EXPERIMENTAL STUDY OF PELVIS TOLERANCE IN LATERAL IMPACT

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Lateral impact accidents constitute 20 % of traffic accidents. They have a specific injury typology : 15 % of people involved in these traffic accidents sustain a pelvic fracture whereas only 4,5 % of occupants involved in all traffic accidents suffer this lesion.

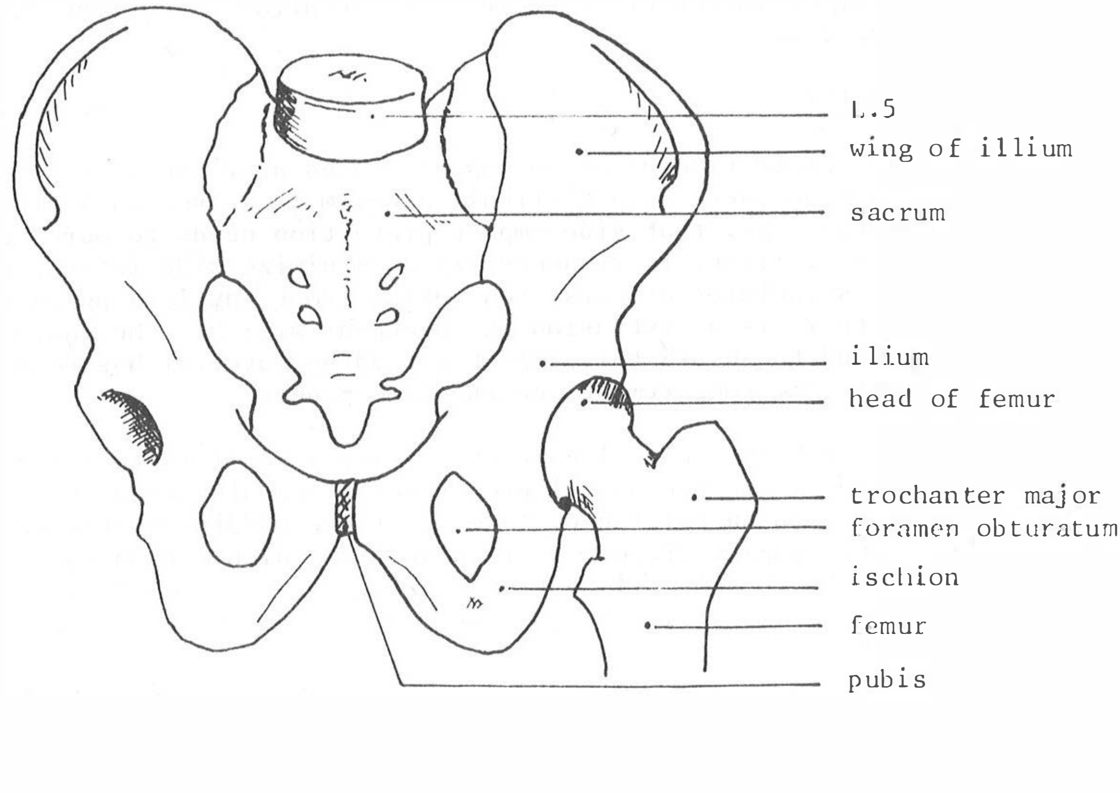
Moreover, lower limbs injuries of nearside occupants are frequent, especially the upper part of femur.

The human tolerance of pelvis and femur is insufficiently known and the aim of the study is to give ideas of fracture mechanisms of pelvis and pelvis-femur complex. This study will also help us to determine the force levels creating these injuries.

A bibliographical survey confirms the frequency of side impacts between 20 % and 30 % of traffic accidents. Side impact accidents are more severe than others and their mortality is 7,45 % which is higher than frontal impact mortality (4,4 %).

1. ANATOMIC RECALLS AND PELVIC INJURIES

Human pelvis is made with two hip bones joining in front end with the symplisis pubis and in rear end on the sacrum.



STATES (1) considers that acetabulum fractures, pelvic rami fractures and disjunction of the sacro-iliac joint are typical lesions in lateral impact. LISTER and NEILSON (2) indicate a high frequency (12 %) of pelvic injuries in lateral impacts. HARTEMANN (3) says that 9 % of injured occupants in lateral accident suffered pelvic girdle lesions, particularly the occupants seated at the impact side, so, in contact with the intrusion of the lateral structures.

