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# Accuracy of the field triage protocol for severe trauma patients due to winter sliding sports within the northern French Alps trauma system (TRENAU)

Florent Cheminal

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UNIVERSITÉ GRENOBLE ALPES  
UFR DE MÉDECINE DE GRENOBLE

Année : 2020

ACCURACY OF THE FIELD TRIAGE PROTOCOL FOR SEVERE TRAUMA  
PATIENTS DUE TO WINTER SLIDING SPORTS WITHIN THE NORTHERN  
FRENCH ALPS TRAUMA SYSTEM (TRENAU)

THÈSE  
PRÉSENTÉE POUR L'OBTENTION DU TITRE DE DOCTEUR EN MÉDECINE  
DIPLOME D'ÉTAT

Florent CHEMINAL

*[Données à caractère personnel]*

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# Abbreviations

**ACS-COT:** American College of Surgeons' Committee on Trauma

**AIS :** Abbreviated Injury Scale

**GCS :** Glasgow Coma Scale

**CI :** confidence interval

**ICU:** Intensive care unit

**IHT :** interhospital transfer

**ISS:** Injury Severity Score

**NISS:** New Injury Severity Score

**OR :** Odds ratio

**RENAU :** Réseau Nord Alpin des Urgences

**SAMU :** Service d'Aide Médicale Urgente

**SBP :** Systolic blood pressure

**SD :** Standard deviation

**SMUR :** Service Mobile d'Urgence Réanimation

**SpO2 :** pulse oxygen saturation

**TRENAU :** Trauma system du Réseau Nord Alpin des Urgences

**WSS :** Winter sliding sport (alpine skiing, ski touring, snowboarding)

# Résumé

Florent CHEMINAL  
UFR MÉDECINE  
FILIERE : Médecine générale

PERFORMANCE DU TRIAGE PRÉHOSPITALIER DES TRAUMATISÉS SÉVÈRES DES SPORTS DE GLISSE D'HIVER AU SEIN DU RÉSEAU NORD ALPIN DES URGENCES (RENAU).

## RÉSUMÉ :

**Introduction :** Le triage préhospitalier pour la reconnaissance des patients traumatisés sévères est la pierre angulaire d'un réseau de soins de traumatologie. Ce triage au sein du réseau de traumatologie du RENAU, dans les Alpes Françaises, semble moins performant dans la reconnaissance des traumatisés sévères en cas d'accident de sport de glisse d'hiver (Ski alpin, snowboard, ski de randonnée).

**Méthode :** Il s'agit d'une étude rétrospective portant sur l'ensemble des traumatisés sévères inclus dans la base de données du RENAU de 2012 à 2018. Ces patients grièvement blessés ont été classés en deux groupes en fonction de la nature de l'accident. D'une part les accidentés des sports de glisse d'hiver (SDG) et d'autre part tous les autres accidents. Le taux de sous-triage a été défini par la proportion de patients sévèrement blessés ( $ISS > 15$ ) qui ont été transportés dans un centre de traumatologie de niveau 3 ; et inversement pour le sur-triage. Le taux de transfert inter hospitalier ainsi que la gradation préhospitalière selon le protocole de triage préhospitalier du RENAU ont été analysés. Une analyse des lésions présentées par les traumatisés des SDG a été réalisée.

**Résultats :** Au total, 8052 patients ont été enregistrés dans la base de données du RENAU durant cette période. Après application des critères d'exclusion, l'analyse a porté sur 7872 patients dont 1342 (17%) traumatisés sévères des SDG. Le taux de sous triage des patients accidentés des SDG était plus élevé que dans le groupe des autres accidents avec un taux de 10.9% vs 6.5% ( $p < 0.001$ ). Le taux de sur-triage n'était pas significativement différent (43.2% vs 45.1% ;  $p = 0.2$ ).

La gradation préhospitalière selon le protocole du RENAU a été réalisée dans 48.8% des cas dans le groupe des accidentés des SDG et dans 62.6% concernant le groupe des autres accidents ( $p < 0.001$ ).

Chez les traumatisés des SDG, on retrouve un taux plus élevé de traumatismes dans le territoire abdomino-pelvien par rapport aux autres types d'accidents (20.3% vs 12.1%  $p < 0.001$ ).

**Conclusion :** Le taux de sous triage est plus élevé en cas d'accident de SDG qu'en cas d'autres accidents au sein du RENAU. Ce taux est essentiellement influencé par la proportion élevée de patients non gradés en préhospitalier selon le protocole de triage du RENAU en cas d'accident de SDG. Il en résulte une élévation du nombre de transferts inter hospitaliers chez ces patients. La présence d'un taux élevé de lésions abdomino-pelviennes dans ce groupe pourrait également avoir une influence dans ce sous triage.

## MOTS CLÉS :

Triage, réseau de soins, RENAU, ski, médecine d'urgence

# Abstract

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## ACCURACY OF THE FIELD TRIAGE PROTOCOL FOR SEVERE TRAUMA PATIENTS DUE TO WINTER SLIDING SPORTS WITHIN THE NORTHERN FRENCH ALPS TRAUMA SYSTEM (TRENAU)

### ABSTRACT:

**Introduction:** Prehospital triage for the recognition of severe trauma patients is the cornerstone of a trauma system. This triage within the regional trauma system of the RENAU in the northern French Alps, seems less effective in the recognition of severe trauma in the event of an accident of winter sliding sports (alpine skiing, snowboarding, ski touring).

**Study design:** A retrospective analysis of all severe traumatic injuries included in the RENAU database from 2012 to 2018 is performed. These critically injured patients were classified into two groups according to the nature of the accident. On the one hand the victims of winter sports sliding (WSS) and on the other hand all other accidents. Undertriage rate was defined as the proportion of severely injured patients (ISS $\geq$ 16) who were transported to a Level 3 trauma center; and vice versa for overtriage. The interhospital transfer rate as well as the prehospital gradation according to the RENAU prehospital triage protocol were analyzed. An analysis of the lesions presented by the traumatized WSS was carried out.

**Results:** A total of 8052 patients were registered in the RENAU database during this period. After application of the exclusion criteria, the analysis involved 7872 patients including 1342 (17%) severely traumatized WSS. Undertriage of patients with WSS injuries was higher than in the group of other accidents with a rate of 10.9% vs. 6.5% ( $p = 0.001$ ). Overtriage rate was not significantly different (43.2% vs. 45.1%,  $p = 0.2$ ).

The prehospital gradation according to the RENAU field triage was carried out in 48.8% in the group of accident victims of the WSS and in 62.6% in the group of other accidents ( $p = 0.001$ ).

Among the trauma patients due to WSS accident, there is a higher rate of trauma in the abdominopelvic territory compared with other types of accidents (20.3% vs 12.1%  $p = 0.001$ ).

**Conclusion:** Undertriage rate is higher in the event of an WSS accident than the other accidents. This rate is mainly influenced by the high proportion of prehospital patients who are not graded according to the RENAU triage algorithm in the event of an WSS accident. As a consequence, there is an increase in the number of inter-hospital transfers in these patients. The presence of a high rate of abdominal and pelvic lesions in this group could also have an influence in this rate.

### MESH:

Triage process; RENAU; severe skiing trauma; French trauma center; Emergency medicine

# Background

## Trauma networks

### *1. History review*

Trauma care systems have proven their effectiveness by allowing a significant reduction in mortality in severe trauma patients in the areas where they have been set up (1) (2)

These networks are based on early treatment of severely traumatized patients, adequate allocation of resources to the various victims and standardization of emergency care procedures.

Historically, this concept of trauma network emerged in the United States of America (USA) following the experience and lessons learned from the armed conflicts in which this country was involved during the 20th century.

It is shown that patient survival is closely dependent on rapid evacuation, early resuscitation and referral to specialized surgeons.(3)

After the publication by the American College of Surgeons in 1976 of the various criteria and requirements to define a "trauma center" and the publication of the guidelines for care of injured patients, many states of the USA organized their health system into trauma systems. Many Anglo-Saxon countries were then inspired by this concept of healthcare from the early 90's. It was not until 2007 that France created its first regional healthcare network, RENAU (North Alpine Network of Emergencies).

## 2. French organization:

In France, patients with severe trauma are cared for by a medical team from SMUR (Structure Mobile d'Urgence et Réanimation), including a physician-staffed of the emergency medical system, a nurse and an ambulance. The severity of patients suffering from a severe acute pathology is evaluated in prehospital by the physician-staffed who can use the French triage algorithm called "critères de Vittel" (Figure 1) The team provides initial on-scene assessment, and if needed, extrication, initiation of resuscitation and stabilization of the patient and timely transport to the closest trauma center or acute care facility.

This system is different from many other countries, especially Anglo-Saxon, composed only of paramedics.

The activity of the SMUR is coordinated by the SAMU (Emergency Medical Aid Service) created in 1968 whose main mission is to organize the emergency medical response in prehospital (4).

At present, there is no study with a sufficient level of evidence, allowing to show a superiority of a rescue system compared to the other (5)(6).

The success of the regional organization of the RENAU healthcare system has inspired the creation of other trauma systems in France. The largest of them is in the *île-de-France*, the region around Paris city, located in an urban area, which covers nearly 12 million inhabitants. However, in the absence of a national organization policy, these trauma systems remain rare and do not have standardization of procedures or a common register. The recent terrorist attacks in France seem to have helped advance the idea of such a common organization on a national scale (7).

## 3. The RENAU

RENAU is a French healthcare network bringing together the main hospital structures in the Northern Alpine region. It covers three departments (Isère, Savoie and Haute Savoie) as well as part of the departments of Ain and Hautes-Alpes (see Figure 2).

