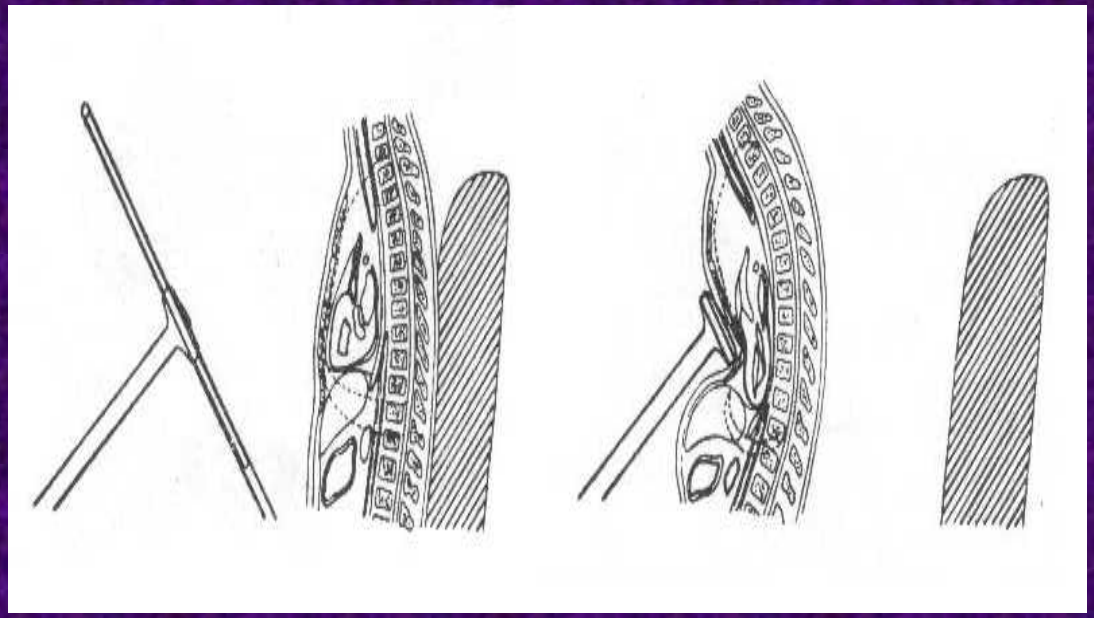


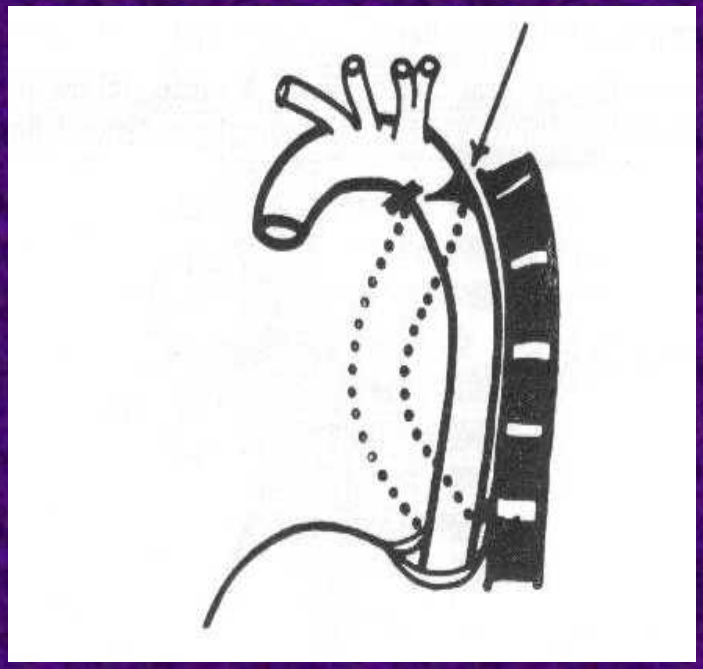
The mechanism of costal fractures



The mechanism of pulmonary contusions

Traumatic lesions of the heart are present in ¼ of the total collisions, with an even distribution to the occupants .





The aortic rupture appears as unique, isolated injury or accompanied by other lethal or non-lethal injuries. Most sectioning and ruptures occur in the proximal segment of the descending aorta and the rest on the ascending aorta, on the aortic arch and on the distal descending portion.

