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Parametrization of Injuries by the FORTIS System and its Utilisation at Solving Traffic Accidents with Pedestrians by the Police

Ján Mandelík[a*], Nikita Bobrov[b]

[a]*The University of Security Management in Kosice , ul. Kukučínova 17, 040 01 Kosice, Slovak Republic*
[b]*Department of Forensic Medicine, Faculty of Medicine of University Hospital of P. J. Šafárik and University Hospital of L. Pasteur in Košice, Trieda SNP 1, 040 11 Kosice, Slovak Republic*
[a]*Email: emg@dodo.sk*
[b]*Email: emg@emg-kosice.sk, nikita.bobrov@upjs.sk*

Abstract

This paper deals with the FORTIS forensic system for parametrization of injuries, which allows to make the scoring of injuries, while it offers possibilities for its utilisation for the needs of the road transportation experts at the analysis of vehicle - pedestrian accident cases. The paper points out the present limited possibility of using the verbal description of injuries for the needs of experts from the field of road transportation, as well as the options of the FORTIS system that creates a new area for a deeper interdisciplinary approach in the field of expert evidence. The work presents forensic investigation of fatal injuries of pedestrians and an assessment carried out via the FORTIS system in comparison with AIS. Consequently, the PC FORTIS program is introduced that is designed for parametrization and localization of injuries made by the medical examiners, with outputs usable for the needs of the road accident analysts for calculations in the PC Crash program. Further the process on the side of the examiner necessary for co-ordination of interdisciplinary investigation of the accident and its possibility to understand the process of the accident via video-recording from calculations attached to the expert opinion is described. At the end is assessed the overall impact of the mentioned process on the increase of effectiveness of investigation, and on the creation of possibility for making the legal proceeding shorter.

Keywords: pedestrian; injury; description of injuries; system of parametrization of injuries; localization of injuries; PC program for parametrization and localization of injuries FORTIS; collision analysis; forensic medicine; forensic engineering; signature; accident case analysis; PC crash; interdisciplinary examination; investigating a traffic accident.

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* Corresponding author.

1. Introduction

At present, the road transport expert has, at solving the accident case, the considerably limited possibilities of using the information about manner and extent of injury of a pedestrian during the accident case. It results from the fact that most often it is only a verbal description of injuries elaborated by a physician, but such form of the information only partially helps to disseminate necessary knowledge of the vehicle – pedestrian system. However, it is obvious that type, extent and localization of injuries of a pedestrian are one of the significant information about conditions and course of collision between a vehicle and a pedestrian. In the event that the information fail to correspondent with outcomes of technical analysis or simulation of collision, it is possible to consider it incomplete, or even in some cases incorrect, or in extreme cases to be technically unacceptable [2]. At solving the given issue, it is necessary:

- on the side of a medical examiners: to use knowledge in the field of forensic medicine in a form usable for analysis of collision, i.e. FORTIS system
- on the side of an analysts of accident case: to use computer technique for analysis (PC Crash or Virtual Crash)
- on the side of a police investigator: targeted co-ordination of interdisciplinary evidence between medical examiner and analyst of accident case

which results in qualitative and comprehensive outcome of overall expert evidence and final legal assessment of the case [1].

1.1. Parameterization of injuries in crashes involving pedestrian injuries – FORTIS system (Forensic Traumatology Injury Scale)

At present, the medical forensic analysis of traffic injuries is not always standardized, especially due to non-existence of an established, well defined sequence for standardization of injury parameters. The proposed procedure for the assessment of traffic injuries, including the key element of injury parameter standardization according to internationally accepted AIS/ISS scale (Abbreviated Injury Scale/Injury Severity Score) is as follows:

1.1.1. Materials and methods

- Investigated circumstances, accompanying documentation, autopsy reports, image documentation and results of supplementary investigation evidence from traffic accidents involving pedestrian fatalities
- Complete autopsy report in accordance with the requirements of International Disease Classification (10th revision)
- Assessment of injury parameters using proprietary modified FORTIS system, comparison of FORTIS values with AIS/ISS values

