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## Can we predict missed injuries? a quantitative analysis of contributing factors

### Czy możemy przewidzieć występowanie pominiętych rozpoznań? Analiza ilościowa czynników wpływających na wystąpienie MI

Autorzy pragną przedstawić, po raz pierwszy w literaturze, ilościową i jakościową ocenę pominiętych rozpoznań (MI - missed injuries) u pacjentów z urazem wielonarządowym. Cel: Celem niniejszej pracy jest ilościowa analiza pominiętych rozpoznań u pacjentów z urazem wielonarządowym, określenie klinicznych wskaźników prawdopodobieństwa wystąpienia MI oraz stworzenie narzędzia do oceny wpływu MI na wynik leczenia chorego z mnogimi obrażeniami ciała. Metoda: Analiza retrospektywna 81 pacjentów u których stwierdzono 130 pominiętych rozpoznań. Wyniki: Autorzy szczegółowo przeanalizowali przypadki 81 pacjentów spośród 421 ofiar urazów wielonarządowych, u których stwierdzono 130 pominiętych rozpoznań, głównie z powodu niedostatków diagnostycznych i leczniczych. Najczęściej MI występowały w klatce piersiowej (54 przypadki) i w obrębie kończyn (26 przypadków). Według opinii zespołu ekspertów, wystąpienie MI jest związane z niedostateczną oceną badań obrazowych lub ich brakiem (44 przypadki). W 32 przypadkach ujawniono znaczące niedociągnięcia w badaniu klinicznym. Podsumowanie: W wieloczynnikowej analizie regresyjnej statystycznie istotny niezależny wpływ zmiany TRISS (delta TRISS) na wystąpienie zgonu został przedstawiony jako wskaźnik MI. Autorzy proponują wprowadzenie wskaźnika MI celem oceny częstości występowania pominiętych rozpoznań u pacjentów z ciężkim urazem.

#### Introduction

Missed injuries (MI) are a source of grave concern in trauma and a surgeons nemeses, because they lead to preventable morbidity and mortality and have medico-legal implication?

It is often difficult to identify injuries in multitrauma patients because they often present with altered consciousness, the precise mechanism of injury may be unclear, and obtaining a reliable history is often impossible. Furthermore, severe shock can mask the clinical symptoms of specific injuries, and intoxication often compromises the accuracy of physical examination. All this may lead to missed

*The authors are presenting, for the first time in literature, the quantitative and qualitative assessment of missed injuries (MI) in patients following multiple trauma. Aim: The aim of this study is to analyze quantitatively missed injuries in multiple trauma patients to identify clinical predictors of such injuries and to develop a tool for assessing the impact of a missed injury on the injured patient's overall trauma burden. Methods: A detailed retrospective analysis of 81 patients with 130 missed injuries was performed. Results: The authors analyzed in detail 81 patients with 130 missed injuries among 421 victims of multiple trauma using a peer-review panel of experts, resulting mainly from diagnostic and therapeutic issues. The most frequent missed injuries were detected in the chest (54 cases) and limbs (26 cases). According to the judgement of the audit committee, missed injuries were connected with poor assessment of X-ray and/or its lack (44 cases). In 32 cases considerable shortages in clinical examination were revealed. Conclusions: In multivariate regression analysis statistically significant independent influence of the TRISS change (delta TRISS) on the probability of death has been demonstrated as MI index. The authors propose to introduce the MI index in order to evaluate the incidence of missed injuries in patients following severe trauma.*

injuries during the primary and secondary survey, with a resulting delay in treatment, until a tertiary survey is performed the next morning? [1]

Many attempts have been made to analyze and classify MI [1-8]. However, most of these studies are descriptive, and no attempts have been made to identify quantitatively contributing factors that predispose to a missed injury, nor to measure the impact of a missed injury on the patient's overall clinical condition.

The aim of this study is to develop a new tool to assess quantitatively the clinical impact of MI based on the TRISS methodology and to identify factors that increase the risk of missing a diagnosis of an injury.

## Materials and Methods

During a 5 year period (January 1, 1999 - December 31, 2003), 421 patients with multiple trauma were treated in the Department of Trauma Surgery of Gdansk University School of Medicine in Gdansk, Poland. Multiple trauma was defined as injuries in at least 2 anatomical regions each one of which required admission, and an Injury Severity Score of  $\geq 13$  [1,9-12]. MI were defined as those injuries first diagnosed later than 24 hours from admission, or at autopsy [1,2,8,11,12].

Clinical data on all patients were extracted retrospectively from the chart, and the Trauma Score, Revised Trauma Score, Injury Severity Score and Probability of Survival-PS (using TRISS methodology) [5] were calculated for each patient. Data included demographics, injury mechanism, time line of treatment, blood alcohol level, clinical course of the patient, missed injuries, and all parameters needed to calculate the abovementioned scores. Mean age was 42 (range 14-83) with the majority of patients being males (73%) involved in motor vehicle accidents (66%).