3. Abdominal injuries

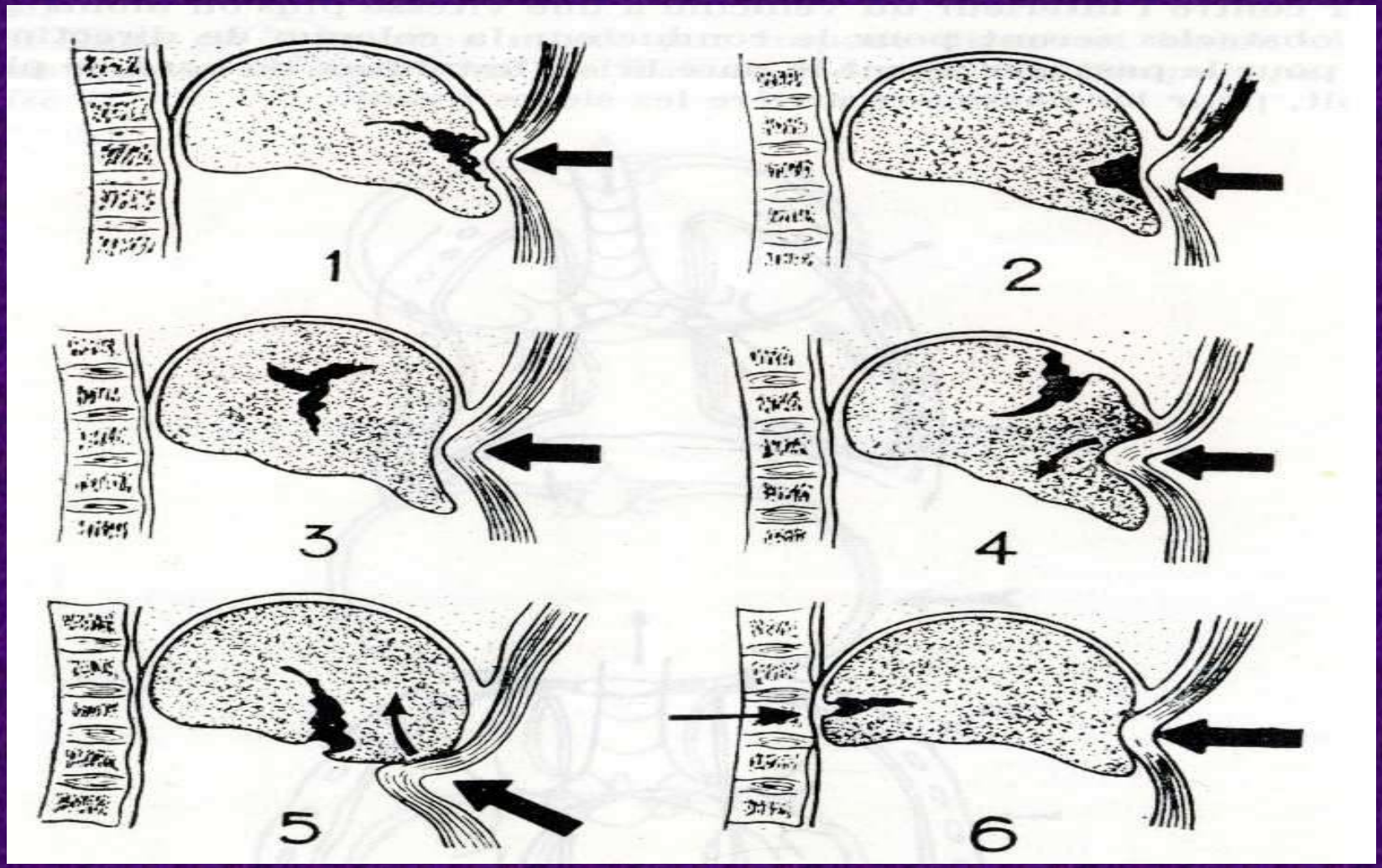
Abdominal traumatisms include, in decreasing order of frequency: hepatic, spleen and renal contusions, resulting from impacts with violent agents.

The liver is most frequently involved; it can display fissures or superficial lacerations, usually on the anterior side and the superior margin of the right lobe. Injuries can also be severe, such as parenchymal ruptures.

Sometimes parenchymal lesions leave the surface intact. In many cases severe liver injuries are associated with internal, especially thoracic injuries.

The spleen is injured in approximately ¼ of the cases and its lesions usually accompany liver traumatisms; occasionally the spleen injury appears singular and it can benefit from surgical treatment is discovered in time.

The kidneys, the suprarenal glands and the intestines can also suffer injuries of various intensities. Surprisingly, the kidneys are often injured, despite of their protected location.