1.1.2. The modified system FORTIS

- The result is a modified FORTIS – system, the use of which enables a more comprehensive definition of the extent of the injuries, thus enabling its application in the assessment of traffic accidents. The FORTIS system uses a proprietary modified point value system, which besides determining the basic injury to health (ZPZ), proposes classification of accompanying complications in two groups: Ko 1 primary post-injury complications - such as traumatic shock, hemorrhagic shock, cardiac tamponade, hemothorax, pneumothorax) and secondary complications Ko2 – such as inflammatory changes, edemas of non-traumatic origin, thromboses, conditions arising from surgeries, etc [3].
- Such division provides an opportunity to indirectly assess quality of healthcare provision in case of a surviving injured. To verify the proprietary modified **FORTIS** system, 12 fatal traffic accidents were subjected to assessment by forensic pathologists, evaluating each case as a single event and subsequently each relevant item in the autopsy report was assessed in a similar way. The results acquired through above analysis were compared to standard assessment of injury parameters – AIS/ISS in order to demonstrate new possibilities of the FORTIS system in quantification of injury parameters, especially in non-fatal traffic trauma involving pedestrians, to develop documentation for health insurance organizations in relation to the analysis of the quality of the provided health care as well as for possible prognosis of post-injury outcomes.
- Point values of the 12 assessed pedestrian fatalities using standard AIS/ISS method and the modified FORTIS system can be seen in table 1.

Table 1: Scoring of traffic accidents of pedestrians, using classical methodology AIS/ISS and respective modified FORTIS system

Case No.	Name, age	M/W	Car	Period of survival (hours)	ISS	FORTIS total	FORTIS ZPZ	FORTIS Ko1	FORTIS Ko2
1	P.U., 41 years	M	Car	0	66	44,1	22,4	11,7	13
2	M.J., 38 years	M	Car	0	75	82,8	47,7	16,1	19
3	A.P., 67 years	W	Car	0	75	78,2	53,6	17,6	7
4	E.P., 9 years	M	Car	0	75	57,1	41,1	9	7
5	P.S:, 49 years	M	Car	0	75	66,3	65,3	1,0	0
6	A.Č., 80 years	W	Car	0,8	57	83,2	66,2	12	5
7	J.N., 58 years	M	Car	2	75	97,4	77,4	7,3	12,7
8	J.B., 57 years	M	Car	24	75	99,2	60,8	20,7	17,7
9	I.M., 47 years	M	Car	72	75	102,7	46,9	16,1	37,7
10	S.Ch., 57 years	M	Lorry	239	75	59	19,1	14,5	25,4
11	F.K., 51 years	M	Car	288	75	27	9,3	7,7	10
12	M.P., 39 years	M	Car	291	75	60,8	24,2	8,5	28,1

It is apparent that the possibilities of the **FORTIS** injury classification system are wider, the system is more flexible and relevantly differentiates the injuries resulting from the accident.

1.1.3. Illustrative examples of scoring of forensic examination of fatal injuries with a different ratio ZPZ, Ko1 and Ko2

A. Results - case No.4

Investigated circumstances: involving motor vehicle VW Passat, whereas the vehicle with its right side collided

with underage pedestrian who entered its trajectory from the right side, causing him head injury to which he succumbed shortly after the accident.

Immediate cause of death: Rupture of the connection between medulla oblongata and cerebral pons and contusion and laceration of brain and intracranial hemorrhage resulting from fragmented fractures of cranial calvaria and base.

