Thorax Injuries in VRU Accidents – an Evidence-based Approach

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I. INTRODUCTION

Automotive pedestrian protection addresses the major injured body regions head, lower extremities and pelvis. Lately, thorax injuries got increasingly into the focus. Different publications worldwide have investigated the relevance of thorax injuries caused by car accidents. [1-3] Due to different scopes, assumptions, data sources and focus of investigation, the results are not easy to compare.

Next to the bare numbers of injuries, the crucial questions are the exact genesis and injury mechanisms. Their understanding allows to find the best strategies to deal with those injuries and their outcomes.

To evaluate the effectiveness of pedestrian protection systems, a deep understanding of the injury mechanisms and causalities is necessary.

This study provides a current GIDAS analysis regarding thorax injuries. To evaluate the relevance for future pedestrian protection and the potential for improvement objectively, a generic approach based on case-by-case analysis (CbC) is presented.

II. METHODS

Frontal pedestrian vs. car accidents have been evaluated in a current GIDAS database (June 2021), applying the proposed filter set (see Fig. 1), focusing on collision velocities ≤ 45 kph:

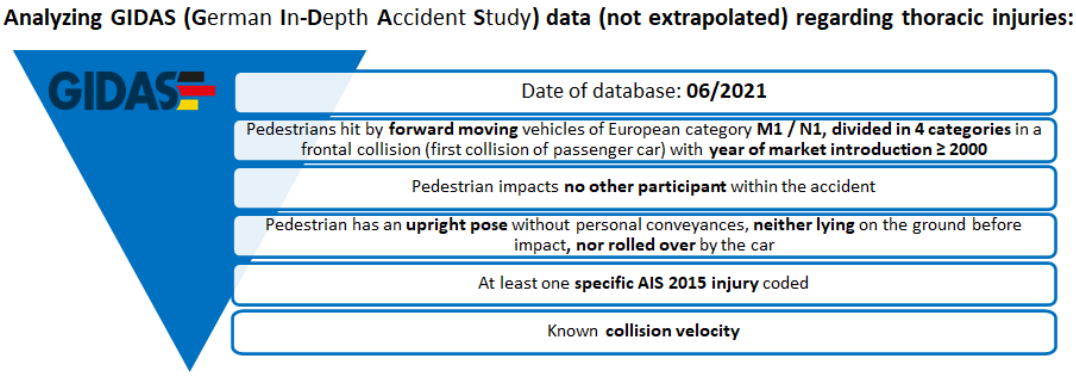

Fig. 1. Filter scheme regarding thorax injuries.

To focus on severe injury causing accidents, all pedestrians have been split into 3 Maximum known AIS (MBAIS) groups 0-1, 2 and 3+. All cases with at least one AIS2+ thorax injury were analysed regarding correlations, i.e., with other injuries, collision velocities, etc., to allow a deeper understanding of injury mechanisms.

Different body regions show different genesis of injuries. Taking this into account, thorax injuries have been identified according to AIS body region 4 (cp. [1][4]), while other upper body injuries, e.g., thoracic spine, cp. Fig. 4, were evaluated during CbC (cp. [2]).

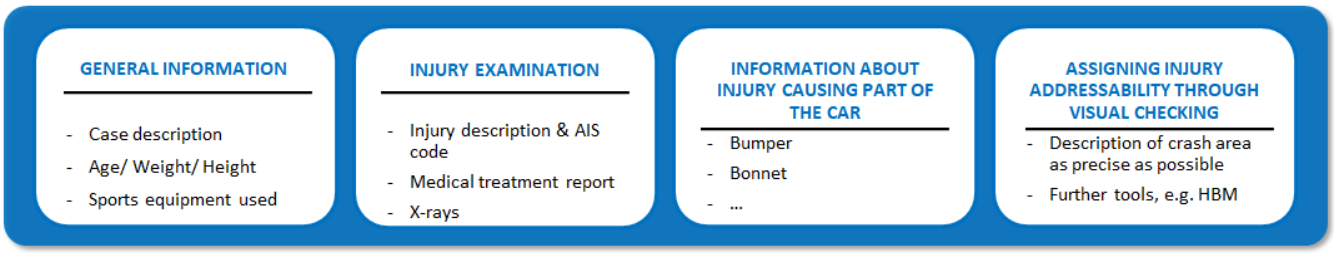

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Fig. 2. Proposed constructive approach for case-by-case analysis.

Further, the focus has been set on injury adressability by vehicle design. To understand the injury mechanism, -genesis and involved car structures, a CbC of the identified accident constellations is needed. Here, a procedure (see Fig. 2) is proposed. If validity is given, numerical HBM simulations should optionally be taken into account.

III. INITIAL FINDINGS

Eighthundred injured pedestrians with 2986 injuries can be identified for collision velocities ≤ 45 kph (all velocities: 885/ 3775). Focusing on MBAIS2+ injured pedestrians, 1570 injuries (all injury severities) distributed over 297 pedestrians (all velocities: 2281 on 359) were found.