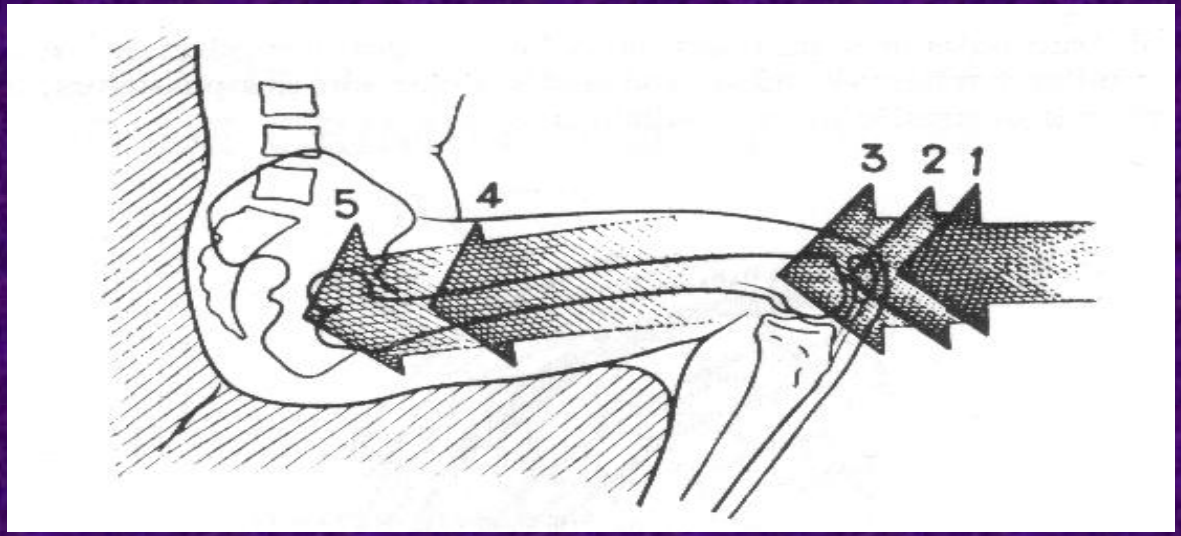
The mechanism of hepatic injuries

4. Pelvic injuries

Pelvic fractures are often dislocations of pubic symphysis with or without fractures of superior or inferior branch.

5. Injuries of the limbs

Injuries of the limbs are caused by the direct impact with surfaces inside the vehicle, while the victim is projected into the steering wheel, the board, the doorframe or the corner pillars. Fractures of the shoulder (scapulo-humeral) joint and of the arms are more frequent in drivers than in the front seat passenger. Femoral fractures are mainly due to impacts with the board or the steering wheel axis while shank and ankle injuries are the result of upwards pressure on the foot.



The mechanisms of femoral and/or pelvic fractures

6. Injuries due to seat belts and air bags

Seat belts **by themselves can favour traffic accidents. Frequently they are incriminated for lumbar column stretching or traumatisms of the abdominal organs.**

Still, the correct use of the seat belt determined a significant reduction of deaths by traffic accidents in the last decades. The most important benefit is the reduction of head injuries, followed by the reduction of thoracic injuries. Moreover, the seat belt minimizes the possibility of ejection from the vehicle (important cause of severe injuries and death).

An efficient seat belt insures the following functions:

- Protects the body against intense deceleration and against impacts with the wind-shield, the wheel or other frontal obstacles;

- Disperses the deceleration forces on a considerable surface – the width and length of the belt on the body – so the force per surface unit is much lower than the one during the collision between the forehead and various car structures (only a few cm^2);

- The belt stretches considerably during a severe deceleration, thus reducing the G-forces by prolonging the deceleration period;

- The belt prevents the expulsion of the occupant outside the vehicle through the windscreen or the opened doors – frequent causes of severe injuries and death.

Although they reduce the probability and severity of the injuries in many situations, seat belts have their own lesion patterns. Authors show an increase of facial and cranial fractures in drivers because of a higher probability of impact with the steering wheel; also, other trunk injuries like costal and sternum fractures and abdominal bruises are cited for the occupants. Minor cervical injuries ("neck sprains") are more frequent in subjects secures with seat belts. More severe injuries that incriminate the seat belts are: abdominal muscles ruptures, sudden rupture of abdominal wall muscles by thoracic or pelvic bone structures, intestinal ruptures due to the compression between the anterior abdominal wall and the vertebral column, Chance fracture – fracture of the posterior processes and/or the vertebral body of the lumbar vertebrae due to the column hyper-flexion.

Air bags have become almost standard automobile equipment, at least for drivers, in most automobiles built after 1992.

The air bag inflates as response to abrupt deceleration, detected by a sensor from the collision surface of the vehicle.

Generally the air bag does not inflate at speeds lower than 30 km/h. Air bags have their own pattern of injuries: face, neck and thorax abrasions, minor skin irritations due to friction on the superior limbs and the eyes, and ocular injuries – from simple corneal abrasions to retina detachments.