The hospitals in this intervention area are classified into three levels of care according to material, human and technical resources, level 1 representing the highest level. (Figure 3)



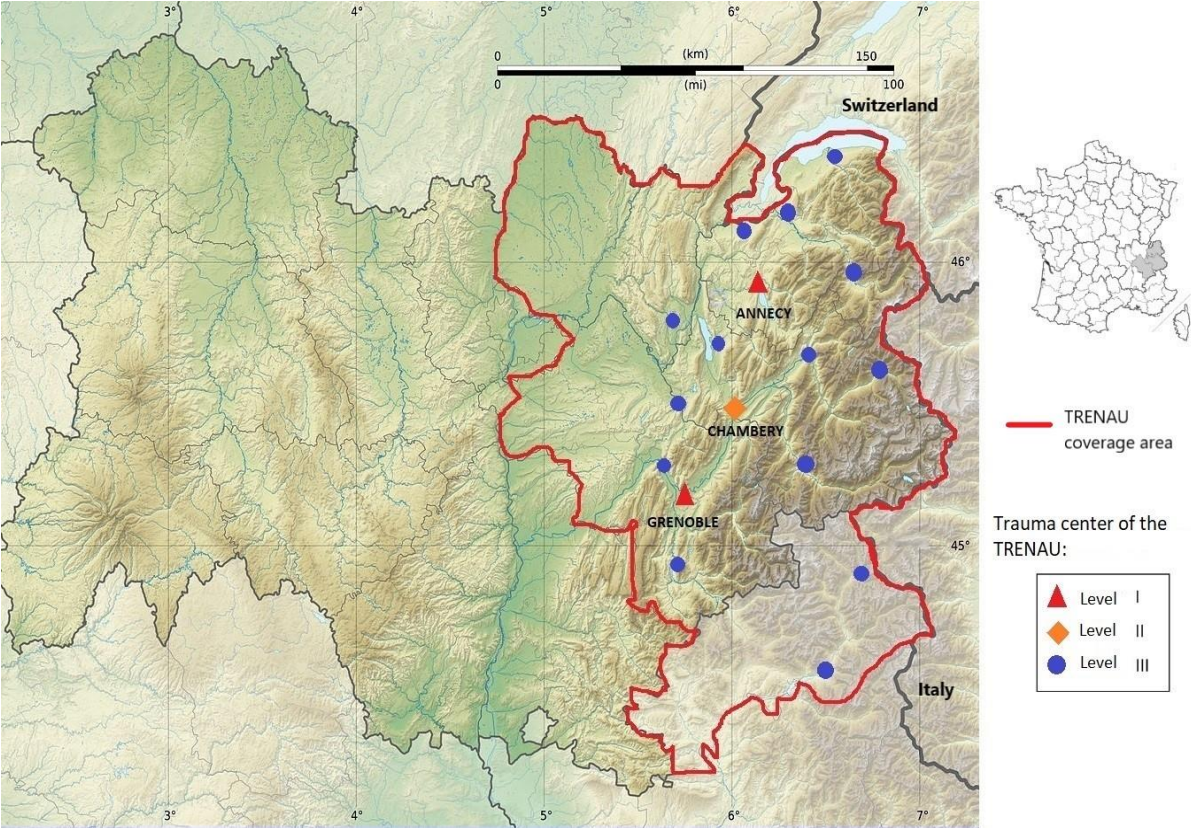
This network covers a population of 2 million inhabitants with a high seasonal variation (8 million tourists each year).

It is an inclusive system where all centers participate according to the means of their technical platform. It opposes exclusive networks, where only advanced centers participate in the healthcare network.

This network has a specific branch for severe trauma patients, the Northern French Alps Trauma System (TRENAU). In this trauma system, patients are classified according to the TRENAU field triage protocol in Grade A, B or C according to physiological, anamnestic, therapeutic or clinical criteria by the SMUR physician-staffed. (See Figure 4).

Once the evaluation and the gradation done, it possible to orient the patient to a suitable center according to an algorithm taking into account the patient's seriousness and the time needed to get to the most suitable hospital center. (See Figure 5)

**Figure 2 : Map of the trauma system of the Northern French Alps (TRENAU).**



## Skiing injuries and TRENAU

Alpine skiing and snowboarding are popular winter sports, with an estimated 200 million participants worldwide.

In France and worldwide, accidents with severe trauma represent one of the leading causes of morbidity and mortality and the main cause of death in 10-19 year olds (8) (6)

Due to its geographical location in the heart of the French Alps, the emergency services and the rescue teams that are part of the RENAU are required to take care of mountain casualties regularly, they represent the 3rd cause of trauma in this region after road accidents and falls (9)

The main cause of these mountain accidents remains the practice of winter sliding sports (WSS) including alpine skiing, ski touring and snowboarding. The conditions of care are sometimes difficult especially since the rise these last years of off-piste skiing and ski touring.

The austere environment of the high mountains can make the assessment, management and evacuation of patients complex.

## Evaluate to improve

In the interests of performance and in order to guarantee its effectiveness, it is necessary to ensure regular evaluation of the trauma system.

This is also part of the RENAU motto: "Uniting and assessing oneself to improve the quality of care for serious trauma victims"

Prehospital triage is the cornerstone in the organization of a trauma care network to refer the severely traumatized to the most suitable hospital centers, thereby reducing intra-hospital mortality. (10). The prehospital trauma system is driven by the goal of getting the right patient to the right place at the right time.

Overtriage and undertriage are both important components to evaluate accuracy and quality of a trauma system.

Overtriage corresponds to a patient with slight lesions who is transported to a level 1 or 2 center. Conversely, undertriage corresponds to a patient with severe lesions, treated in a level 3 or less. This classification is false-negative triage.

In general, the priority is to obtain a trauma system with a low undertriage rate, since undertriage is associated with an increase in the avoidable morbidity and mortality rate. Undertriage is a real medical issue.

The ideal according to the American society of surgery (ACS-COT) is to obtain a rate lower than 5%(10),

If overtriage does not have a direct medical consequence for the patient, the improper use of network resources leads to the risk of no longer being able to ensure its proper functioning for severe trauma patients. Overtriage results in overutilization of finite resources (financial and human).

Thus, the acceptable rate of overtriage to be obtained, still according to ACS-COT, is between 25 and 35%(10).

The evaluation of the reliability of the organization of the regional trauma system of RENAU has already been the subject of publications (11) (12). However, the specific triage performance of severe trauma patients due to winter sliding sports accidents within this same network has never been evaluated.

The aim of the study was to assess the performance of the prehospital orientation of patients with severe winter sliding sports (WSS) injuries through the TRENAU.

To do this, we determined and compared the undertriage rates between severe trauma patients from WSS and severe trauma patients from other causes of accidents using the ISS score.

# Materials and methods

## Study setting and design

We carried out a retrospective study using data from the TRENAU register, prospective and multicentric register, from 2012 to 2018.

## Study Population

Only severe trauma patients are included in the TRENAU's registry. This inclusion is done on the presence of one of the French criteria of severity called "Critères de Vittel" (Figure 1)

Our work focused on all of the patients from this register, included between 2012 and 2018. We then carried out a subgroup analysis of trauma patients in sliding sports.

Patients were excluded if :

- The initial care was not carried out in a hospital center that is part of RENAU
- Non-accidental trauma
- The patient arrived on his own at the hospital
- The mechanism or the circumstances at the time of the accident were not known.
- Dead patient on scene

## Définitions and primary endpoint

### Abbreviated Injury Scale (AIS) :

One of the best-known and oldest scores of anatomical scores, AIS determines nine territories (head, face, neck, thorax, abdomen, spine, upper limbs, lower limbs, outer surface), in which the lesions are scored from 1 (minor) to 6 (constantly fatal).

The AIS describes only one lesion at a time and therefore is not suitable to a polytrauma patient with several lesions mutually aggravating

### Injury Severity Score (ISS) :

This score allows the simple evaluation of polytrauma patients. It is calculated using AIS.

The three highest AISs belonging to three different territories are noted. The sum of the squares of these AISs gives a score ranging from 1 to 75. By convention, if a lesion is rated AIS 6 (fatal), the ISS score is arbitrarily set to 75.

The ISS, benchmark score in trauma, cannot be used in prehospital because it requires knowledge of the patient's definitive lesions. It allows an *a posteriori* evaluation of the severity of the patient's injuries.

#### Definition Major trauma:

In the 90s, the US Major Trauma Outcome Study (MTOS) found that an ISS > 15 was associated with a mortality risk of more than 10%, defining severe injuries (13).

Since then, most international studies analysing prehospital patient triage in trauma systems networks have used this definition. The severely traumatized are patients who have an ISS > 15, the others are considered to be mild or moderately traumatized.

#### Primary endpoint:

In order to assess the performance of prehospital triage of severe trauma patients from WSS, we compared the proportion of undertriage of WSS accidents with other types of accidents.

Undertriage is defined as a patient with an ISS > 15 and treated in a level 3 center and conversely, overtriage is defined by a patient with an ISS score  $\leq$  15 sent directly to a level 1 hospital or 2.

This definition corresponds to the definition used in international studies for the evaluation of a trauma system.

#### Secondary endpoint :

- Interhospital transfer (IHT) rate of the WSS group compared to other types of accidents
- WSS overtriage rate compared to other types of accidents
- Variation of prehospital and hospital grade in the RENAU field triage (Grade A/B/C)
- Survival rate
- Average ISS according to grades A-B-C of trauma victims

## Data collection

For each patient included in the TRENAU register, a large amount of data is collected on a triptych for further research work. (See Figure N°6)

Part is filled out by the SMUR physician on site, then the triptych is completed by the RENAU team using the patient's medical file.

The following data was collected for each patient:

- Patient: age, sex
- Accident: type, place, date
- Hemodynamic constants, filling, transfusion, amines, intubation in prehospital and hospital.
- Prehospital and hospital grade A-B-C in the regional grading system
- Hospital admission, service, interhospital transfer (IHT)
- Hospitalization in intensive care unit (ICU)
- Lesion balance and become: Death, ISS scores, AIS

The Regional Institutional Ethics Committee approved the implementation of the TRENAU registry (Comité d'Ethique des Centres d'Investigation Clinique de l'inter-région Rhône-Alpes-Auvergne, IRB number 5708) and, given its observational nature, waived the requirements for written informed consent from each patient.