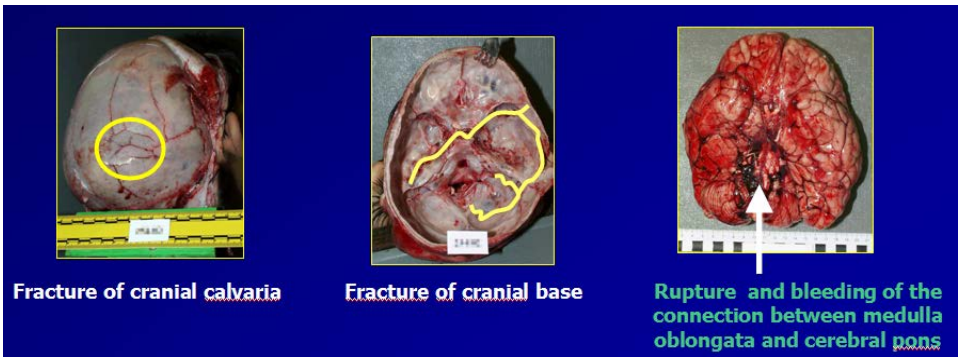


Figure 1: Documentation of finding - illustration to case no. 4

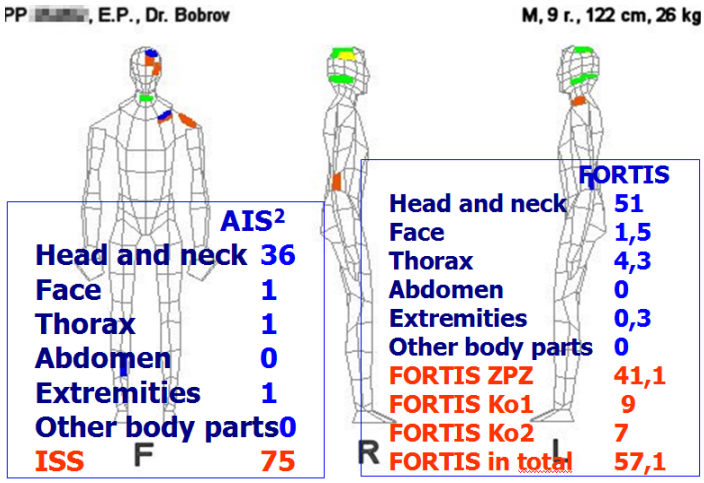


Figure 2: Evaluation of parameters of injuries in the case no. 4 via custom modified FORTIS system and comparison of FORTIS values with AIS/ISS values

B. Results - case No.11

Investigated circumstances: involving a collision between passenger vehicle and pedestrian. The injured pedestrian was subsequently hospitalized at the traumatology department with bilateral fracture of pelvis (treated by conservative – Kirschner's extension of left leg). On 12th day of hospitalization, F.K. died.

Immediate cause of death: Bilateral focal catarrhal-purulent broncho-pneumonia.