INJURY MECHANISMS IN PEDESTRIANS

The main factors involved in pedestrian injuries are: the nature of the vehicle its speed and the nature of the impact; the severity of the injuries is proportional with the weight and the speed of the vehicle.

In decreasing order of frequency, there are five main post-impact trajectories:

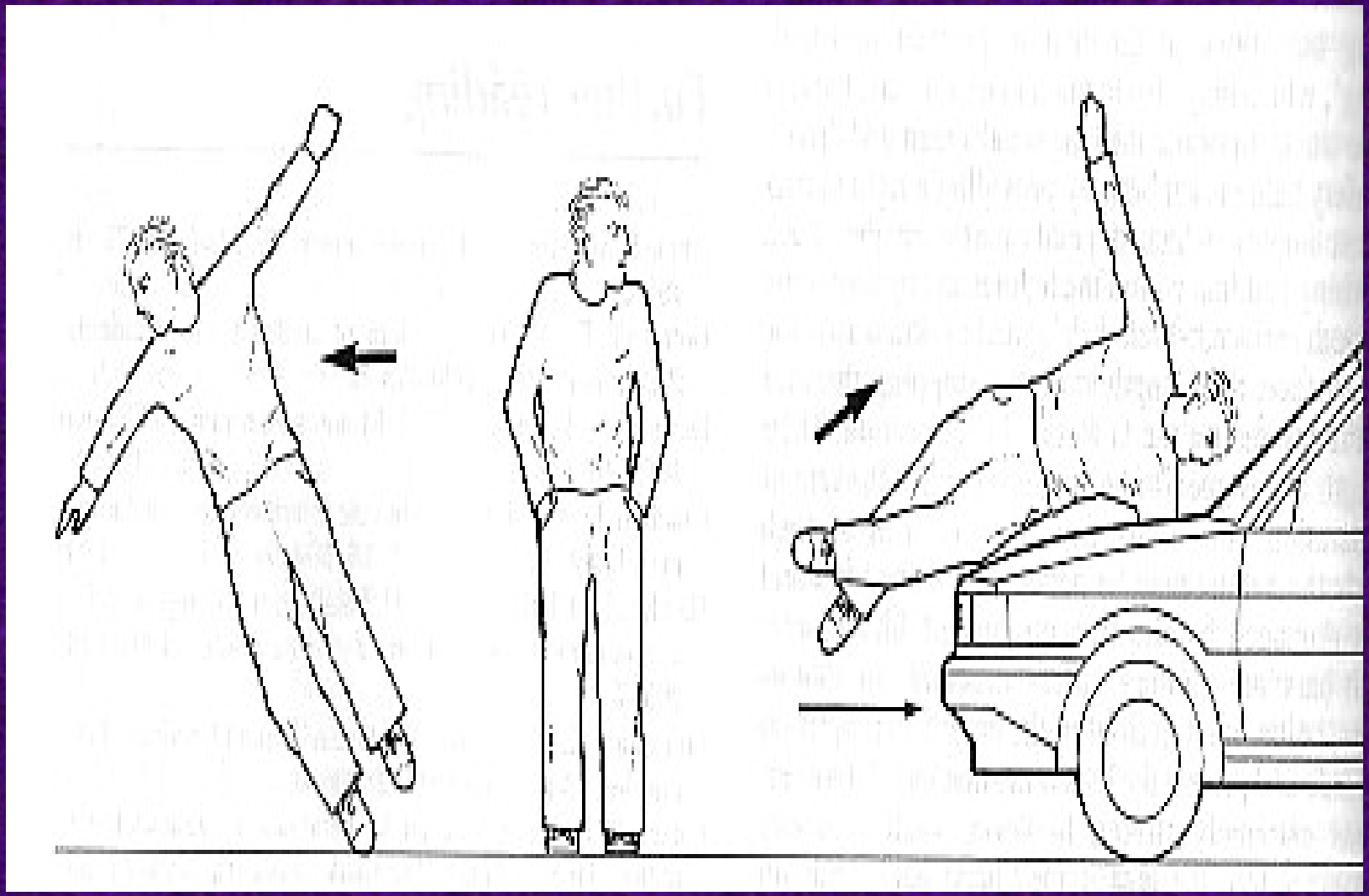
- *contact with the frontal mask*
- *forward projection*
- *contact with the frontal wing*
- *contact with the roof*
- *rolling over.*

1. The contact with the frontal mask

Is responsible for the existence and the aspect of most external lesions.