## Statistical analysis

These are descriptive analyses enabling the characteristics (treatment mode, lesion assessment, age and sex of patients, severity indicators (constants, ISS), grades) of WSS accidents to be compared with other types of accidents (all combined). The categorical variables will be compared by Chi2 or Fisher tests if the numbers require it. The quantitative variables will be compared by Student or Mann-Whitney tests in the event of non-compliance with the conditions of normality.

Exploratory multivariate analyses (logistic regressions) were performed to identify the characteristics related to transferring patients.

Statistical analyses were performed with SPSS version 25. All parameters were noted with a 95% confidence interval (95% CI). Means were noted with standard deviation

(SD), median numbers were with an interquartile range (IQR). A  $p$ -value of  $\leq 0.05$  was considered statistically significant.

# Results

During the study period, 8,052 patients were included in the TRENAU registry. We secondarily excluded 180 patients. In total, the data analysis involved 7,872 patients.

## Patients Characteristics

A total of 1,342 (17%) patients were treated for severe injuries related to winter sliding sports (WSS). The mean age of accident victims in these sports was 32 years (SD: 18,3) with a large male prevalence (76.0% WSS and 76.7% other accidents).

The prehospital physiological parameters were less severe in the WSS accidents group compared to the other accidents, 95.4% had an SBP  $\geq 90$  mmHg against 94% ( $p = 0.048$ ), the Glasgow score was lower than 8 in 6.9 % of WSS accidents victims versus 10.4% in the other accidents group ( $p < 10^{-3}$ ). This difference is maintained after the hospital evaluation.

Only the proportion of patients with Spo2  $< 90\%$  was higher in the WSS group with 11.4% compared to the other accidents group, at 8.4% ( $p = 0.01$ ). This difference is no longer found during hospital care, it concerns 3.2% of WSS accidents victims and 3.3% in the group of other accidents ( $p = 0.8$ ).

The need for prehospital mechanical ventilation with intubation affected 8.6% of the WSS group and 12.4% of the other accidents group ( $p < 10^{-3}$ ).

Prehospital vascular filling was performed in 4.4% and 8.6% respectively ( $p < 10^{-3}$ ).

Prehospital gradation of severe trauma patients according to the RENAU trauma field protocol was performed in 48.8% in the group of WSS victims and in 62.6% in the other accidents group ( $p < 10^{-3}$ ). These rates increase once taken in hospital to reach 77% and 81.9% gradation respectively ( $p < 10^{-3}$ ).

An ISS  $> 15$  was found in 41.1% of WSS accidents victims compared to 44.6% for other accidents ( $p = 0.02$ ). In contrast, the average ISS was 13.9 (SD 10.1) and 15.5 (SD 12.1), respectively ( $p < 10^{-3}$ ).



When we look at the average ISS according to the prehospital grade in the RENAU triage system, it is higher in the "B", "A" and "non-graded" categories of the group of other accidents types.

The average ISS in the "non-graded" patient category is 16.2 (SD 12.1) in the other accidents group against 14.4 (SD 10.6) in the WSS group, ( $p < 10^{-3}$ ). Likewise, in the "grade B" category, the average ISS is 20.4 (SD 11.4) compared to 16.9 (SD 9.4) among WSS accidents victims ( $p < 10^{-3}$ ).

The survival rate in the WSS accident group was higher with a rate of 97.6% against 93.5% ( $p < 10^{-3}$ ).

The rate of hospitalization in ICU was not statistically different in the two groups with 7.0% of hospitalization in ICU in the WSS group and 6.5% for other accidents ( $p = 0.5$ ), but the traumatized patients WSS stayed there less (length of stay: 3 days (IQR: 2-10) vs 4 days (IQR: 2-7),  $p < 10^{-3}$ ).

Patient characteristics are tabulated in Table 1

Table N°1: Patient Characteristics, Injury, and Outcomes Data

	Other accidents (n=6530)	WSS accidents (n=1342)	P
<b>County, n (%)</b>			<10 <sup>-3</sup>
<b>38 (Isère)</b>	2463 (37.7)	412 (30.7)	
<b>73 (Savoie)</b>	1573 (24.1)	576 (42.9)	
<b>74 (Haute Savoie)</b>	2494 (38.2)	354 (26.4)	
<b>Mechanism of Injury, n (%)</b>			
<b>Close</b>	6267 (97.2)	1320 (99.5)	<10 <sup>-3</sup>
<b>Penetrating trauma</b>	179 (2.8)	7 (0.5)	
<b>Male gender, n (%)</b>	5006 (76.7)	1019 (76.0)	0.6
<b>Age, mean (SD)</b>	40.2 (20.6)	32.6 (18.3)	<10 <sup>-3</sup>
<b>Hemorrhagic shock</b>	269 (4.1)	30 (2.2)	0.01
<b>Prehospital resuscitation, n (%)</b>			
<b>Assisted ventilation</b>	807 (12.4)	115 (8.6)	<10 <sup>-3</sup>
<b>Volume load &gt; 1000 ml</b>	561 (8.6)	59 (4.4)	<10 <sup>-3</sup>
<b>Prehospital physiological signs, n (%)</b>			
<b>SBP ≥ 90 mmHg</b>	5915 (94.0)	1213 (95.4)	0.048
<b>GCS &lt;9</b>	660 (10.4)	88 (6.9)	<10 <sup>-3</sup>
<b>Spo2 &lt;90 %</b>	381 (8.4)	76 (11.4)	0.01
<b>Prehospital Grade, n (%)</b>			<10 <sup>-3</sup>
<b>Grade A</b>	385 (5.9)	34 (2.5)	
<b>Grade B</b>	991 (15.2)	223 (16.6)	
<b>Grade C</b>	2713 (41.5)	398 (29.7)	
<b>Non-graded</b>	2441 (37.4)	687 (51.2)	
<b>ISS, mean (SD)</b>			
<b>Grade A</b>	31.17 (14.1)	25.21 (13.5)	0.02
<b>Grade B</b>	20.36 (11.4)	16.9 (9.4)	<10 <sup>-3</sup>
<b>Grade C</b>	10.89 (8.9)	10.37 (7.7)	0.3
<b>Non-graded</b>	16.18 (12.1)	14.43 (10.7)	<10 <sup>-3</sup>
<b>Hospital resuscitation, n (%)</b>			
<b>Blood transfusion</b>	63 (1.0)	4 (0.3)	0.02
<b>Assisted ventilation</b>	955 (14.6)	153 (11.4)	0.02
<b>Hospital physiological signs, n (%)</b>			
<b>SBP ≥ 90 mmHg</b>	5317 (94)	1146 (96.3)	<10 <sup>-3</sup>
<b>GCS &lt;9</b>	912 (15.0)	132 (10.9)	<10 <sup>-3</sup>
<b>Spo2 &lt;90 %</b>	184 (3.3)	37 (3.2)	0.8
<b>ICU length stay, Days (median (IQR))</b>	4 (2-10)	3 (2-7)	<10 <sup>-3</sup>
<b>ICU admission, n (%)</b>	423 (6.5)	94 (7.0)	0.5
<b>Hospital Grade, n (%)</b>			<10 <sup>-3</sup>
<b>Grade A</b>	657 (10.1)	94 (7.0)	
<b>Grade B</b>	1333 (20.4)	288 (21.5)	
<b>Grade C</b>	3359 (51.4)	652 (48.6)	
<b>Non-graded</b>	1181 (18.1)	308 (23.0)	
<b>ISS &gt;15, n (%)</b>	2857 (44.6)	543 (41.1)	0.02
<b>ISS (mean, SD)</b>	15.5 (12.1)	13.9 (10.1)	<10 <sup>-3</sup>

<b>Survival, n (%)</b>	6105 (93.5)	1310 (97.6)	<10 <sup>-3</sup>
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SD, Standard deviation; n, number; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; SpO2, pulse oxygen saturation; SBP, systolic blood pressure; ICU, Intensive care unit;

## Accuracy of prehospital triage

The undertriage rate of WSS accidents patients was higher compared to the undertriage rate of the other accident group with a rate of 10.9% vs 6.5% respectively ( $p < 10^{-3}$ ).

The overall undertriage rate is 7.2% with an overtriage rate at 43.5%.

See table N°2.

Table N°2: Undertriage and overtriage rates by type of accidents:

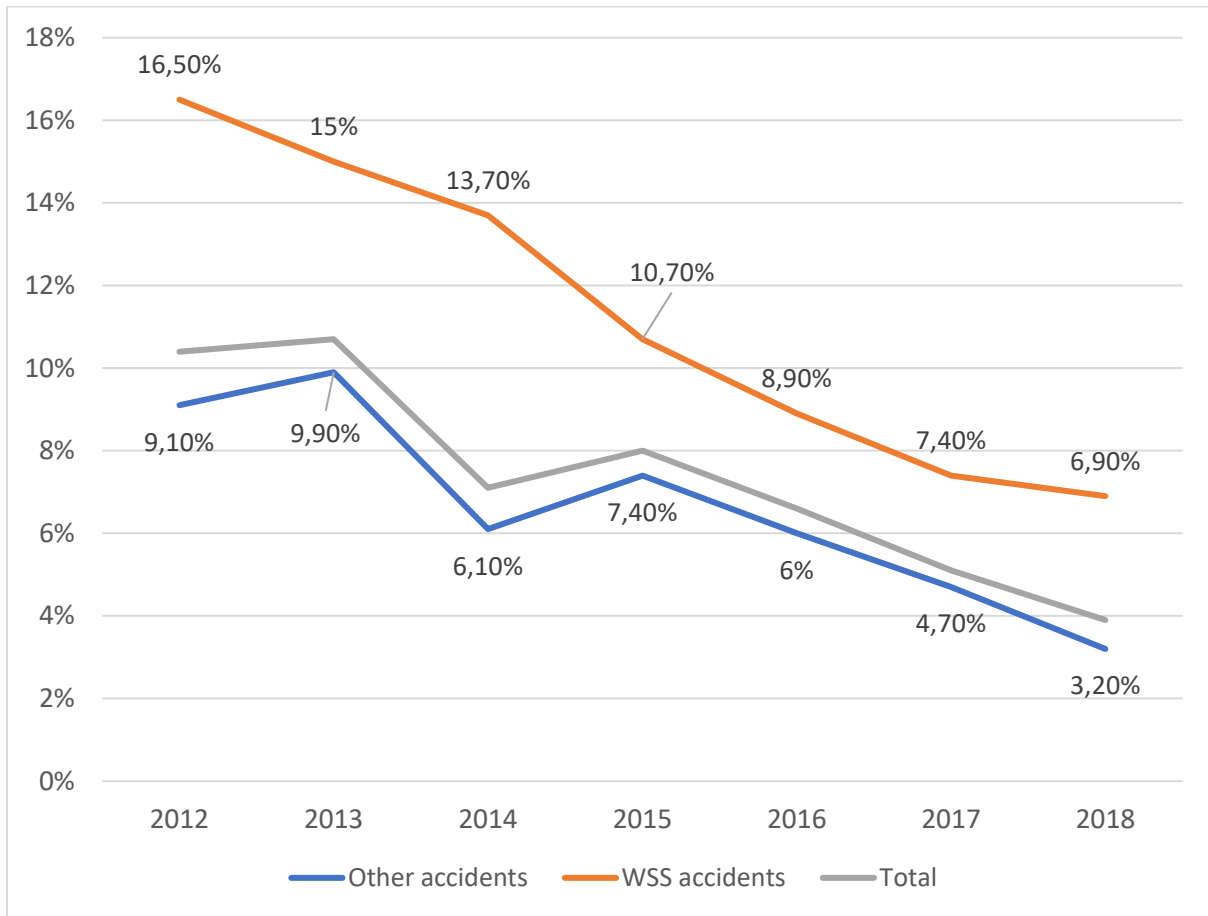
	Other accidents		winter sliding sport accidents		<i>p</i>
	Numbers	%	Numbers	%	
<b>Overtriage</b>	2822	43.2%	605	45.1%	0.2
<b>Undertriage</b>	424	6.5%	146	10.9%	< 10 <sup>-3</sup>

*Definition from the American College of Surgeon's Committee on Trauma (ACS-COT): undertriage = severe trauma patient (ISS > 15) admitted to a level III or lower center; Overtriage = non-severe trauma (ISS < 16) admitted to a level II or I center.*

This undertriage rate is constantly improving and reaches 6.9% in 2018 for WSS victims and 3.2% for other types of accidents.

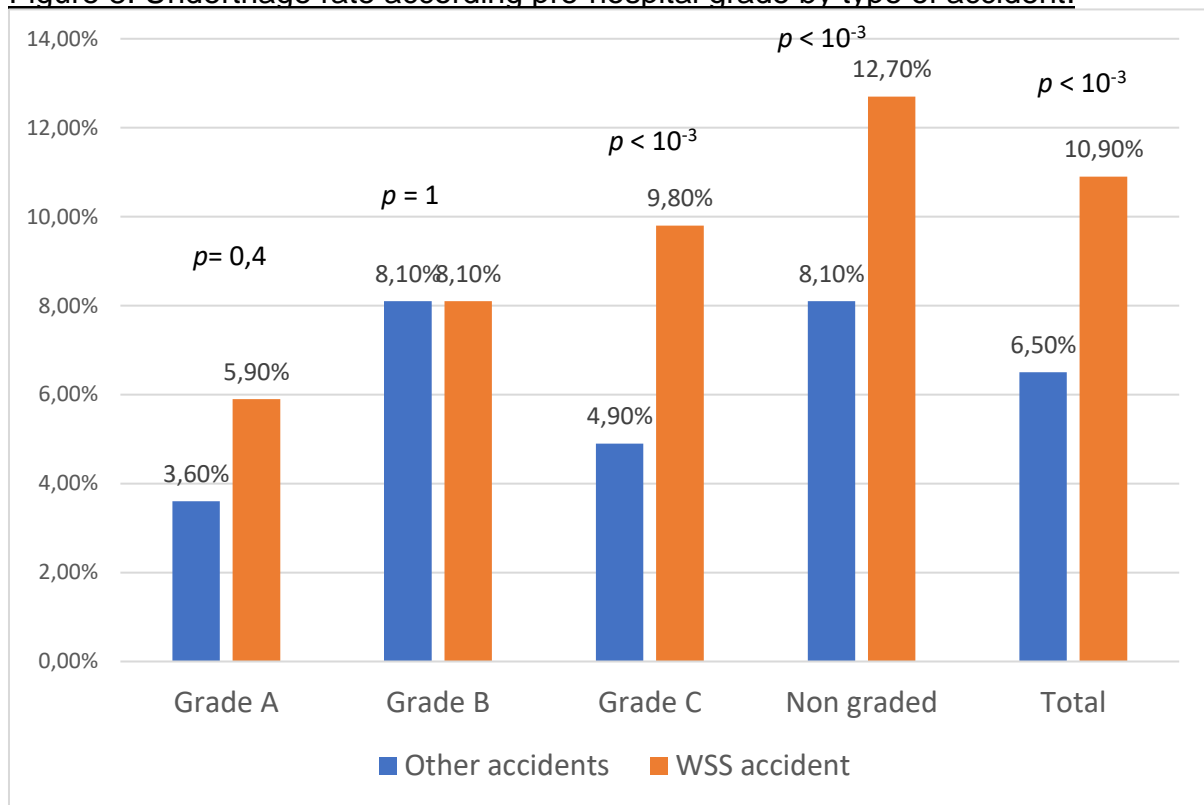
See Figure 7.

**Figure 7: Undertriage rates of severe trauma patients within TRENAU according to years (2012 to 2018):**



When we analyze in sub-group, this undertriage rate of severe trauma patients according to their prehospital grades, we note that patients graded "C" and patients "non graded" have a higher undertriage rate in the group of winter sliding sports accidents (Grade "C": 9.8% vs 4.9%  $p < 10^{-3}$  and "non graded": 12.7% vs 8.1%  $p < 10^{-3}$ ). There is no statistically significant difference between the other Grade categories. See Figure 8

**Figure 8: Undertriage rate according pre-hospital grade by type of accident:**

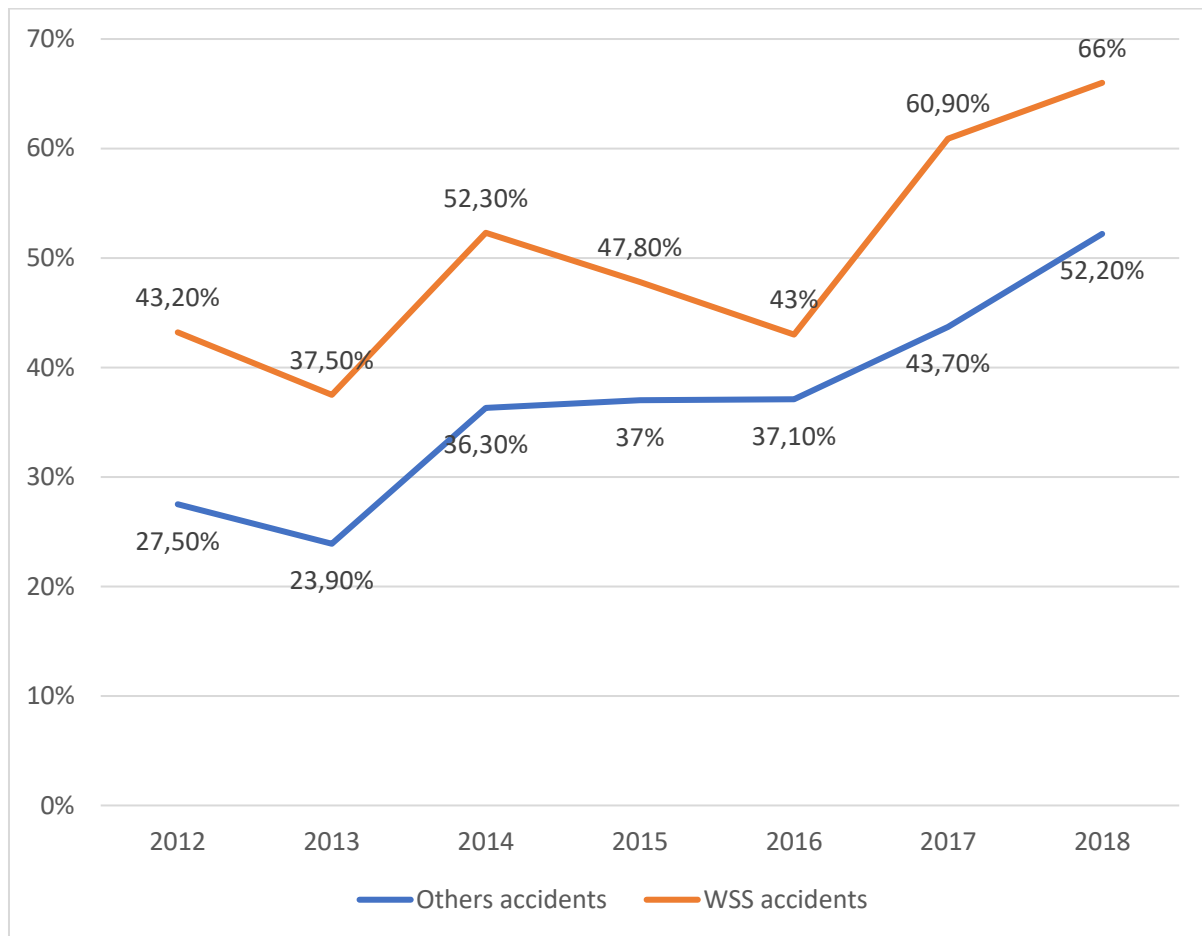


### Prehospital triage according to the RENAU field triage protocol

As we have already explained previously, in the RENAU trauma system, severely traumatized patients are classified as prehospital in grade "A", "B" or "C" according to their severity.

