Predictive factors of bad outcome in children severely injured in road accidents
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Road traffic injury is the leading cause of death in children after one year of age. Most of the studies in the field of prognosis factors analysis are confined to reducing the number of fatalities. The prevention of long term impact on health-related quality of life is also a major issue of road safety research. The most severely injured children are likely (75% of them) to have a traumatic brain injury. Furthermore, children with severe brain injury appear to have more persistent cognitive, intellectual and academic problems than physical or motor disabilities [1,2]. Assessment of the exact long term consequences of severe nonfatal traumatic injuries on the children, their family, and society at large is necessary in order to optimize resource utilization. Consequences of road traffic injuries have some specificity, particularly in neuro-psychological disabilities. Moreover, children have their specificity: assessment of their cognitive and behavioural deficiencies should take their developmental level into account [3-5]. At the same time, premorbid characteristics of injured children
and their families can influence outcomes. In order to compare studies with each other, validated and standardized scales and tests should be used to assess all the aspects of handicap [6]. The identification of predictive factors of handicap could allow us to identify children who need a specific rehabilitation program or a specific treatment during the acute phase. The aim of our research is to identify these predictive factors of bad outcome.

Methods:

We first performed a six-year retrospective study of severe and fatal paediatric road traffic injuries from the Rhône registry [7]. This registry is based on the collection of medical data from public, private, civil and military centres dealing with road crashes: emergencies, intensive care units, surgery and rehabilitation departments, liable to receive victims of road crashes occurring in the "département du Rhône". We decided to include all road accidents, including those which happen on roads other than those open to public road usage, not to make an *a priori* decision to exclude any type of vehicle. A victim is defined as any person showing at least one injury of severity level equal to one or more, as defined by the Abbreviated Injury Scale (AIS) [8]. The information collected consists of the characteristics of the victim (forename, sex, date of birth), characteristics of the accident (place, date, time, road user category, type of collision, type of antagonist, and safety device use), the medical assessment and the injured person's subsequent progress. All the data is entered on computer for statistical analysis, all precautions being taken to preserve confidentiality.

Children were included in the study if they were less than 14 years old and severely injured (Injury Severity Score $\geq$ 16) or killed in a road traffic accident between 1996 and 2001. ISS is the sum of the squares of the highest code in each of the three most severely injured ISS body regions.

Children were qualified according to their age, sex and road user category. Injuries were described according to the AIS 90; predictable impairments of the surviving children were described according to the Injury Impairment Scale or IIS [9]. We used the IIS which predicts impairment according to the injury description by AIS. It is based on an expert's judgment. An IIS $\geq$3 corresponds to a severe persistent handicap. A traumatic brain injury (TBI) was defined as a head injury of AIS$\geq$3. We subdivided the patients into four groups. The "isolated severe TBI" group includes children with an isolated $\geq$4 AIS score for the head >=4. The "multiple injuries with TBI" group includes children with AIS score $\geq$3 injuries in two or more different body regions including head. The third category "isolated severe no-head injury" includes children with one severe injury (AIS$\geq$4) in any region but the head. The last category groups all the other children (multiple injuries without TBI or isolated TBI AIS=3). In order to measure the effect of safety devices we defined 4 categories of road users: no-motor road users (pedestrians, cyclists), motor vehicle occupants (MVO) including car, bus, moped,

motorcycle, tractors and trucks. We distinguished protected (by a belt or helmet) MVO, unprotected MVO and unspecified protection MVO.

The outcome was defined as "bad" if the child died following his/her hospital admission or if he/she had an injury of IIS score ≥3. We performed a univariate analysis, and a multivariate one (using a logistic regression) including variables that may be a risk factor of "bad outcome".

Results

From 1996 to 2001, among the 8392 victims under 14 years old included in the Rhône road traffic accident registry, 126 children (1.5%) were severely injured (ISS≥16) or killed. The annual incidences of non-fatal severe injury were respectively 6 and 4 per 100 000 in boys and girls and the annual mortality respectively 3 and 2 per 100 000.

Deceased: Among these 126 children, 30% were killed (n=38), the mean age was 7.3+/- 4 years. Road user type frequency ranking was = 1) pedestrians, 2) car passengers, 3) cyclists. Boys were 1.8 times more numerous. Thus, 6 of the 8 children under 5 years of age were pedestrian boys. Between 5 and 9 years of age, car occupants and pedestrians represented more than 80% of fatalities, whereas older children were predominantly cyclists then pedestrians. Of the fatalities, 15 died before reaching hospital or during the first hour after admission and 16 died between 2 and 24 hours after admission. 7 died after one day, of whom two more than 6 days later. The majority of the immediate deaths of children under 5 years of age (pedestrians or car passengers) were due to chest injuries and brain injuries. In the 5-9 years group, even though brain injuries were the most common cause of death, severe chest, abdominal and spine injuries were observed. In the oldest group (cyclists in the majority), brain injuries were the most common cause. Among the 10 car passengers killed, 6 were not restrained, and no restrained car passenger died immediately.