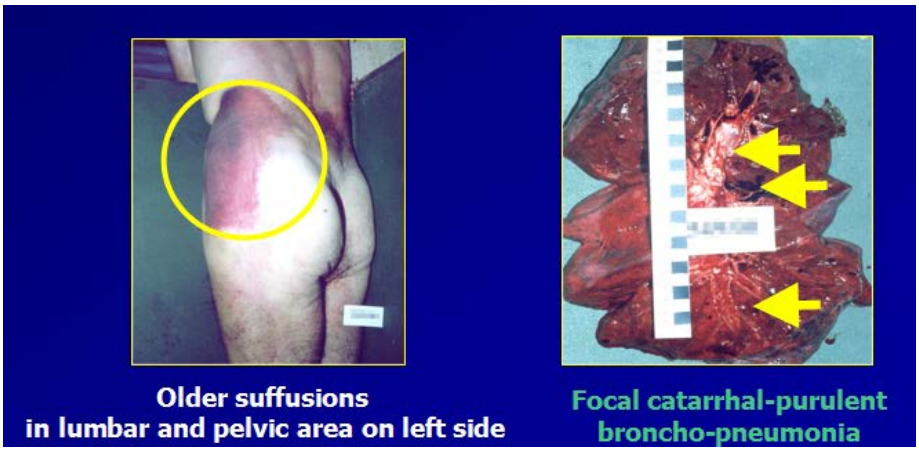


Figure 3: Documentation of the finding - illustration to case no. 11

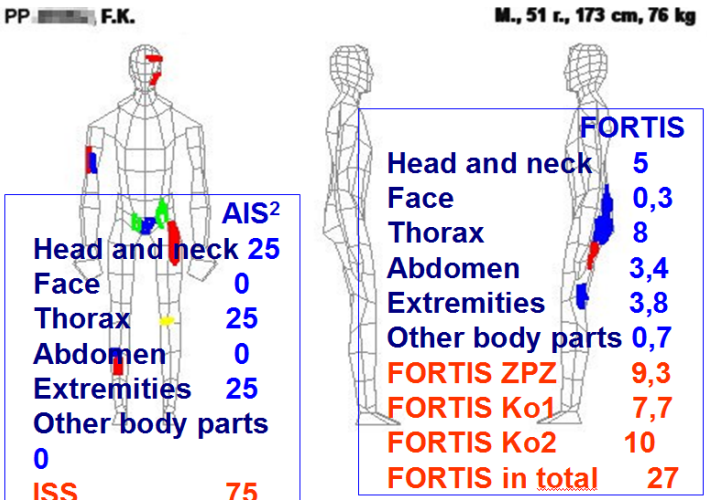


Figure 4: Evaluation of parameters of injuries in case no. 11 via custom modified FORTIS system and comparison of FORTIS values with AIS/ISS values

1.2. Evaluation and benefits of the modified FORTIS system

The results of the abovementioned cases indicate that in case of pedestrian death at the site of the accident, the point values yielded by **FORTIS** are relatively greater for items ZPZ and Ko1, in case of surviving victim, the values of FORTIS Ko2 are progressively increasing, because there are more secondary complications, while the values of FORTIS Ko2 can be viewed also from the viewpoint of the provision of healthcare, with the point value proportion of the basic injury to health, primary and secondary complications, is specific for each type of accident event.

Evidence value of the modified FORTIS system according to the type of injury in relation to immediate consequences of the violent force and secondary complications in selected situations.

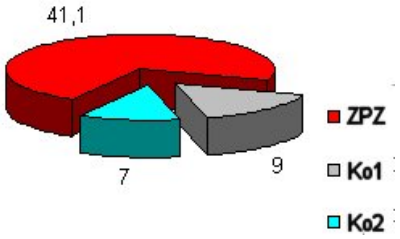


Figure 5: Relationship of FORTIS ZPZ, Ko1 and Ko2 in the event of death on the spot DN- case no. 4

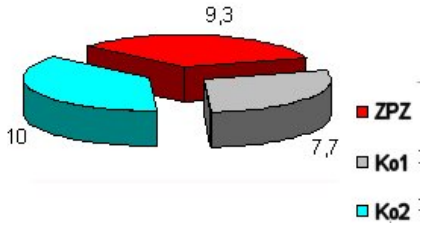


Figure 6: Relationship of FORTIS ZPZ, Ko1 and Ko2 in the event of survival - case no. 11

The research conducted so far, outcomes of which are presented herein, enables us to state that the technique of standardization of pedestrian injury parameters in case of traffic accidents (quantification of injuries) requires the application of the proprietary modified scoring system **FORTIS**, that enables (subject to good quality of input parameters) to calculate the degree of the basic injury to health, primary post-injury complications and secondary complications, including painful treatment procedures and poor quality of healthcare and in case of fatal injuries it enables to determine the immediate cause of death.

Based on the **FORTIS** score assigned to the injuries, the injuries can be divided into light, moderate and life-threatening, whereas a very important aspect is the possibility of forecasting of future outcome to a certain degree. It is also possible to use this standardized injury score to determine the degree of fault of a person responsible for the traffic accident from other circumstances, such as irresponsible attitude on the part of the victim or insufficient or inadequate treatment of the resulting injuries.

Traditional methods of injury parameter standardization (AIS/ISS) have proven to be insufficient with respect to the assessment of the extent of injuries, since – especially in case of higher energy acting upon the body – the score does not change. On the other hand the FORTIS score reflects the extent of the injuries more accurately, thus making this quantification of injuries a possible basis for application using a computer calculation program that would enable not only a simulation of the accident sequence but also verification of its accuracy using the FORTIS at pedestrians, as it is clear that FORTIS reflects the severity of injuries occurring during traffic accidents depending on the mechanical energy that caused the injuries during the impact.

The quantification of injuries resulting from traffic accidents represents a significant forensic and traumatological problem that requires a comprehensive assessment of the accident sequence and post-injury changes and the proposed **FORTIS** system contributes to the resolution of this problem also from the viewpoint

of possible assessment of complications, quality of health care and reconstruction of the accident sequence.