However, the application of this field triage guidelines is not always carried out. The evolution of the prehospital non-graded rate of severe trauma patients, in both groups, is globally increasing, with a maximum reached in 2018 at 66% for patients with WSS accidents and 52% for victims of other types of accidents. See Figure 9.

**Fig. 9: Prehospital non-graded rates according to the TRENAU field triage protocol:**

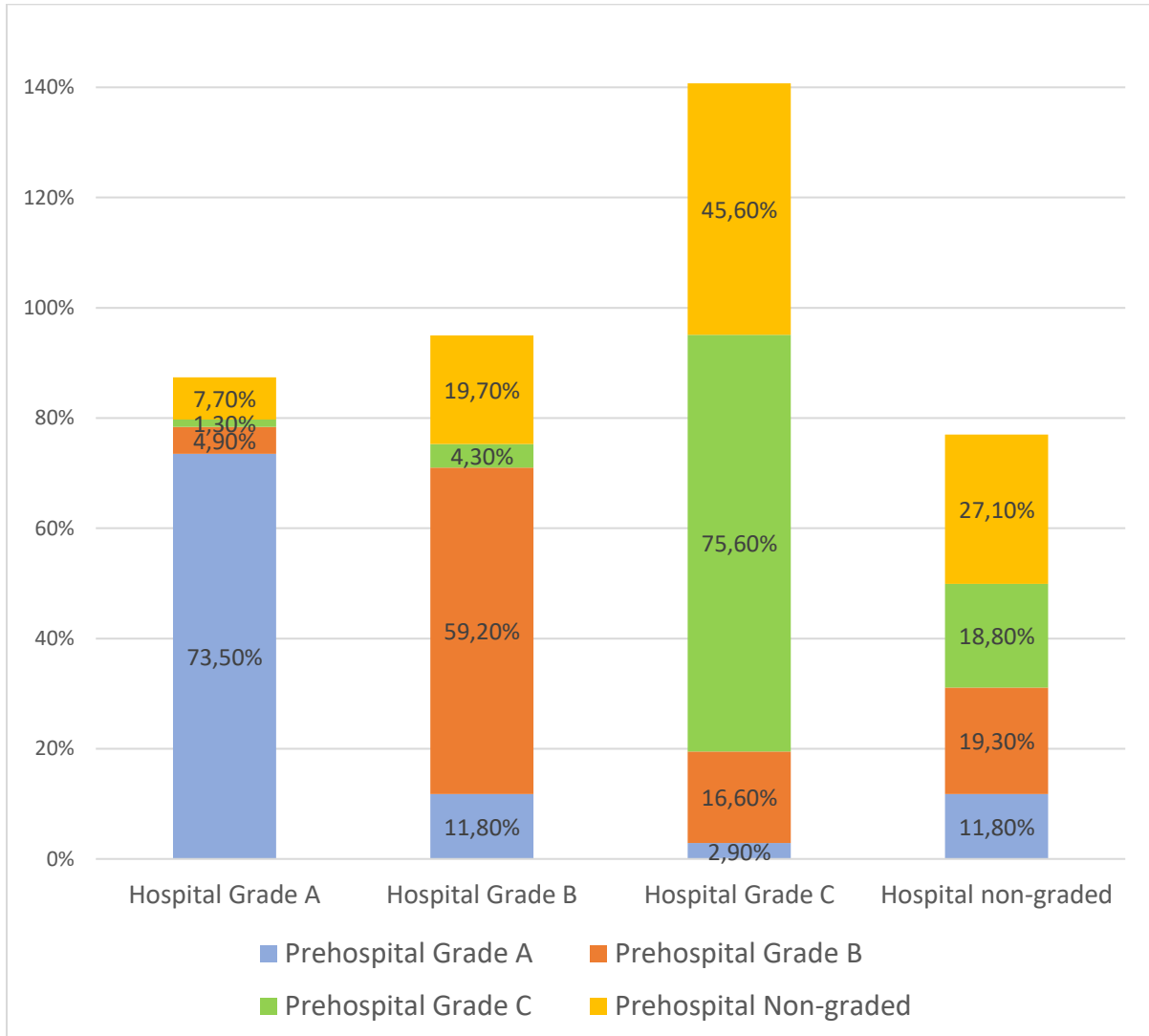


When performed, this gradation corresponds to an early estimation of the patient's severity. This estimation is therefore likely to change in hospitals after medical reassessment.

In our study, out of the 398 severely traumatized WSS patients classified in prehospital as "grade C", 301 (75.6%) remained graded "C" in hospital after medical reassessment. This grade is revised upwards to "grade B or A", respectively in 4.9% and 1.3%.

The "non-graded" prehospital patients in this same group of trauma victims of WSS are classified as "Grade C" in 45.6% of the cases, as "Grade B" in 19.7% and as "Grade A" in 7,7%. See Figure 10.

Fig 10: Composition of hospital grades after reassessment of prehospital grades in the WSS accident group according to the TRENAU protocol:



Thus, between the prehospital and hospital assessment, the gradation of trauma patients in the RENAU trauma system, all grades combined, was revised upwards in 7.8% in the group of other accident victims and in 6.1% in the group WSS casualties. Conversely, the gradation of the patients was reduced in 5.3% and 7.8% of the cases, respectively. See table N °3

Table N°3: Variation in categorization of grades according to the RENAU triage protocol between the prehospital and the hospital of severe trauma patients according to the type of accident:

	Grade decreased	Grade unchanged	Grade increased
Other accidents, n (%)	182 (5.3)	2983 (86.9)	266 (7.8)
winter sliding sport accidents, n (%)	42 (7.8)	462 (86.0)	33 (6.1)
<b>Total, n (%)</b>	<b>224 (5.6)</b>	<b>3445 (86.8)</b>	<b>299 (7.5)</b>

### Interhospital transfer (IHT)

The interhospital transfer rate is 9.2% in the category of “non-graded” patients in the WSS accident group and it is 5.4% in the group of other accidents for the same category ( $p < 10^{-3}$ ).

The transfer rate is also higher in “C” grade patients in the WSS accident group compared to the group of other types of accidents of equal grade (2 vs 0.4%,  $p = 0.02$ ). See table N °4.

Table N°4: IHT according to prehospital grade

	Other accidents	winter sliding sport accidents	<i>p</i>
<b>Prehospital grade, n (%)</b>			
Grade C	12 (0.4)	8 (2.0)	0.02
Grade B	23 (2.3)	7 (3.1)	0.4
Grade A	8 (2.1)	1 (2.9)	0.5
<b>Non-Graded</b>	<b>131 (5.4)</b>	<b>63 (9.2)</b>	<b>&lt;10<sup>-3</sup></b>

In patients in the "grade C" and "non-graded" groups, the mean ISS when IHT occurred was 22.5 (SD = 8) and 18.9 (SD = 10.4) respectively. See table N °5.



Table N°5: Average ISS score of WSS accident victims for “grade C” and “non-graded” patients in pre-hospital depending on the performance of an IHT

<b>winter sliding sport accidents</b>					
	<b>IHT</b>	<b>Numbers</b>	<b>ISS mean</b>	<b>SD</b>	<b>p</b>
<b>Grade C</b>	No IHT	384	10.1	7.5	<10 <sup>-3</sup>
	IHT (to level 1 or 2)	8	<b>22.5</b>	8.0	
<b>Non-graded</b>	No IHT	612	14.0	10.6	<10 <sup>-3</sup>
	IHT (to level 1 or 2)	63	<b>18.9</b>	10.4	

IHT, Interhospital transfer; SD, standard deviation

In multivariate analysis, some variables, such as skiing (OR = 1.9, CI 95% [1.5; 2.6];  $p < 10^{-3}$ ), the female gender (OR = 1.4, CI 95% [1.03; 1.8];  $p = 0.03$  :), the absence of prehospital gradation (OR = 4.3, CI 95% [2.1; 8.7];  $p < 10^{-3}$ ), have been associated with an increased risk of IHT in severe trauma patients. See table N °6.

Table N °6: Multivariate analysis of the characteristics associated with IHT

<b>Risk factor</b>	<b>OR (CI 95%)</b>	<b>p</b>
<b>Prehospital Grade A</b>	Reference data	
<b>Prehospital Grade B</b>	(OR=1.5 [0.7 ; 3.3])	0.3
<b>Prehospital Grade C</b>	(OR=0.6 [0.2 ; 1.3])	0.2
<b>Prehospital Non-graded</b>	<b>(OR=4.3 [2.1 ; 8.7])</b>	<10 <sup>-3</sup>
<b>Ski accident</b>	<b>(OR=1.9 [1.5 ; 2.6])</b>	<10 <sup>-3</sup>
<b>Gender. Female</b>	(OR=1.4 [1.03 ; 1.8])	0.03
<b>Face AIS&gt; 3</b>	(OR=0.5 [0.1 ; 1.5])	0.2
<b>Head AIS ≥3</b>	<b>(OR=2.4 [1.8 ; 3.1])</b>	<10 <sup>-3</sup>
<b>Thorax AIS&gt;3</b>	(OR=1.0 [0.8 ; 1.3])	0.8
<b>Abdomen AIS≥3</b>	<b>(OR=2.7 [2.0 ; 3.6])</b>	<10 <sup>-3</sup>
<b>Pelvic and limbs AIS≥3</b>	(OR=1.4 [1.1 ; 1.9])	0.02

AIS, Abbreviated Injury score; OR: Odd ratio; IHT: Interhospital transfer

## Injury profile depending on the type of accident

Thoracic injuries are the most frequent among the severely injured in the other accidents group. (32.3% other accidents group and 28.3% WSS accidents group,  $p = 0.01$ ). They are also more likely to experience multiple traumatic injuries affecting multiple areas of the body.