The pedestrian is initially hit with the bumper - so he will display injuries to the inferior extremity of the inferior limbs, or with the anterior margin of the hood – so the injuries will be on the superior part of the lower limbs or/and in the pelvic area.

The impact can be frontal or oblique, but most impacts are frontal or with the lateral-front mask of the vehicle. This is the ***primary impact*** and in an average adult it will most probably determine injuries in the distal femoral half and the proximal half of the shank.



After the first impact, the victim is twisted and the superior half of the body (head, shoulders, and thorax) is thrown over the hood. This is *the secondary impact*.

In the next moments, the victim will follow the vehicle's trajectory and speed, while the driver pushes the brakes as a reflex reaction to the impact. The car will decelerate rapidly, pushing the victim that will fall in front of the vehicle and will hit the surface of the road – *the third impact*.

2. The forward projection

Usually, this mechanism takes place when the frontal impact is with a truck or bus, or if the victim of the impact with a vehicle is a child.

Immediately after the primary impact the victim is projected upwards, after which it falls on the road, at risk of also being run over.

The secondary injuries are often more severe than the primary ones, especially those to the head, thorax and pelvic area.

The impact with the road can determine multiple linear abrasions caused by friction during side splits.

Rarely the victim remains on the vehicle for a few seconds after which it falls on the road on the lateral side; secondary impact lesions are associated with the risk of being run over by other moving vehicles.

3. Contact with the frontal wing

- appears when the victim is hit with an anterior angle of the vehicle. In this case, the victim is carried along the lateral wing and falls on the lateral side of the vehicle or near the rear end.

4. The contact with the hood

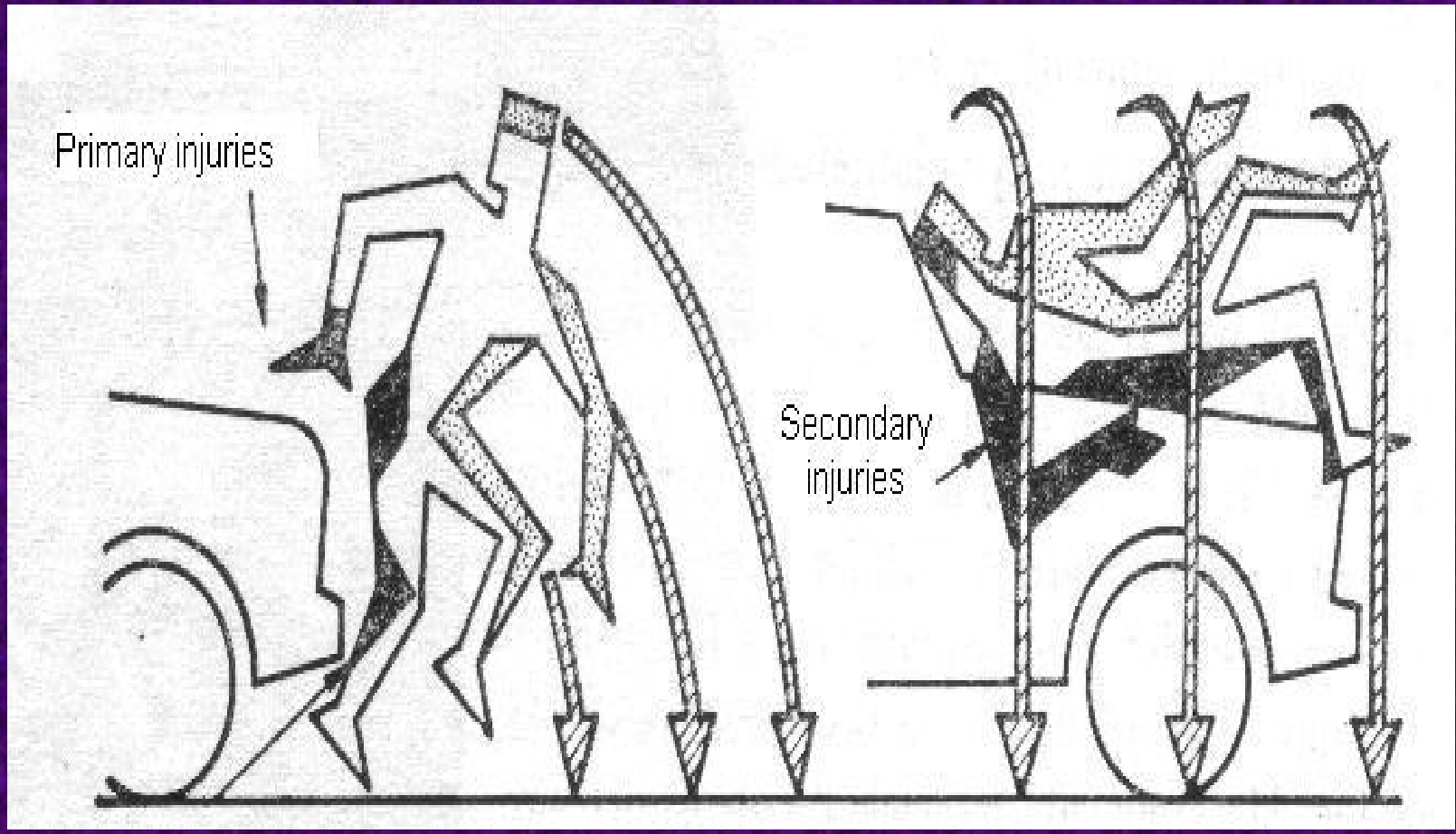
- takes place either at high speed impact or if the driver accelerates after impact. After the secondary impact with the hood, the victim slides over the wind screen, over the roof and falls at the rear end of the vehicle, on the road. The contact with the roof is usually involves adult victims with high balance centre.