The modified system of injury scoring differs from the existing systems in the following aspects:

FORTIS *vs.* AIS/ISS

- **Scoring of injuries and their complications using modified tables *Injury Score in Forensic Medicine***
    - **Special scoring of the basic injury to health (ZPZ)**
    - **The complications are divided in two categories:**
        1) primary post-injury complications (Ko1)
        2) secondary complications (Ko2)
    - **The score values include decimal positions**
    - **Maximum score of FORTIS is not limited**

It is clear that the above mentioned differences between **FORTIS** and the scale of the AIA/ISS system significantly increase FORTIS´s utility, accuracy resulting in certain parameter of the injury expressed in the form of a number, enabling the generation of characteristic signatures with respect to the parameters of the collision between the vehicle and the pedestrian, or in general to the mechanism of injuries. An expert in the field of road transport would thus clearly understand which injuries are directly related to the accident (ZPZ) and which injuries are a result of the subsequent response of the pedestrian's body (Ko1), health condition, treatment procedures, etc. (Ko2), while it should be emphasized that the **FORTIS** score is dimensionless and determined on the basis of a certain arbitrary scale [3].

At present, a total of 39 tables are available for scoring of injuries in individual parts of the body, with respect to critical health consequences, in respect of the applied level of forces. This data is gradually being validated and supplemented by additional data and the method is being continuously improved.

2. Program designed for parametrization and localization of injuries

A software application PC FORTIS was developed for parametrization and visualization of injuries on the surface of the body. When a doctor uses this application during the first and during subsequent treatments, the quality of the data on pedestrian and his injuries should be greatly improved for the needs of TA analysts. A 3D static strength prediction program – 3DSSPP (University of Michigan, USA, freeware) was used as auxiliary graphics software.

An expert in the field of road transport should consider it a benefit to use this or similar program which graphically presents the injuries, as it greatly improves the information on the location of individual injuries.

When color coding is used to distinguish between ZPZ, KOo1 and Ko2, it can be assumed that such information will be significantly more valuable for the expert, whereas the tables with scores should be located next to the figure with identified locations and color coding of individual injuries. It can be assumed that in case of primary medical intervention (traumatology in survivors) the doctor should have available a PC software showing the injuries identified by score value in colors corresponding to the assigned score. **The PC FORTIS** program, which in addition to data o patient (age, height, weight, clothes, verbally described diagnosis, etc.), enables direct localization of injuries and scoring of individual injuries using the provided classification tables and instructions for their use.

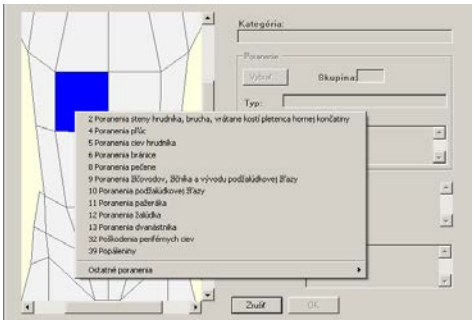
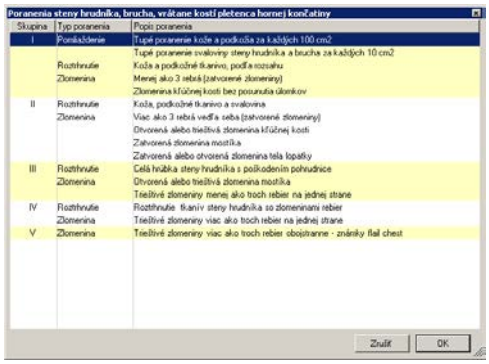


Figure 7: Illustration of the use of classification tables in the PC Fortis program