Lesions affecting the abdominal and pelvic region (excluding the pelvis) are more common in trauma victims of WSS (20.3% vs 12.1%,  $p < 10^{-3}$ ).

Table N°7 summarizes the locations of the various injuries of severe trauma victims.

Table N °7: Distribution of injuries according to the type of accident

	Other accidents	winter sliding sport accidents	<i>p</i>
	Numbers (%)	Numbers (%)	
<b>Body region injured,</b>			
<b>Head Neck AIS<math>\geq</math>3</b>	1775 (27.2)	307 (22.9)	$<10^{-3}$
<b>Face AIS<math>\geq</math>3</b>	116 (1.8)	15 (1.1)	0.09
<b>Thorax AIS<math>\geq</math>3</b>	2107 (32.3)	380 (28.3)	0.01
<b>Pelvis abdomen AIS<math>\geq</math>3</b>	790 (12.1)	<b>272 (20.3)</b>	$<10^{-3}$
<b>Basin Member AIS<math>\geq</math>3</b>	1575 (24.1)	191 (14.2)	$<10^{-3}$
<b>External lesion AIS<math>\geq</math>3</b>	16 (0.2)	0	
<b>Regions injured,</b>			$<10^{-3}$
<b>1</b>	2796 (64.4)	<b>721 (78.4)</b>	
<b>2</b>	1126 (25.9)	159 (17.3)	
<b><math>\geq</math>3</b>	418 (9.6)	40 (4.3)	

AIS, Abbreviated Injury score;

## Discussion

The main objective of the RENAU trauma system is to reduce the mortality of severe trauma victims, mainly for trauma victims of WSS, particularly numerous in the region of the Northern French Alps. Time is an essential determinant of outcome in the early care of trauma patients. Time taken to care for patients between the trauma and a trauma center must be as short as possible. This is also true in physician-staffed trauma systems. Total prehospital time is independently associated with increasing all-cause in-hospital mortality in a physician-staffed trauma system (14)

This requires optimal care and assessment of victims as well as referral to the most suitable trauma center. The accuracy of field triage protocols is therefore essential. The purpose of such a protocol would ideally be that all severely injured patients (ISS > 15) would be transported to a level one trauma center and all non-severely injured patients to a level two or three trauma center.

Undertriage and overtriage determined using the ISS are reliable parameters and widely used in the literature to assess the performance of a trauma system (10) (15). Undertriage is associated with an increase in the morbidity and mortality rate (2) (16) (10).

An early evaluation of the TRENAL system had been carried out by Bouzat et al [7] in 2015, study which focused on these first 3 years of operation. A rate of undertriage close to 18% (95% CI: 15.4; 19.8) and overtriage at 77% (95% CI: 74.3; 78.8), were noted. These rates, while unsatisfactory, were found to be average for some other trauma systems around the world. They probably testified to a certain immaturity of the newly created network as evidenced by the evolution of undertriage rates within RENAU in recent years.

Nathens et al (17) showed in 2000 that it took 10 years for the organization of the trauma center in the USA to have a significant impact on the mortality of road accident patients.

In our study, which focused on the years subsequent to those analyzed by Bouzat et al, we find a clear improvement in triage parameters with a rate of undertriage at 7,2%

and overtriage at 43,5%. These rates approach the objectives set by the ACS-COT (Undertriage <5% and overtriage <35%)(10). Currently, no trauma system has managed to achieve these goals. (15).

### Accuracy field trauma protocol

The objective of our study was to assess the performance of the triage for severely traumatized patients in the event of a WSS accident. We therefore compared the undertriage rate of severe trauma victims of WSS accident to other types of accidents.

The WSS accident patients undertriage rate was 11% with an overtriage rate of 45%. This undertriage rate was significantly higher compared to the group of patients with other types of accidents, which was only 6.5% ( $p < 10^{-3}$ ).

This rate is also far removed from the theoretical acceptable rate of undertriage in a trauma care system, set at 5% by ACS-COT (10). In addition to the increase in morbidity and mortality, undertriage is associated with a diagnostic and therapeutic delay, undiagnosed lesions, an increase in post-traumatic hospital readmission (2) (10) (18)

The consequences of this undertriage are real and his rate is higher in our trauma system when the patient is involved in a winter sports accident compared to other patients.

We therefore sought to explain this result. Several causes seem to be involved.

- First, a geographic cause.

The mountainous region of the northern Alps represents a logistical challenge for the transport of patients to hospital centers of suitable level. It has been shown, by various studies on patient management in rural areas, that the presence of a large geographic distance between the level center adapted to the trauma and the place of the accident, reduce the probability that the patient is supported in a level one center (19) (20) (21). Thus, the location of these WSS accidents, in rural, mountainous and hilly areas, probably provides an initial response to this higher undertriage rate.

➤ Second, the prehospital non-gradation of patients.

In the event of severe trauma linked to a WSS accident, more than 50% of patients do not benefit from prehospital gradation according to the RENAU local field triage protocol. The undertriage rate for these “non-graded” patients is 12.7%.

On the other hand, prehospital non-gradation concerns only 37% of patients in the group of other types of accidents ( $p < 10^{-3}$ ). It is interesting to note that the undertriage rate is also higher in this population (8.1%).

Thus, compliance with the RENAU prehospital grading protocol seems to decrease the rate of undertriage.

Unfortunately, it seems that the gradation of patients, whatever the nature of the accident, is less and less performed in prehospital. The latest data in our study, which covers the year 2018, shows that the absence of prehospital gradation affects 66% of victims of WSS accidents and 52% victims of other types of accidents.

➤ Third, the case of “grade C”

In our study, 9.8% of severely traumatized WSS graded “C” in the RENAU field triage are under-triaged. In other words, 9.8% of these patients have an ISS > 15 and are treated in a hospital center level III or less. This rate is much higher than the undertriage rate for prehospital “C” grade patients in other types of accidents (4.9%,  $p < 10^{-3}$ ). How to explain this difference?

A difference related to the injury severity between the two groups?

Looking at the average ISS of “C” graded patients, there is no statistical difference between trauma victims of WSS and other types of trauma (10.37 and 10.89,  $p = 0.3$ ). The “grade C” of WSS accidents are as serious as the “grade C” of other types of accidents.

A difference related to a prehospital grading error?

Once in hospital, patients are reassessed medically, and the prehospital grade can be changed up or down.

After subgroup analysis, a prehospital “grade C” remains a hospital “grade C” after medical reassessment in 75.6% ( $n = 301$ ) of cases and becomes a “grade B or A” in 4.3% ( $n = 17$ ) and 1.3% ( $n = 5$ ) of the cases. Thus, only 5.6% of patients graded “C”

have an increased hospital grade. Unfortunately, a significant number of patients graded in prehospital in the regional field trauma protocol in "A / B / C" were not graded in hospital. It is impossible to know if the gradation was not performed in hospital or if the data was lost secondarily. Thus, 18% (n = 75) of patients graded "C" in prehospital are no longer graded in hospital, which makes the interpretation of this analysis in subgroup delicate.

A "grade C" in the TRENAU triage protocol unsuitable for WSS severe trauma patients?

This is another hypothesis to explain this mismatch between the grade of some of these patients and their ISS. Should we consider WSS trauma patients as a special population requiring special assessment?

It is difficult to explain, with our data, the reason for such a difference in undertriage between the "grade C" of the two groups.

### Definition of undertriage

The choice of the definition of undertriage is a redundant problem in the literature evaluating prehospital triage.

The ISS > 15 to define a severe patient is the most used international definition (15). In the absence of a Gold standard, this definition seemed to us to be the most robust and allowed us to compare our results with international publications. However, this definition is not perfect, so Newgard et al (22) have shown that there may be a discrepancy between ISS and the resources necessary for proper care. Some patients with an ISS <15 may require resources from a hospital center higher than that of level III (For example: the elderly, patients with many active comorbidities, etc.)

Conversely, some patients with an ISS > 15 may very well be managed in level III centers (example used by Bouzat et al (10) : a patient with an open leg fracture (AIS 3) and an asymptomatic pneumothorax, (AIS 3); corresponds to a patient with an ISS at 18, but can very well be treated in a level III center).

However, the impact of the use of different definitions on the accuracy of the under- and overtriage rates is not major. Thus, Lossius et al (23) have shown that the use of the ISS or the NISS or of these two scores to which other criteria have been added, to

retrospectively define the severity of a patient and therefore define under and overtriage, does not change significant calculation of these rates.

### Interhospital transfer (IHT)

We then looked at the interhospital transfer (IHT) rate. This rate corresponds to the percentage of severe trauma patient indirectly admitted to a level I or II trauma center via a level III or less care facilities.

Providing trauma care within a trauma center is now known to save lives and prevent long-term disability, so the direct transportation of severely injured patients to designated centers, while bypassing closer nonspecialized facilities, is considered optimal. This has been shown in various international studies (16) (24) (25).

However, a recent meta-analysis on the subject failed to support or refute a conclusion that all severe trauma patients should be routinely transported directly to a level I or II trauma center (26). Yet, it is important to underline the absence of French study retained in this meta-analysis.

As a matter of fact, few studies have analyzed the relationship between the mortality of severe trauma patients and direct or secondary transport to a trauma center in France. In a study published in 2019 within the Paris trauma system, conducted by Hamada et al, no excess mortality was found in patients transferred secondarily to a trauma center compared to patients transported directly to these centers (27). However, these results cannot readily be extrapolated to other areas of the country because Paris has an exclusive trauma system, only urban, with a very large level one trauma center coverage.

If the impact on mortality of a direct transfer to a trauma center compared to a secondary transfer remains debated, the final destination of a severe trauma patient has to be a level one or two center.

Actually, the mortality rate is lower for seriously injured patients transferred secondarily to a level one or two trauma center, compared to seriously injured patients receiving definitive care in a lower level trauma center.(2) (15).

The rate of IHT is therefore an important parameter which reflects the prehospital triage accuracy of a trauma system.