Pelvic lesions seem to be a mechanism occuring by direct impact on the iliac crest or on the head of femur. These forces, working transversally on the pelvis lateral part, bring closer the 2 parts of the pelvic girdle : there is then either a pubis symphisis disjunction, or a sacro-iliac or a posterior fracture of the iliac-wing. But the compression works on the foramen obturatum sides and then there are the classical fractures of the ilio and ischio-pubic rami. If the transversal force works at the level of trochanter major, we observe an acetabulum fracture sometimes associated to a rami fracture particularly fracture of the ischio-pubic ramus.

In a recent thesis (DEJEAMMES, 4) dealing with 14 pelvic lesions in lateral impact, we notice :

- 1 case of ramus fracture
- 5 cases of 2 rami fracture (on the same side)
- 2 cases of 3 rami fracture
- 2 cases of 4 rami fracture
- 1 case of 4 rami fracture associated to fracture of iliac crest
- 1 case of 3 rami fracture associated to acetabulum fracture
- 1 case of 3 rami fracture associated to fracture of iliac crest
- 1 case of sacro-iliac fracture associated to a pubic symphisis disjunction

We will try to determine to which impacted area corresponds which type of fracture. We will see if the lesion extension is bound only to the increasing of forces or if there is an occuring chronology according to the load levels.

2. AIM OF THE STUDY

The protection of car occupant seated near the impacted side in lateral impact accident is a difficult problem to solve. In a previous study (5) we established that side impact protection needs to work at least in two directions : first, it is necessary to minimize side intrusion by stiffening side structures of cars, and making front end less agressive ; second even if there is no intrusion the occupant will hit the inside of the door panel and to absorb this impact a padding material has to be placed inside the car compartment, on the door panels.

If no biomechanical data is necessary to minimize intrusion, the determination of the mechanical properties of padding needs the knowledge of pelvis fracture human tolerance. Indeed, if the padding is too stiff, it will during the impact produce a crushing force higher than the pelvis fracture force, and then it will not play as a protective device. If the padding is too soft, it will not dissipate enough energy before being completely crushed ; then, the pelvis will sustain a very low impact force during the crush and a high impact force at the end of the padding crush.

So it is obvious that it is necessary to know the pelvis tolerance in terms of fracture force, to determine the force/deflection characteristics of the padding. The main aim of this study is to determine the value of the force applied transversally on the pelvis which is necessary to fracture it. From this value, we will determine the force induced by a padding system which has not to be overpassed.

3. IMPACTOR CHARACTERISTICS

To reproduce pelvis fractures on cadavers, we decided to use an impacting system which we called "impactor". The first problem was to determine the mass, the speed of the moving part and the shape of the impacting area.

3.1. Mass and speed of the impactor moving part

To determine the mass and the speed of the impactor, we modelized the system composed by the striking car, the struck car, and the occupant seated in the struck car near the impacted side. By analogy with frontal impact (6) and if we call A the striking car, B the struck one, MA and MB their masses, and if VA is the impact speed and the struck car is stationnary (VB = 0) we can determine the velocity change (VB) of the struck car :

$$VB = \frac{MA}{MA + MB} VA$$

Almost during the intrusion, the occupant does not sustain this value of velocity change of the door. Analysis of car to car tests reported in a previous study (5) show that we can consider the mass of the front door as the impacting mass on the occupant seated near this door. That means that the impacting mass should be close to 20 kg.

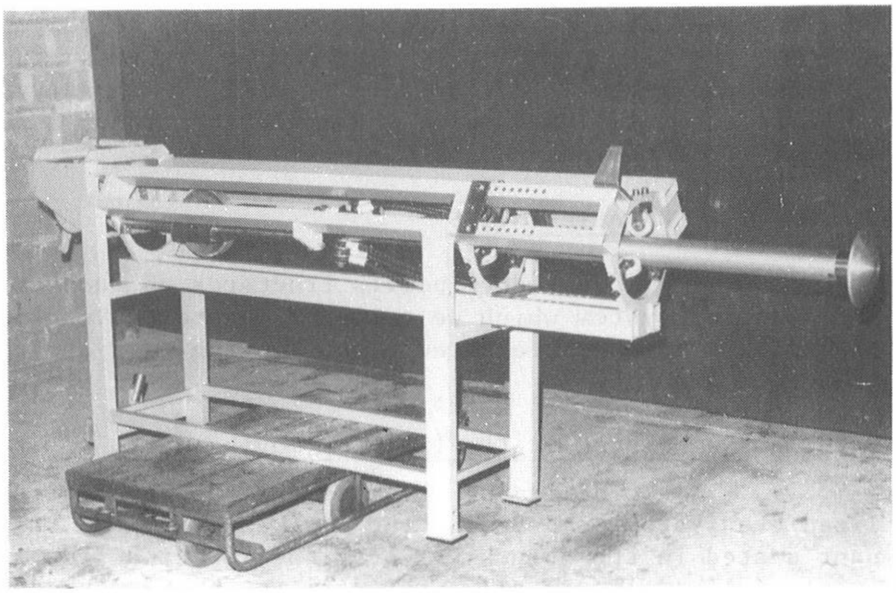
Analysis of real accidents shows that pelvis fracture seems appear in car to car collisions occuring between 40 and 50 km/h impact speed (orthogonal collisions, struck car stationnary and the two cars having the same mass). Analysis of the impact between the door and the pelvis show that the pelvis impact speed is in the same order of magnitude as the car impact speed. This means that the impactor has to reach an impact speed equal at least to 50 km/h.