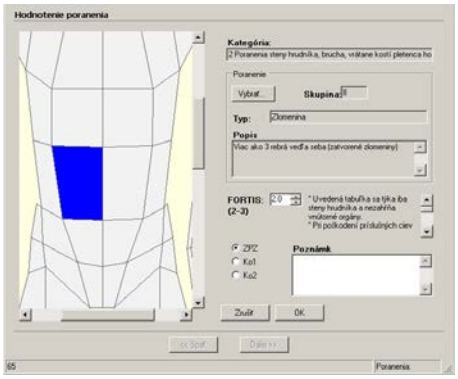
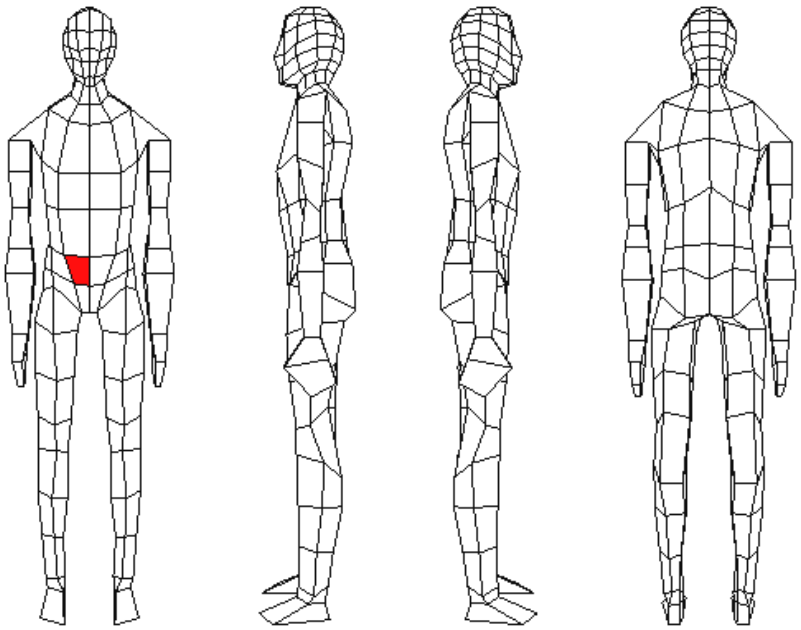


Figure 8 -1,2: Example of classification tables and their use in the PC Fortis program

Output presents depiction of localization of individual injuries, overall point value as well as local point value and its distribution on the body of a pedestrian – patient.



Name:

FORTIS

	Total	ZPZ	Ko1	Ko2
Torso	0	0	0	0
Hip	1	1	0	0
Femur right	0	0	0	0
Lower leg right	0	0	0	0
Foot right	0	0	0	0
Femur left	0	0	0	0
Lower leg left	0	0	0	0
Foot left	0	0	0	0
Left upper arm	0	0	0	0
Left lower arm	0	0	0	0
Right upper arm	0	0	0	0
Right lower arm	0	0	0	0
Neck	0	0	0	0
Head	0	0	0	0
Left knee	0	0	0	0
Right knee	0	0	0	0

Total FORTIS ZPZ	1
Total FORTIS Ko1	0
Total FORTIS Ko2	0
Total FORTIS	1

Figure 9: Illustration of FORTIS output after classification of one injury

Detailed score – result of FORTIS classification – is compatible with multi-body system used at calculations in PC Crash, enabling approximate analysis of forces acting during collision on individual parts, or to recognize the consequences of the force acting upon patient´s body.

2.1. Assessment and advantages of FORTIS system and PC FORTIS program

The FORTIS system represents a universal instrument usable in practice which enables to substitute, for the

needs of experts – analysts of traffic accidents, the medical verbal description of injuries with the description of injuries expressed in point scoring by means of their parametrization with high evidence value [**11].**

The PC FORTIS program can be considered as a tool for expert practise at using the modified system FORTIS, and even in combination with video-recording from simulation of contacts of the pedestrian's body during collision and other outputs with their physical parameters from the PC Crash program or V Crash program. The localisation and parametrization of injuries made in the PC FORTIS program by a medical examiner provides an option of direct visualisation of injuries as significant information for the road transport expert. As its advantage can be considered also the fact that it enables not only visualisation of injuries localisation, but also generation of individual signature of injuries (ratio of forces acting at the time of injury on individual parts of the body according to its distribution corresponding to a calculation multi-body system in PC Crash) for a particular type of collision and for specific conditions, such as characteristics of pedestrian's body, his position, movement, type of vehicle, its speed, dynamics at the time of collision, etc. When conducting the research, the following data on energy distribution on the pedestrian's body at the time of collisions were also collected and calculated from the PC Crash program. We could state that for a particular collision such data has always individual features, from which it is possible to generate characteristic signatures.