Survivors: The average ISS of the 88 survivors was 22.5 +/- 7, their mean age was 8.6+/-4 years and the sex ratio was 1.7. Among the 20 car passengers, 5 were not restrained, 10 were restrained and 3 were front seated. Table 1 shows the body regions injured by at least one injury with an AIS3+ and for each road user type. In brackets, are shown the number of injuries with an IIS3+ which is predictive of serious impairments at one year. Only brain and spinal injuries were predictive of sequelae. The spinal injuries were observed only in car passengers. We notice that car passengers under 5 years of age had more chest and brain injuries than the children above 10 years of age. On the other hand, they had less extremity injuries than the oldest group. The rate of children restrained was higher in the group of 0-4 years than in the other groups. Therefore, use of a restraint device reduced the head injuries but not the chest and abdominal injuries.

Table 1. Body regions injured by at least one AIS3+ injury (and IIS3+ injury)
(one child can have several body regions injured)

	n	Cranium, brain, face	Thorax	Abdomen and pelvic contents	Spine	Upper extremity	Lower extremity
Pedestrians	*36*	28 (11)	9 (-)	*5* (-)	- (-)	*5* (-)	2 (-)
Car	*20*	17 (8)	*7* (-)	4 (-)	3 (2)	3 (-)	2 (-)
Bicycle	*24*	20 (7)	6 (-)	2 (-)	- (-)	4 (-)	6 (-)
Moped, motorcycle	*4*	3 (2)	1 (-)	1 (-)	- (-)	1 (-)	1 (-)
TOTAL	*84*	68 (28)	23 (-)	12 (-)	3 (2)	13 (-)	11 (-)

Two children had an unknown road user type, one was in a truck and one in a bus

In a univariate analysis immediate deaths and bad outcomes (table 2) were more frequent in children under 10 years of age (18% and 58% respectively) than in children older than 10 years (6% and 36 % respectively). The youngest also had more severe injuries, as we observed a greater rate of injuries with an AIS4+ (86% vs 70%), and they more often had

multiple injuries (21% vs 3%). An isolated severe TBI or a multiple trauma with TBI are both linked to a bad outcome.

Table 2. Bad outcome (deaths after admission or IIS3+) according to victim characteristics and injury patterns.

		Bad outcome		
	Total	n	%	p
Age (years)				
0-4	17	10	58.8	
5-9	43	25	58.1	0.066
10-13	50	18	36.0	
Sex				
girls	42	21	50.0	0.85
boys	68	32	47.6	
Protection/Type of road user	76	34	44.7	
Pedestrians and cyclists	13	5	38.5	
Protected MVO	7	10	71.4	
Not protected MVO	14	4	57.0	
Unspecified MVO				
Severity				
MAIS3	24	0	-	
MAIS4	54	21	38.9	0.000
MAIS5	29	29	100.0	1
MAIS6	3	3	100.0	
Injury pattern				
Isolated severe TBI	43	25	58.1	
Multiple injuries with TBI	45	26	57.8	0.000
Isolated severe no head injuries	12	1	8.3	8
Other	10	1	10.0	

Three conclusions can be drawn from the logistic regression on bad outcome (table 3). The first is about the relationship between head injury severity and outcome. Children who underwent an isolated severe TBI and those who underwent multiple injuries among which a TBI, were more likely to have a bad outcome than those who were severely injured in one body region other than the head (OR=18.7 [2.1;168.4] and OR=17.8 [2.0;157.3] respectively). The second conclusion is about the relationship between age and outcome. After adjusting on injury severity pattern, type of road user and protection, it was found that children aged between 5 and 9 years had more often bad outcome than the children aged 10-13 years (OR=2.7]1.0; 7.1]). Although the odds ratio was the same for children under 5 years of age as for the 5-9 group, it was not significant, probably because of the small number of cases. Thirdly, the analysis shows that the not-protected MVO represents a group at risk of bad outcome despite the lack of statistical power. It is unfortunate that we could not have more complete information about the use and type of safety device by the children in our registry.