3.2. Shape of the impacting area

The impactor has to reproduce the contact between the pelvis and the door in the actual accident. In a car to car side impact collision the striking car makes an intrusion more important in the middle of the door that near the edges. In the same way, the deformations are generally less important near the lower beam or near the car belt level than in the middle which is close to the H point projection of the front occupants. Such car deformations can be approximately be described as a large radius spheric form (photo 1).

On the pelvis of the seated occupants two points can be impacted in side impact : either the illium or the trochanter major. It is also possible to impact both at the same time. For these reasons, we decided to design the impacting area of the impactor as a 20 cm diameter disc with a large radius spheric front.

Photo 1



4. TEST METHODOLOGY

The aim of this study is to determine the force which is necessary to produce a pelvis fracture in a lateral impact. When this force value will be known it will be necessary to reproduce on a dummy an impact with the same impactor, at the same speed. To determine this force value, we are performing tests on cadavers. On the same cadaver, we will make several tests at increasing impact speed until we get pelvis fracture. The evidence of fracture is done by a X ray picture made between each test, and during each test we measure the impact speed, the impact force and the impact acceleration. Before each test we measure the static force pulling on the rubber extensible springs, which move the impactor. This force value es necessary to predetermine the impact speed value.

There is probably a large variation of pelvis force fracture in the population, and to minimize this variation we will try to scale the results with age, sex, pelvis geometry, and bone characteristics, which are the main parameters to be considered.

5. FIRST TEST RESULTS

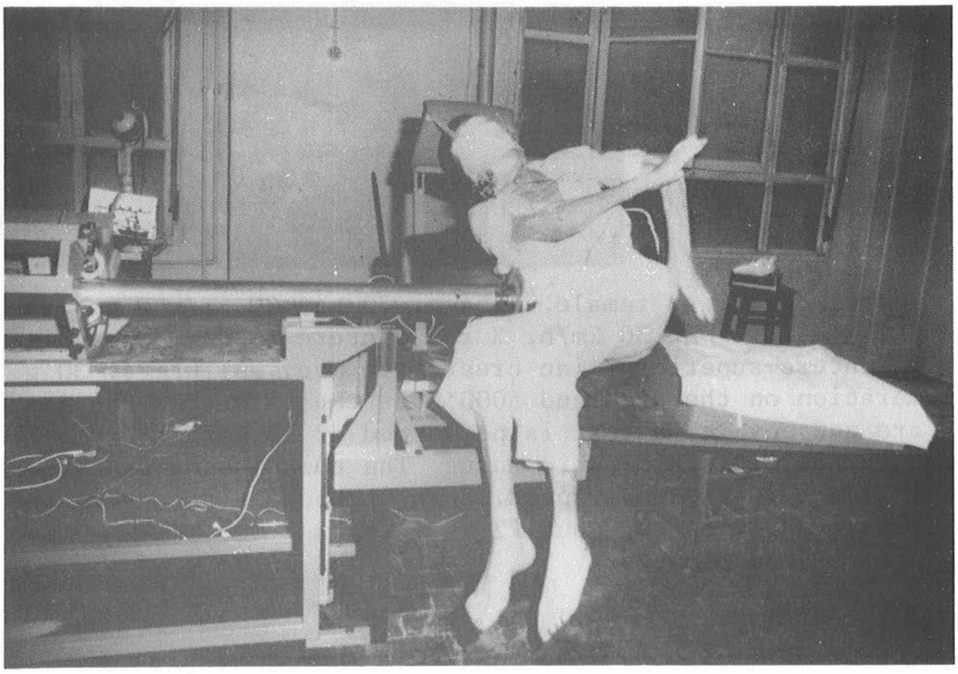
The tests are performed with fresh cadavers at increasing speeds : 20 then 30 km/h, then from 5 to 5 km/h till we get the osseous fracture.

The subject is maintained seated and the impactor is adjusted on the right pelvis : X ray pictures are made after each test to confirm the clinical examination.