Each MI identified in the series of polytrauma patients was then analyzed in detail using a peer-review process. A team consisting of a trauma surgeon, intensive care specialist, emergency medicine specialist, forensic medicine specialist and radiologist reviewed each case and identified the cause of missed injury from the following list:

- Inappropriate facility: The injured patient was transferred to a facility which lacked the conditions to perform appropriate diagnostic and therapeutic interventions

- Error in clinical examination: An injury overlooked during the primary or secondary surveys

- Failure to perform a tertiary survey - When the team did not repeat the clinical examination on the morning after admission

- Inadequate diagnostic workup - incorrect assessment of X-ray and laboratory tests or their absence

- Injuries missed at operation

- Precarious condition of the patient - clinical situations where the precarious clinical condition of the patient prevented a comprehensive diagnostic workup

In order to assess quantitatively the clinical impact of a MI, we introduced a "Missed Injury Index" (MI Index). This index reflects the additional trauma burden caused by the missed injury when compared to the initial evaluation where the missed injury was overlooked.

Own index MI was introduced, making missed injuries conditional on remainder: final TRISS - initial TRISS (delta TRISS) and on probability of survival (final Ps) [10].

The variable DTRISS (delta TRISS) was calculated as difference between the final TRISS (TRISS<sub>f</sub>) and the initial one (TRISS<sub>i</sub>). The initial TRISS was calculated at the admission to the hospital and the final TRISS was calculated after the definitive diagnosis was established. The DTRISS reflects the clinical impact, or additional trauma burden, of the diagnosis missed on admission.

DTRISS formula:

$$DTRISS = TRISS_k - TRISS_p$$

$$DTRISS = \frac{1}{1 + e^{-X_i}} - \frac{1}{1 + e^{-X_f}}$$

where:

TRISS<sub>f</sub> = final TRISS

**Table I**

**Anatomical distribution of missed injuries (n=130).**

BODY AREA	TYPE OF MISSED INJURY	n	%	
HEAD	brain contusion	8	18	13.8%
	intracerebral haematoma	5		
	skull fracture	3		
	cervical spine fracture	2		
FACIAL SKELETON	facial skeleton fracture	6	8	6.2%
	organ of sight injury	2		
CHEST	lung injury (pneumothorax, haematoma, contusion)	36	54	41.5%
	rib fracture	11		
	heart and big vessels injury	4		
	thoracic spine injury	3		
ABDOMEN	parenchymal organs injury	12	24	18.5%
	bowel injury	6		
	others	6		
LIMBS	long bones fracture	7	26	20%
	short bones fracture	7		
	pelvis and scapula fracture	10		
	soft tissue injury	2		
		130	100%	

TRISS<sub>i</sub> = initial TRISS

X<sub>f</sub> = final X value

X<sub>i</sub> = initial X value

X = factor calculated after the formula:

(for blunt trauma)

$$X = 1,1430 \times RTS - 0,1516 \times ISS - 2,6676 \times (1 \text{ if age } \geq 55, 0 \text{ if age } < 55) - 0,6029$$

(for penetrating trauma)

$$X = 0,9544 \times RTS - 0,0768 \times ISS - 1,9052 \times (1 \text{ if age } \geq 55, 0 \text{ if age } < 55) - 1,1270$$

Chi-square test with Yates correction and Spearman rank correlation test were used for analysis of the categorical variables (deaths). Differences between changes of TRISS values were compared by means of the Mann-Whitney U test. Multivariate analysis was conducted using stepwise forward logistic regression, and odds ratio (OR) with 95% confidential intervals were reported. A p value of  $< 0.05$  was considered significant. All statistical analyses were performed using Statistica® 6.0 (StatSoft Inc., Tulsa, OK).

## Results

A group of 421 patients with multitrauma consisted 6.4% of admissions to the trauma surgery department during the study period. The mean Glasgow Coma Score (GCS) was 12 p., mean RTS was 10+2.5 and mean ISS was 31+13 p. Roughly one patient in four (111 patients = 26%) were in shock. Seventy six percent (319 patients) underwent operative interventions, the majority during the first 24 hours since the admission (245 patients = 58%). One hundred and eleven patients (26.4%) required reoperation. Sixty two

patients died, for a mortality rate of 14.7%.

A total of 130 missed injuries were identified in 81 patients (19% of the total series). The anatomical distribution of missed injuries is given in Table I. Lung injuries were the most commonly missed.

The results of peer-review analysis of the factors contributing to MI are given in Table II. By far, the most common cause was an error in the interpretation of diagnostic studies. In 56 patients there was one contributing factor and in 25 patients there were 2 or more factors. Only two injuries were missed at the operation.

The following variables were independent predictors of missed injuries: treatment error, changes of TRISS values, time since accident to admission, number of body areas, initial ISS, probability of survival by RTS, transfer from another hospital. Detailed data is presented in the Table III.

The missed injury changed the ISS in 61 of 81 patients (75%). Using multivariate regression analysis, the magnitude of the TRISS change (delta TRISS) was an independent predictor of mortality. The mortality rate was directly related to the value of the delta TRISS (Figure 1).