In our study, the rate of IHT was higher among the “non-graded” prehospital patients in the event of trauma linked to a WSS compared to other types of accidents (9.2% vs 5.4%  $p < 10^{-3}$ ) with a mean ISS at 18.9 (SD 10.4) among these transferred patients. Likewise, patients graded "C" had a higher rate of IHT (2% vs 0.4%,  $p = 0.02$ ). For this last category, the small number ( $n = 8$ ) does not allow us to draw any conclusion.

After multivariate analysis, the absence of prehospital gradation according to the field triage protocol of RENAU and the fact of undergoing an accident during the practice of a WSS are independent variables which increase the risk of undergoing an IHT in our trauma center (Practice of a WSS, (OR = 1.9, 95% CI [1.5; 2.6];  $p < 10^{-3}$ ); absence of prehospital gradation (OR = 4.3, 95% CI [2.1; 8.7];  $p < 10^{-3}$ )).

These results are in line with the previous findings. Patients with severe WSS trauma who are not graded in prehospital according to the regional field triage protocol are more often misdirected and more frequently require an IHT.

## Mortality

In our study, the survival rate of patients in the WSS accidents group is higher (97.6% vs 93.5%  $p < 10^{-3}$ ) and the length of stay in ICU shorter (3 days (IQR, 2-10) vs 4 days (IQR, 2-7),  $p < 10^{-3}$ ). This low mortality rate among winter sports trauma victims is similar to that observed in the literature (28) (29). These results are probably linked to a bias due to the population studied among winter WSS casualties. Like the “healthy worker effect” well described in the literature, this low mortality rate can be explained by the nature of the population studied. The WSS practitioners are generally in good health, young and have little or no comorbidity. In our study, accident victims of WSS are younger than victims of other types of accidents (median age 27 years (IQR, 18-48) vs 38 years (IQR, 23-55)). However, we do not have data on patient comorbidities in our registry.

Despite this higher survival rate and a lower mean ISS than other types of accidents (mean ISS: 13.9 (SD 10.1) vs 15.5 (SD 12.1)  $p < 10^{-3}$ ), the severely traumatized WSS are serious patients as evidenced by the rate of hospitalization in ICU which is not statistically different between the two groups (7% vs 6.5%,  $p = 0.05$ ).



## Injury and WSS

We then looked at the injury's characteristics of WSS patients to try to understand this undertriage and the prehospital non-gradation of these victims.

The description of the injuries in the event of WSS accident, highlights a higher rate of trauma in the abdomino-pelvic territory (pelvis excluded) compared to other types of accidents (20.3% vs 12.1%  $p < 10^{-3}$ ).

Our data corroborate the findings of other studies that severely traumatized patients associated with the practice of WSS are at increased risk for abdominopelvic injuries. These injuries are often serious enough to require surgery (30) (31).

Severe abdominal trauma is associated with high mortality of around 20% and are difficult to assess (2).

After multivariate analysis, the presence of a severe abdominopelvic lesion (AIS $\geq$  3) is associated with an increased risk of IHT (OR = 2.7 95% CI [2.0; 3.1];  $p < 10^{-3}$ ). This is also what is found in a recent study by Hamada et al. (AIS abdomen  $\geq$  3, OR = 3.6 95% CI [2.6–4.9]  $< 10^{-3}$ ) (27).

The literature review conducted by Nishijima DK et al (32) published in 2012, showed that clinical examination alone was not effective enough to confirm or rule out the presence of an abdominal lesion in severe trauma patients.

The latest French recommendations for the management of severe abdominal trauma in adults, issued jointly by the SFMU (French Society of Emergency Medicine) and the SFAR (French Society of Anesthesia and Resuscitation) in 2019 (33), recommend “not to limit yourself to the clinical examination for this type of trauma”.

Thus, this high rate of abdomino-pelvic lesions in traumatized WSS patients may also explain this higher rate of prehospital non-gradation due to the clinical difficulty in recognizing severe lesions in this anatomical location.

The use of FAST and its extended form, E-FAST (Extended Focused Assessment with Sonography for Trauma) to improve clinical recognition of these lesions was not analyzed in our study because of a lack of data.

The use of FAST prehospital to improve the triage of patients suffering from this type of lesion is still debated due to its low sensitivity. So, there is no formal recommendation for the realization of FAST in prehospital in this context. According to French recommendations for the management of severe abdominal trauma (33) it is "probably recommended to use prehospital FAST ultrasound to diagnose the presence of intraperitoneal effusion".

## Limitations

There exist several limitations to this analysis. The main limitations are related to its design. It is an observational, retrospective study, carried out on a prospective database.

There is an information bias, specific to studies based on registers. This is linked to missing data and especially to severe trauma patients not included in the RENAU register. There is no study on the completeness of patient's inclusion for this database. Using digital tools (digital tablet for example) on the accident site could help reduce this data loss.

In the RENAU databases, there is no data on "technical stops" consisting in stabilizing the patient outside of a hostile environment in the nearest hospital center. Although not recommended in RENAU procedures, this possibility cannot be excluded. We cannot therefore differentiate in our study, an IHT related to a poor initial orientation of the patient, from an organized IHT, carried out following a "technical stop"

## Conclusion

Since decades, lots of studies have shown that the organization and development of regional trauma system has reduced the morbidity and mortality of severe trauma patients and provided better care.

Regular evaluation of these healthcare networks is necessary in order to improve their performance and guarantee patient safety. Prehospital trauma triage is essential by ensuring transportation of patient to the right type of hospital. Undertriage and overtriage are reflections of this accuracy.

The TRENAU (Northern French Alps Trauma System) is the first trauma system created in France, it combines the organization of trauma system of the USA with French medical expertise in prehospital care.

More than 7800 severe trauma patients were treated in this regional trauma system between 2012 and 2018, including 1342 (17%) for trauma linked to a winter sliding sport (WSS) accident.

With 7,2% undertriage rate and 43,5% overtriage rate, the prehospital orientation within TRENAU has clearly improved in recent years and approaches the objectives set by ACS-COT. On the other hand, the undertriage rate among WSS severe trauma patients is higher than for other severe trauma patients (10.9%,  $p < 10^{-3}$ ).

Abdomino-pelvic lesions are more frequent in the event of severe trauma linked to a WSS compared to other accidents (20.3% vs 12.1%  $p < 10^{-3}$ ). These lesions are difficult to assess and are associated with significant morbidity and mortality. Ultrasound could be a useful tool to improve the detection of these lesions and reduce the undertriage rate, but additional studies on the subject should be carried out.

The rate of non-graded prehospital patients according to the regional field triage protocol in the event of WSS accidents is higher than in other types of accidents (51% vs 37.4%;  $p < 10^{-3}$ ). The proportion of undertriage in this group of non-graded patients is significantly higher than in the group of graded patients. Thus, compliance with the TRENAU prehospital grading procedure seems to decrease the rate of undertriage. Unfortunately, it seems that the realization of this protocol is less and less performed. Respect for the application of the regional field triage algorithm should be an imperative objective to improve the performance of their management.

Severe traumatized patients linked to a WSS accident, with prehospital grade "C" in the TRENAU field triage protocol, have an undertriage rate of 9.8%. It seems that this population requires special attention to lower the overall undertriage rate. Additional studies appear necessary.

## THÈSE SOUTENUE PAR FLORENT CHEMINAL

TITRE : « PERFORMANCE DU TRIAGE PRÉHOSPITALIER DES TRAUMATISÉS SÉVÈRES DES SPORTS DE GLISSE D'HIVER AU SEIN DU RÉSEAU NORD ALPIN DES URGENCES (RENAU) »

### CONCLUSION :

De nombreuses études ont démontré que l'organisation et le développement des réseaux de soins sous forme de « *trauma center* » ont permis de diminuer la morbi-mortalité des patients victimes de traumatismes sévères et de leur apporter une meilleure prise en charge.

Une évaluation régulière de ces réseaux de soins est nécessaire afin d'améliorer leurs performances et de garantir la sécurité des patients.

Le TRENAU (Trauma system du REseau Nord Alpin des Urgences) est le premier réseau de soins en traumatologie créé en France. Il concilie l'organisation des soins en traumatologie de type nord-américaine à l'expertise médicale française des soins préhospitaliers.

L'objectif de l'étude a été d'évaluer la performance de l'orientation préhospitalière des patients traumatisés sévères des sports de glisse d'hiver (SDG) au sein de ce réseau de soins entre 2012 et 2018.

Pour se faire, les taux de sous-triage des patients traumatisés sévères des SDG et des patients traumatisés sévères des autres causes d'accident ont été déterminés à l'aide de l'ISS (*Injury Severity Score*) et comparés

Plus de 7800 patients traumatisés sévères ont été pris en charge dans ce réseau de soins entre 2012 et 2018, dont 1342 (17%) pour des traumatismes en lien avec un accident SDG.

Avec 6,5% de sous-triage et 42,3% de surtriage, l'orientation préhospitalière au sein du TRENAU a nettement été améliorée ces dernières années et s'approche des objectifs de l'ACSCOT. En revanche, le taux de sous-triage chez les accidentés des SDG est plus élevé que chez les autres patients traumatisés sévères (10,9%,  $p < 10^{-3}$ ).

Les lésions abdomino-pelviennes sont plus fréquentes en cas de traumatisme sévère lié à un SDG par rapport aux autres accidents (20,3% vs 12,1%  $p < 10^{-3}$ ). Ses lésions sont difficiles à évaluer et sont associés à une morbi-mortalité importante. L'utilisation

de la FAST (*Focused Assessment with Sonography for Trauma*) pourrait améliorer la reconnaissance clinique de ces lésions et diminuer ainsi le sous-triage des patients victimes de ce type d'accident, mais des études complémentaires sur le sujet devront être réalisées.