Test 1 : a fresh female, 1.67 m, 58 kg is seated. Her right side in front of the impactor

The first test at 20 km/h does not move the body very much (photo 2). At 30 km/h, the body is ejected out of the seat and falls on a padding surface. At 35 km/h, clinical and radiological examination show that the pelvis is undamaged. The 45 km/h test produces many fractures : right ilio and ischio pubic rami fractures, sacro-iliac joint disjunction, beginning fracture along foramina sacriala dorsala (photos 3 - 4). The acceleration value noted on the impactor is at this time 45 g and the load is 8000 N.

Photo 2



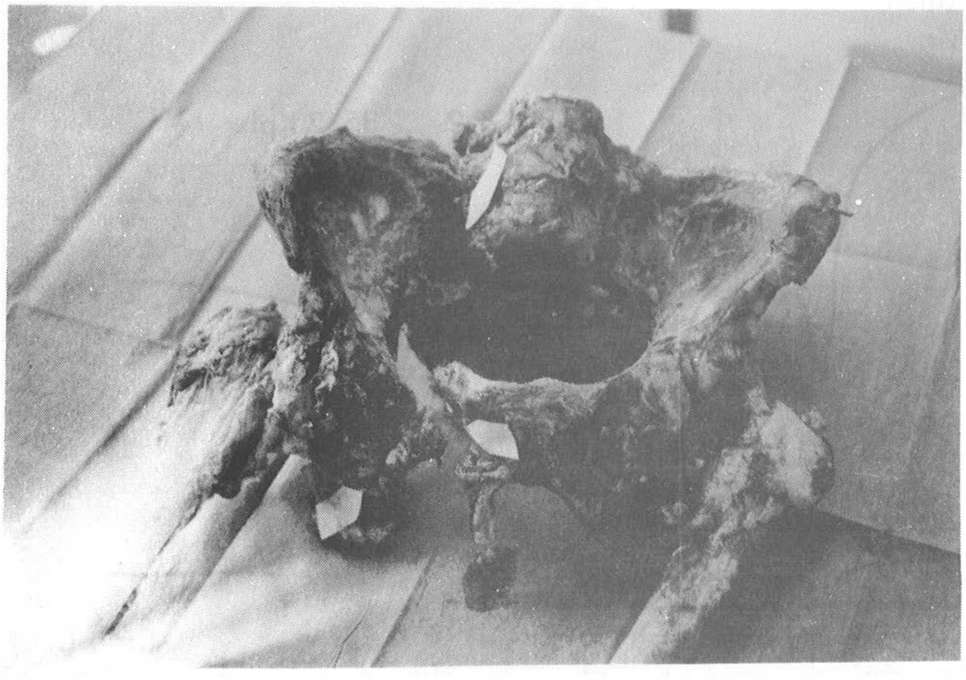
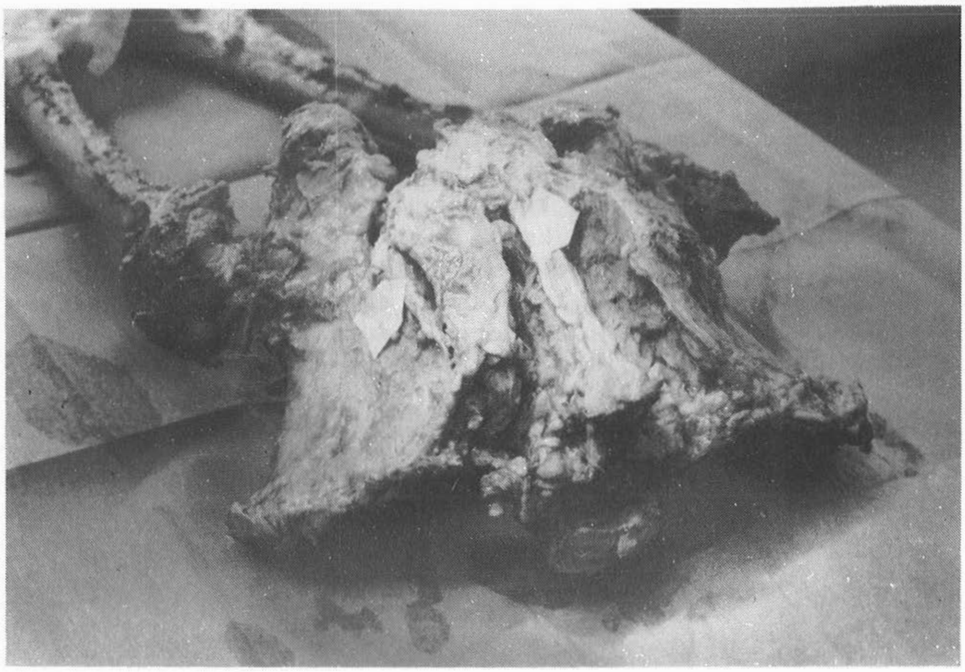
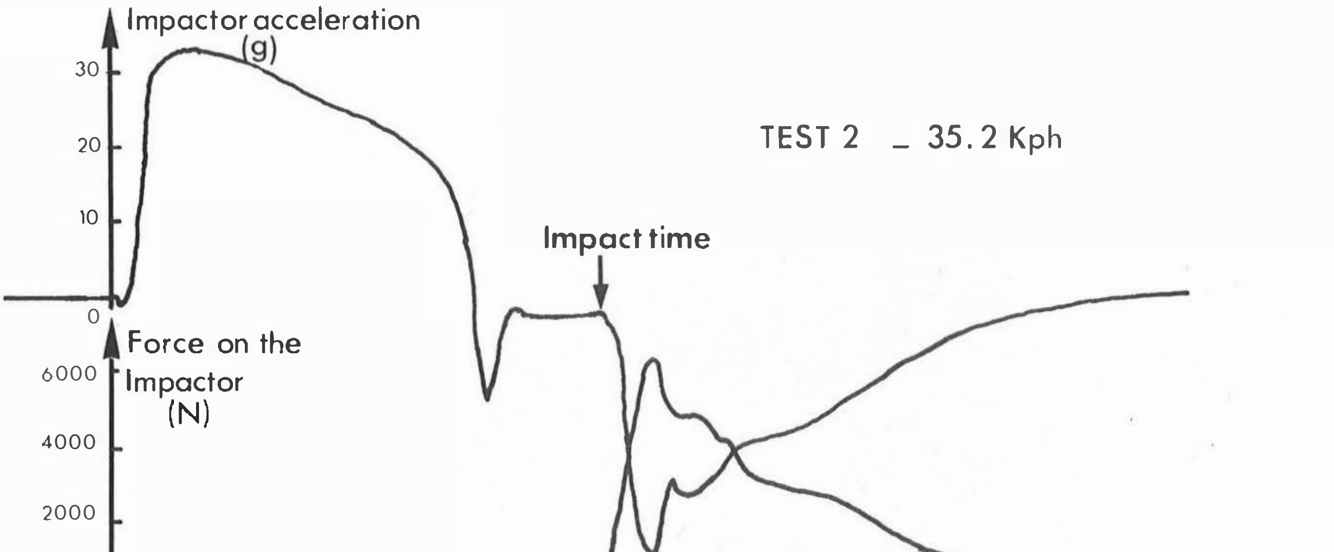