5. The rolling

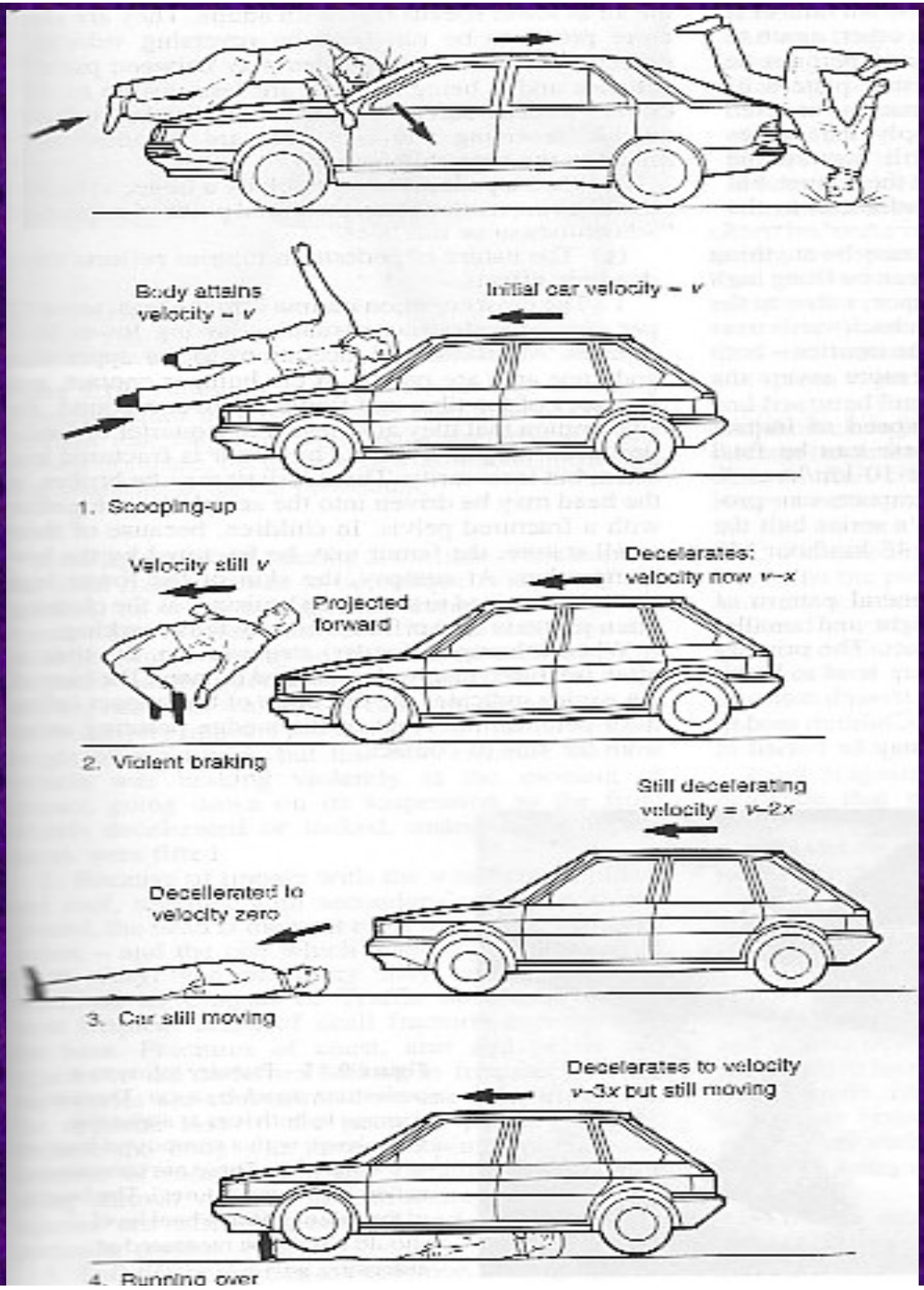
- is rarely involved in the post-impact trajectory. It is caused by high impact speed and it involves a sufficiently strong force applied to the inferior part of the body so it rotates in the air before falling on the road. In this type of mechanism, there are no secondary impact injuries.