A similar relationship was observed for the whole observed population including patients without missed diagnosis.

The missed injury index (MI index)

**Table II**  
Missed injuries' contributing factors.

Reason for missed injury	n
Premature transport of patient to ward	19
Deficiency in physical examination	12
Failure to repeat the clinical assessment	20
Incorrect interpretation of imaging	44
Injuries missed at operation	2
Incomplete assessment due to patient's instability	9
Σ	106

**Table III**  
Missed injuries' independent predictors.

VARIABLE	OR (odds ratio)	95% CI	p
Treatment error	1.35	1.23 - 1.48	< 0.001
change of TRISS values	0.90	0,82 - 0.97	0.001
time from injury to admission	1.12	1.03 - 1.21	0.01
number of body areas	1.18	1.07 - 1.30	<0.001
initial ISS	0.44	0.35 - 0.55	<0.001
probability of survival by RTS	0.86	0.77 - 0.97	0.01
transfer from another hospital	1.10	1.01 - 1.20	0.03

was set, beyond which missed injury is:

- essential for life, endangered by decrease - delta TRISS > 0.02;
- inessential for life, important for therapeutic process - 0.005 > delta TRISS > 0.02;
- inessential for life and for therapeutic process - delta TRISS < 0.005;

### Discussion

Our study offers a quantitative analysis of MI in severely injured multi-trauma patients and introduces a tool for gauging the clinical impact of these missed injuries.

The problem of MI is seldom mentioned in clinical discussions because of the medico-legal implications and because they usually reflect an error in procedure or judgment. Yet, it seems that an objective analysis of underlying causes as well as an assessment of the clinical impact of MI is the key to reducing their incidence.

The concept of MI lacks an accepted definition or a uniform terminology. Several terms such as delayed diagnosis, missed injury, undiagnosed injury, missed fracture, undetected injury, pitfalls, errors in diagnosis, have a similar meaning and result in confusion [3,4,6,16-19] We used the accepted definition of missed injuries as injuries first identified more than 24 hours after admission or at autopsy [7,8,14].

There are many causes exist for MI. Several authors have attempted to define the most important contributing factors and underlying causes leading to MI. Majority of authors agree that main problems lay in organizational and clinical categories [1-4,11,12,14,17,19, 20].

In our series, the most common cause of missing an injury was misinterpretation of X-rays, followed by an incomplete clinical assessment of the patient and failure to repeat these examinations.

Our results are corresponding with other authors opinions, although many among them underline also the fact of putting the patient in inadequate (too specialized) ward (Chan, Enderson) and presence of diagnostic failure is connected with this decision [1,4]. In our material problem concerns rather wards insufficiently equipped and not having proper medical base for management of patients with multiple trauma.

Type and amount of MI is varied and difficult to be estimated statistically. All the authors, analyzing this subject, face this problem. MI percentage range is wide and varies from 1.5% to 34%, depending on research method that was used.

Some authors eliminate certain groups of patients, deciding in that way on statistical imperfections. Chan, presenting MI amount at 12% informs, that it includes only patients with orthopedic injuries [4]. Hirshberg, informing about 117 cases of missed injuries requiring reopera-

tions during ten years activity, counts out traumas that didn't need further surgical aid and "isolated" orthopedic cases [6]. In 1989 Born discusses MI for 3% patients with joints injuries [3]. In 1989 Albreksten analyses 34% of missed injuries revealed during the autopsy [2]. Enderson and Rizoli present 9% MI and 13.6% PR for patients with blunt, non-penetrating injuries [1,7]. Biffl shows necessity of introducing so called "third examination" by analysis of MI in two periods (before and after introducing third examination) and proves reduction of PR percentage on 5.7% and 3.4%, with the same ISS index – 10,7 pts.[16].

All these data and restrictions brought in by the authors do not let us to relate to individual studies equally.

Also authors of this study made preliminary selection, researching severe and mid-severe multiple trauma only, with average ISS index calculated – 30.74 pts. That's why the result received, 19.3% of missed injuries, should not be referred to any of data mentioned above. We can only compare present data with these presented in 1999 by the same authors in similar analysis. Getting significant reduction or missed injuries (from 29.4% to 19.2%) confirms necessity of analyzing these cases and reason for such research [11].

In review of the literature the authors had the possibility to familiarize with, missed injuries were discussed without attempts to estimate them by their severity. Most of the surgeons have heard about MI, comprehend their moral-legal aspect, and also have been trying to reduce their quantity. However, no one has presented by numbers a qualitative assessment for missed injuries, which would let us estimate their clinical outcomes. Our method, by taking into consideration initial and final diagnosis (contained in ISS and TRISS remainder) and relating to probability of survival of a specific patient, allows us to assess to what extent the failure (missed injury) could have been a life threat for this patient. It also enables to pay attention to especially severe missed injuries and to bring in the preventive measures, which would prevent their occurrence in the future. At the present research level it could be used for management assessment in individual trauma centers.

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