Out of these 297 cases, 22 show at least one AIS2+ thorax injury (7,4%), while 40 thorax injuries were found (all velocities: 118).

Almost independent from the velocity, three of four evaluated car fronts show a comparable rate of AIS2+/3+ injuries. The *Van* front shows conspicuous higher rates, although the case numbers are rather low (cp. Fig.3/ left). While 84% of all MBAIS2+ injured can be found at impact velocities ≤ 45 kph (MBAIS3+: 62%) this is the case for only 46% of the thorax injured with the severity of AIS2+ (cp. Fig. 3/right).

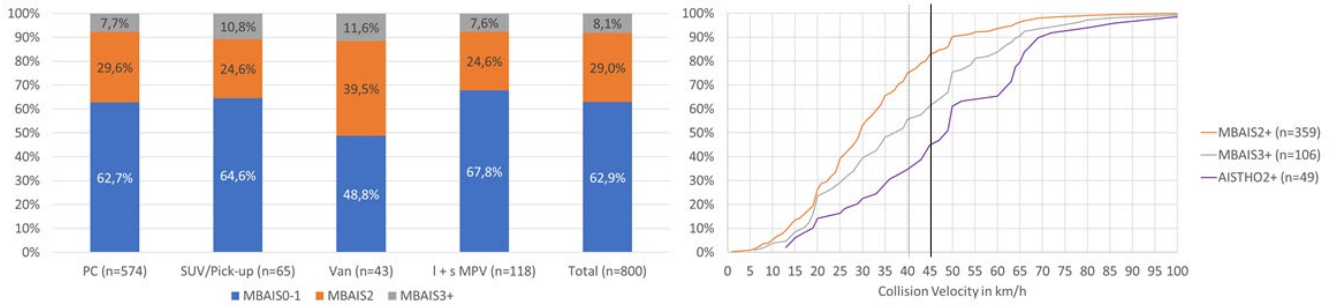

Fig. 3.(Left): Derivation of MBAIS injuries on car fronts, ≤ 45 kph; (Right): velocity-based cumulation of MBAIS injuries.

In 82% of MBAIS2+, at least one further severe injury can be found beside an AIS2+ thorax injury (AISTHO2+). At least one severe head injury occured in more than 77% of the cases with AIS2+ thorax injuries (Fig. 4). Only three pedestrians had at least one AIS2+ thorax injury, as the only severely injured (AIS2+) body region. Sixtyfour percent of all 22 AISTHO2+ cases are polytraumas with an Injury Severity Score (ISS) > 15 [5]. Eight of the 297 accident cases < 45 kph had a fatal outcome – appearing in two cases, thorax injuries could never be identified as the only location of injuries causing the fatality (cp. [1]).

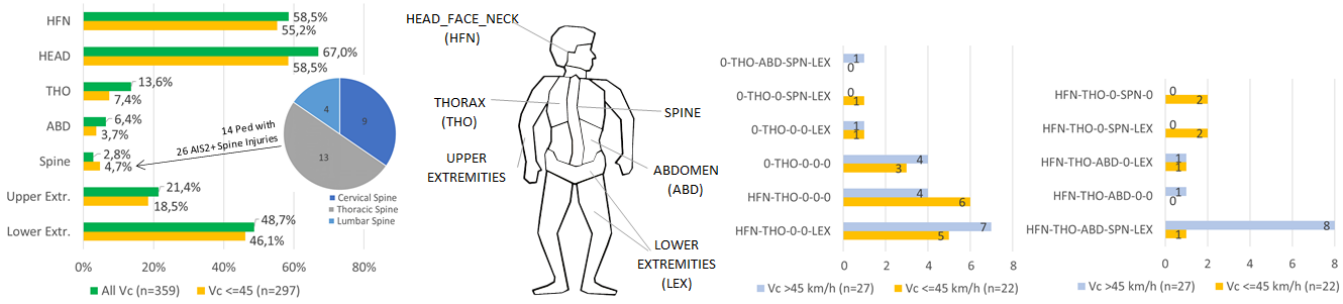

Fig. 4. Distribution of injuries on body regions, including clustering.

The described approach was carried out for cyclists as well. A general tendency for a lower ratio of severe injuries (especially thorax) could be found, while observing a rise of upper extremity injuries.

IV. DISCUSSION

The presented results indicate that thorax injuries are primarily a topic of higher velocities (>45 kph). (Thorax) injury numbers of previous publications [2] could be confirmed, though these injuries can be dedicated to a few accident events, where pedestrians predominantly suffer polytraumas ISS > 15.

The results clearly show the need for accurate case-by-case analysis of all found events to contextualise the numbers and understand the injury genesis of thorax injuries. After doing so, different strategies and their

effectiveness can be evaluated.

V. REFERENCES

[1] Wilsmann J et al., Praxiskonferenz Fußgängerschutz, 2020.
[2] Schick S et al., IRCOBI, 2021
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