The victim is projected and hits the surface of the road at a distance from the impact point – "projection distance". In these cases, there is a good correlation between the vehicle's speed and the projection distance, if the vehicle does not decelerate at impact or immediately after impact. This correlation can only be applied if there are clear tire marks on the road.

If pedestrians suffer a frontal collision and the impact is in the superior part of the body, the risk of being run over is much higher.



The victim is thrown over the hood (Scripcaru)


Body attains velocity = v
Initial car velocity = v
1. Scooping-up
Velocity still v
Projected forward
Decelerates: velocity now v–x
2. Violent braking
Still decelerating velocity = v–2x
Decellerated to velocity zero
3. Car still moving
Decelerates to velocity v–3x but still moving
4. Running over

Patterns of Injuries in pedestrians

1. Superficial lesions **offer valuable information. They are present in most cases and are the result of contact with the involved surface, mostly the face, upper and lower limbs.**

Extensive abrasions **describe the contact with the road and indicate the surface contact with the vehicle. The direction of the abrasions help establishing the direction of the fall, because it is known that the initial part is clearly contoured and the final one is irregular, diffuse. Abrasions can be contaminated with small fragments of glass and paint, important elements for the investigation.**

Patterned injuries **preserve the share of prominent vehicle parts that can help identifying the vehicle.**

Tire marks **are a specific category of injuries. They are usually zigzag abrasions or bruises that show total or partial run over. They appear on the areas of skin forced into the tire profiles, while the run over areas remain clear.**

Crush injuries **can produce expensive skin detachments, usually on the lumbar areas. These injuries are the result of the vehicle crossover the victim's anatomical parts with the wheel. Crush injuries do not necessarily involve skin ruptures; in these cases, large subcutaneous spaces with significant blood collections develop.**

Injuries to the inferior limbs, **associated or not with corresponding fractures, can be mainly considered primary impact injuries. They can be bruises, abrasions or wounds, on one or both inferior limbs. The symmetry of the injuries on one side of the body (anterior, posterior) suggests the orientation of the victim in the moment of impact.**

2. Injuries of the head **are frequent in traffic accidents, with particularities for the pedestrians.**

In most cases the head hits the shield frame or the door pillars. There is a direct relation between the vehicle's speed and the cranial injuries (Ashton) – the higher the speed, the more severe the injuries. Severe injuries are also the result of the impact with the road or other rough objects.

Scalp detachments**, cranial fractures, meningeal haemorrhage and cerebral lesions are also frequent.**

Cranial fractures **are diverse, but the most frequent is the transversal base fracture, determined by the impact with the lateral areas of the head. Multiple comminute fractures of the vault appear especially as result of crushing or compression with the wheels.**

Cerebral lesions **usually accompany the cranial fractures, but there are also cases in which cerebral damage is severe in the absence of skull fractures.**

An important type of lesion is the diffuse haemorrhage in the white matter (diffuse cerebral contusions), sometimes associated with corpus callosum disruptions and focal haemorrhages in the pons.

The diffuse contusions of the white matter are the result of capillary disruptions, caused by scissoring forces. These lesions, due to their localization and extension are usually lethal.

3. Injuries of the neck: the most common injuries are the atlanto-occipital disjunctions, met in high-speed collisions; they are lethal and have a rapid evolution.

4. Thoracic injuries occupy the second place in the order of frequency and severity. Internal injuries can exist even in the absence of external ones.

Costal fractures are the most frequent. Their distributions one side or along symmetric lines on both sides can give indications regarding the impact with the vehicle or the road. The coastal fractures can produce significant haemorrhages, if they injure the pleurae and are accompanied by haemorrhages in the surrounding inter-costal muscles.

Pulmonary contusions are more frequent on the posterior side of the lungs, with accompanying sub-pleural air bubbles (interstitial emphysema). They are secondary to the rib fractures, but can appear even in their absence, because of the impact between the lungs and the thoracic wall, during deceleration.

Ruptures and dilacerations of the lung surface and/or extensive internal disruptions and dehiscences can be found in cases of thoracic crush.