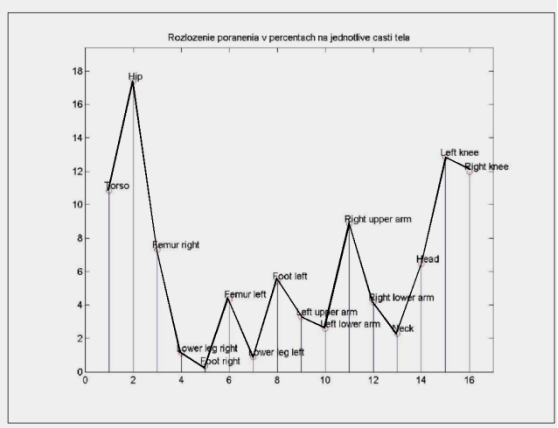


Figure 10: Individual signature of "Contact coefficients", calculated from the PC Crash for individual parts of the body, indexed 1-16, expressed as a percentage of the 30 km/h speed with 30^{o} of the pedestrian's body relative to the vehicle; 46-year old pedestrian. 75kg, 173cm, 4.6 km/h, vehicle Škoda Octavia 1,9D

It is apparent that in such way is created, for the needs of analysts of traffic accidents at solving the vehicle-pedestrian collision, an opportunity to compare a level of concordance of localisation of injuries at own calculations, and even by comparing the concordance of distribution of total energy acting upon collision to the pedestrian's body, using calculation program. The mentioned program has more options for being used in forensic medicine, as it covers not only a field of evaluation of traffic injuries but also all kinds of injuries and accidents (rail accidents, air accidents, violent crimes, etc.). In order to get more from its utilisation options are necessary legislative tools ensuring the FORTIS program to be used at first contact of a physician with a patient who has suffered an injury as well as during patient's recovery, and to be used for investigation purposes. The idea to create database of injuries (traumaregister), which would become a valuable long-term source not only

for the needs of research in the field of injuries, but also for the needs of prevention made by producers of vehicles or other equipment, designers of buildings and roads, state bodies, and last but not least for the needs of investigation of injuries made by police, seems to be appropriate.

3. Interdisciplinary approach to evidence in police investigation

Co-ordination of interdisciplinary evidence carried out on the side of a police investigator is necessary for the use of the presented system. The investigator needs to have a clear idea about evidence methods, value of their outputs and their overall complexity and applicability for the needs of legal assessment of the case.

To use the **FORTIS s**ystem for the needs of accident case analysis it may ensure such procedure of analyses of a medical examiner and a forensic engineer that is aimed:

- for a forensic engineer to have forensic quantification and visual localization of injuries at his disposal before commencement of accident case analysis
- for a medical examiner to have documentation of technical analyses, that is in particular video-recording of collision between a vehicle and a pedestrian as well as its physical parameters at his disposal if there is the need to supplement the investigation

This requires adequate experience of a police investigator based on the knowledge of methods used [8].

The police investigator should, within the scope of his procedures used at investigation of traffic accidents, also utilize video-recording from calculation carried out via PC Crash. Video-recording as a “virtual element” of evidence enables, in particular, to get deeper knowledge about accident case, beyond its verbal description. This allows, in context with personal knowledge of accident case, the qualified assessment of technical conclusions of evidence. The mentioned video-recording enables to “see and acquire” space-time knowledge of accident case as a whole, and from the views of drivers, witnesses and other participants of the accident and gives an opportunity to feasibly evaluate and assess content of their statements, which creates conditions for more qualitative legal assessment of the case. In connection with this also occurs an opportunity to systematically add outcomes of technical calculation to the database of injuries and thus create the qualitative basis for future coordinated interdisciplinary expert evidence that awaits much substantial development at present [9].

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