Table 3. Multivariate analysis using logistic regression: bad outcome in relation to age, type of road user and injury pattern; adjusted on sex.

	Bad outcome

	Odds Ratio	95% Confidence Interval
Age (years)		
0-4	2.9	0.8-10.3
5-9	**2.7**	**]1.0-7.1]**
10-13	1.0	
Not protected MVO	6.6	0.9-47.0
Pedestrians and cyclists	1.8	0.4-7.5
Unspecified MVO	2.1	0.2-18.4
Protected MVO	1.0	
Isolated Severe TBI	**18.7**	**2.1-168.4**
Multiple injuries with TBI	**17.8**	**2.0-157.3**
Other	1.9	0.1-39.4
Isolated severe no head injury	1.0	

The findings indicate that the most important factor to take into consideration for predicting the outcome is a severe TBI or serious TBI associated with another severe injury in another body region. This result is consistent with the studies related to the functional outcome of children with severe head injury [2,10].

The dictum of greater plasticity of the child brain has been questioned by several recent publications emphasizing that younger age at injury does not give protection against adverse outcome results [11-13]. Our study tends to show that actually younger age is a predictive factor of bad outcome (defined by an IIS >=3) or death after admission. However, the major limitation of this study is the absence of clinical assessment of the impairments. We were aware that IIS have not been validated for children but we used a high score (IIS3) as a threshold in order to take into consideration only the most severe impairments, for which uncertainty is small.

The originality of our work is the actual knowledge of the presumptive fatal or impairing injuries. Our study confirms that cerebral injury is the main cause of death in children involved in a road accident. However it emphasizes the proportion of chest injuries in the causes of death in youngest children. Severe chest injuries were more often observed in pedestrians and car passenger fatalities than in cyclists or motorized two wheels users.

This study confirms the vulnerability of the young child's brain and emphasizes the need of a follow-up of these children. However, agreed and validated scales to measure long term functional outcome in addition to threat to life are fundamental in order to assess the overall burden of traffic injury. The next step would identify predictive factors of handicap after severe traffic injury.

Prospect: Therefore, we set up a French multi-institutional prospective study of handicaps in children severely injured in a road traffic accident (SERAC study).

The main objective of our work is to study the prognosis factors of long term impairment, disability and disadvantage (school performance, quality of life, social integration). The secondary objectives are to describe impairment, disability and disadvantage in children who underwent severe traumatic injury after a road accident and who were admitted in a French paediatric intensive care unit. Description of the hospital and rehabilitation course of these children could also point to the need for a specific management of children severely injured in a road accident. The identification of a population at high risk of handicap or poor vocational outcome could the authorities to optimize the resource utilization and enable to adapt their intensive care and rehabilitation programs. Finally, this study could

target prevention measures in order to avoid handicap and severe injuries after a road accident.

In January 2003, we started a multi-institutional prospective cohort study of 200 severely injured children (ISS>= 16) admitted to a paediatric intensive care unit following a road accident. We collect their demographic characteristics and their previous health status. We assess their previous school performance by a questionnaire sent to their teachers and their functional status using the Paediatric Overall Performance Category (POPC); we also assess their social and economic backgrounds. The circumstances and the characteristics of the accidents are recorded (type of road user, antagonist, time and location of the accident, safety device used, location in the vehicle, location of the impact). We collect the injury severity using the AIS and the ISS, and we record data relative to the PICU stay (severity score, length of ventilation, Glasgow coma score, provision of care, length of stay, medicine therapy). Children are followed-up and will be clinically examined and assessed 6 and 12 months after their accident. Impairments are assessed using the POPC scale, the International Classification of Impairments, Disabilities and Handicaps. Cognitive and behavioural disorders will be assessed only one year after the accident, by certified child psychologists, using the Wechsler scales of IQ (WISC III and WPPSI-R) and using the Child Behaviour Check List (a questionnaire for parents). Disabilities are measured using the Functional Independence Measure (FIM) for children above than 7 years of age and the wee-FIM for the others. Disadvantages are assessed by measuring their school performance after the accident, their quality of life using validated and standardized self reported questionnaires and their needs of medical and social assistance.

Conclusion:

The retrospective study of children severely injured or killed in a road accident registered in the Rhône registry highlighted younger age and severe brain injury as two risk factors of bad outcome. However, the real burden of severe road traffic injury in the field of paediatrics has not been assessed prospectively. Its reliable assessment should be the first step before the identification of predictive factors of long term handicaps. Therefore, a prospective cohort study is currently carried out in France which aims at identifying these factors.

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