Cardiac lesions are less often in pedestrians, except for the run-over mechanism.

Aortic rupture is also rarer in pedestrians then in car occupants. The most common rupture location is the initial part of the descending segment, below the origin of the sub-clavicular artery.

5. Abdominal lesions **are less frequent then the thoracic ones. They are primary cause of death in a reduced number of cases. The liver is more often injured; fissures or superficial ruptures are most common.**

6. Pelvic lesions **are present in almost half of the cases. Usually they are the result of a severe impact with one of the anterior angles of the car.**

The most severe pelvic injuries can be associated with extensive haemorrhages in the pelvic soft tissues, including the retroperitoneal space. These cases can have lethal ending, especially in elderly victims.

7. Injuries of the limbs

Injuries of the superior limbs **have various mechanisms. They are frequent in pedestrians; the most affected areas are the superior extremity of the arm and the inferior extremity of the upper arm.**

Injuries of the inferior limbs **are not specific for pedestrians, except for the fractures in the lower extremity. They are the result of the classical primary impact with the bumper.**

Tibia and fibula fractures are the most frequent. Their mechanism can either be angulation (as result of a transversal impact) or rotation (around the vertical axe), or both.

Knee injuries can be femoral or tibial condiles fractures, produced by direct impact or by tearing the ligaments, without bone injuries, during the adduction of the tibia over the femur.

Femur fractures are rare. In adults they are the result of the impact with the margin of the hood that ungulates the thigh and in children the impact with the bumper.

8. Run-over injuries

The cranial vault can be crushed or fragmented; the result is a gross deformity, with brain extrusion.

The crushing of the thorax can also involve the ribs, sternum and vertebral column that present bilateral, extensive, multiple fractures. The result is the so-called “rug thorax”.

Gross ruptures of the lungs and heart, sectioning of large vessels can also be present.

In the abdomen, multiple organ ruptures, extensive ruptures of the mesentery and kidney ruptures can occur.

The lumbar column can be fractured, with large dehiscence.

Extensive areas of skin and subcutaneous tissues can be detached and torn.

TRAIN ACCIDENTS

Most train incidents are accidental, but some of them can also be suicide cases.

Medically speaking, there is no pattern of train injuries, except for the high frequency of severe mutilations. The body can even be sectioned in fragments, with dark stains left by the grease on the train spindle, wheels and tracks.

Suicide victims often place their head on the tracks, so the neck is partially or completely sectioned (decapitation).

THE MEDICAL EXAMINATION IN TRAFFIC ACCIDENTS

The patient or the body must be thoroughly examined.

The examination should include the clothing, because it can provide important information for the reconstruction of the events, especially if the victim is dead or unconscious.

Injuries should be measured, registered and photographed.

If the victim is a pedestrian, the height of the injuries from the base of the heel should be measured, for comparison with the high with the vehicle's profiles.

All foreign objects found on the skin or in various external injuries are collected by the police.

The autopsy can also reveal such foreign objects during the internal examination of the body.

Tire marks can be present on the skin of both live and dead victims.

In the first case the patient may be unable (due to age or medical condition) to describe the vehicle or the accident so collecting images of the tire marks can help identifying the vehicle and the driver.

In lethal cases, if death occurred in the first 12-24 hours after the accident, blood samples will be collected from all parts involved, because not only drivers but also pedestrians can be responsible for the incident.

THE CAUSE OF DEATH IN TRAFFIC ACCIDENTS

Death can be caused by a combination of effects of several lesions (e.g.: cerebral contusion, multiple coastal and pelvis fracture).

Some cases are even more complicated, when minor or medium traumatisms occur on a pre-existing background of pathological, potentially lethal entities, or of severe alcohol abuse.

Elderly victims are especially predisposed to develop fatal complications secondary to mild injuries.

The suspicion of pathological death is another element that has to be taken in consideration. In the presence of a major trauma the pathological aspect is insignificant but a moderate trauma, with reduced loss of blood, associated with pelvic fractures or respiratory complications from coastal fractures or pulmonary contusions can become fatal if the subject also displays coronarian atheromatosis or a chronic illness that involves air ways obstruction.

In most lethal accidents death on-sets immediately or in the first few hours; occasionally the victim survives for a few days or weeks. In these situations death is the result of a complication, such as: progressive brain damage, broncho-pneumonia, adult respiratory distress syndrome, prolonged haemorrhage, pulmonary thromboembolism etc.

The microscopic examination of the heart in subjects that survived in a state of profound coma for one or two days shows myofibrilar necrosis areas with an accompanying inflammatory infiltrate. This aspect is called *traumatic myocarditis* and it is the response to the high adrenaline secretion.