Photo 3

Photo 4



Test 2 : a fresh female, 1.54 m, 70 kg, 20 km/h = no fracture
At 30 km/h, X ray picture shows a wrenching of the tubercule of antero-superior iliac crest with many splinters. 30 g is then the acceleration on the sled and 5000 N is the effort on the impactor. As the lesions are not severe, a test is performed at 35 km/h (curve 1). There is then a fracture of ischio-pubic ramus. The curve shows that the sled needs 45 ms to reach its nominal speed. Then it becomes steady to the impact moment. The impact duration is about 72 ms, with a 7 000 N load and a 30 g acceleration on the impactor.



CONCLUSION

This study, that is just beginning, will go on to determine a range of pelvic tolerance values.

We will determine the law load -deformation of paddings to place between the lateral surfaces and the passenger pelvis to avoid the typical lesions of side impact.

It is obvious that the same approach can be used for the thorax which tolerance to impact is not well known as well as the prevention means of lesions on this part of the body.

REFERENCES

1) The pathology and pathogenesis of injuries causes by lateral impact accidents
J.D. STATES, D.J. STATES
12th Stapp Car Crash Conf. pp 72-93, 1968

2) Protection of car occupants against side impacts
LISTER R.P., I.D. NEILSON
13rd Stapp Car Crash Conf., pp 2570-2581, 1969

3) Occupant protection in lateral impacts
F. HARTEMANN and coll.
20th Stapp Car Crash Conf., pp 191-219, 1976

4) Fractures du bassin au cours des chocs latéraux automobiles
N. DEJEAMMES
Thèse Lyon 1978

5) Injury mechanisms in side impact
D. CESARI, M. RAMET, D. HERRY-MARTIN
22nd Stapp Car Crash Conf. pp 429-447, 1978

6) Mise au point d'une photothèque de chocs contrôlés
D. CESARI
Actions thématiques programmées, Société des Ingénieurs de l'Automobile
14-15 novembre 1978; Paris.