Le taux de patients non gradés en préhospitalier selon la procédure de triage du RENAU en cas d'accidents de SDG d'hiver est plus élevé que dans les autres types d'accidents (51% vs 37,4% ;  $p < 10^{-3}$ ). La proportion de sous-triage dans ce groupe de patients non gradés est significativement plus élevée que dans le groupe de patients gradés. Ainsi, le respect de la gradation préhospitalière des patients selon le protocole du RENAU semble diminuer le taux de sous-triage. Malheureusement, l'application de ce protocole est de moins en moins effectué. Une gradation sur le terrain plus systématique de ces patients traumatisés sévères des SDG selon la procédure de triage du RENAU doit être un objectif impératif pour améliorer la performance de leur prise en charge.

Les patients traumatisés sévères des SDG, gradés « C » en préhospitalier dans le protocole de triage du RENAU, ont un taux de sous-triage de 9,8%. Il semble que cette population nécessite une attention particulière pour faire baisser le taux de sous-triage globale. Des études complémentaires paraissent nécessaires.

**VU ET PERMIS D'IMPRIMER**


Grenoble, le : 10/03/2020

**LE DOYEN**



**Pr. Patrice MORAND**

**LE PRÉSIDENT DE LA THÈSE**



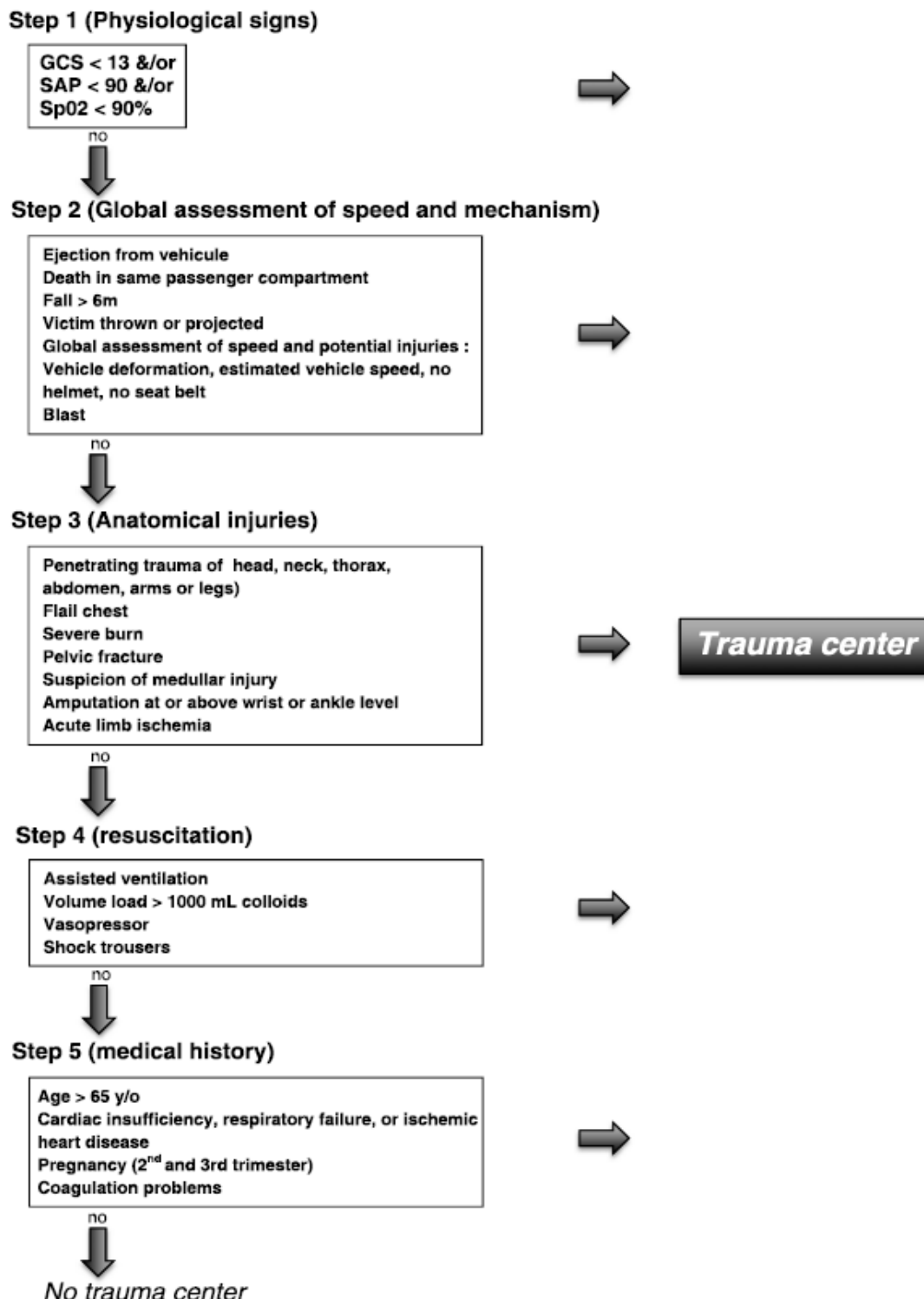
**CENTRE HOSPITALIER UNIVERSITAIRE  
GRENOBLE-ALPES  
POLE ANESTHESIE REANIMATION  
Pr. Pierre BOUZAT**

Pour le Président  
et par délégation

—  
Le Doyen de Médecine  
Pr. Patrice MORAND

# Appendix

Figure N°1 : Field triage criteria : « Critères de Vittel » :



Source : Hamada, S.R., et al., Evaluation of the performance of French physician-staffed emergency medical service in the triage of major trauma patients. J Trauma Acute Care Surg, 2014. 76(6): p. 1476-83

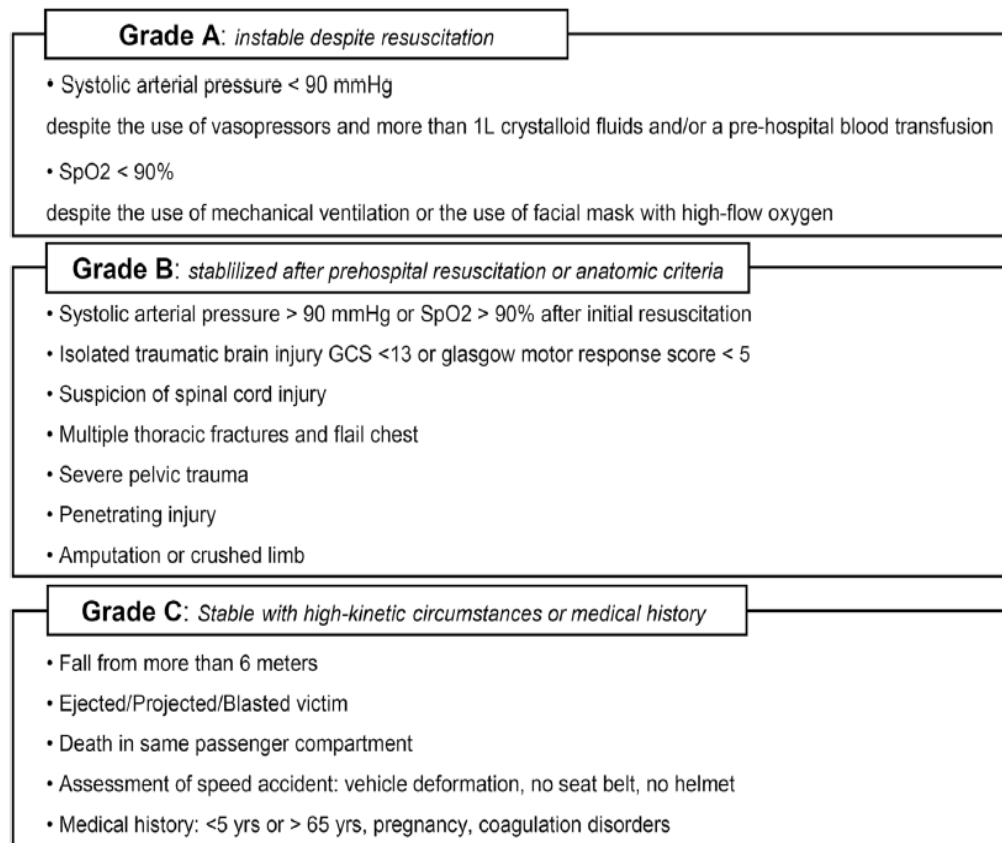
Figure 3 : Trauma Centers requirements at adult centers in RENAU (34)

	Trauma centre Level 1	Trauma centre Level 2	Trauma centre Level 3
Admission Unit	TRU	TRU/ED	ED
Trauma Team	Yes	Yes	No
Critical Care	ICU	ICU	ICU or SDU
Specialised ICU	Yes	No	No
Operating Room H24	Yes	Yes	Yes
Anaesthetist-Intensivist H24	Yes	Yes	On call
General Surgery H24	Yes	Yes	On call
Orthopaedic Surgery H24	Yes	On call	On call
Neurosurgery	Yes	No	No
Cardiac Surgery	On call	No	No
Thoracic/Vascular Surgery	On call	On call	No
Ophthalmic/ENT	On call	On call	On call
Maxillofacial	On call	On call	No
Urology	On call	On call	On call
Gynaecology/Obstetric H24	Yes	On call	On call
Imaging within 30 min	CT/MRI	CT/MRI	CT
AE within 30 min	Yes	Yes	No
Massive Transfusion	Yes	Yes	No
Mobile ICU Ambulance	> 2	At least 2	1
EMS Helicopter	> 1	1	No
Helipad Access	Yes	Yes	Yes
Major trauma (ISS > 15)	> 100	> 50	-
Trauma Research/Education	Yes	No	No

ICU: intensive care unit; SDU: step-down unit; Specialized ICU: burn-ICU, neuro-ICU, paediatric ICU; ISS: injury severity score; EMS: emergency medical system; AE: angioembolisation; TRU: trauma resuscitation unit; ED: emergency department; CT: computed tomography; MRI: magnetic resonance imaging.

Source : Gauss T et al. Strategic proposal for a national trauma system in France. *Anaesth Crit Care Pain* avr 2019; 38(2):121-30

Figure 4: Gradation of trauma patients according to the TRENAU field triage protocol:

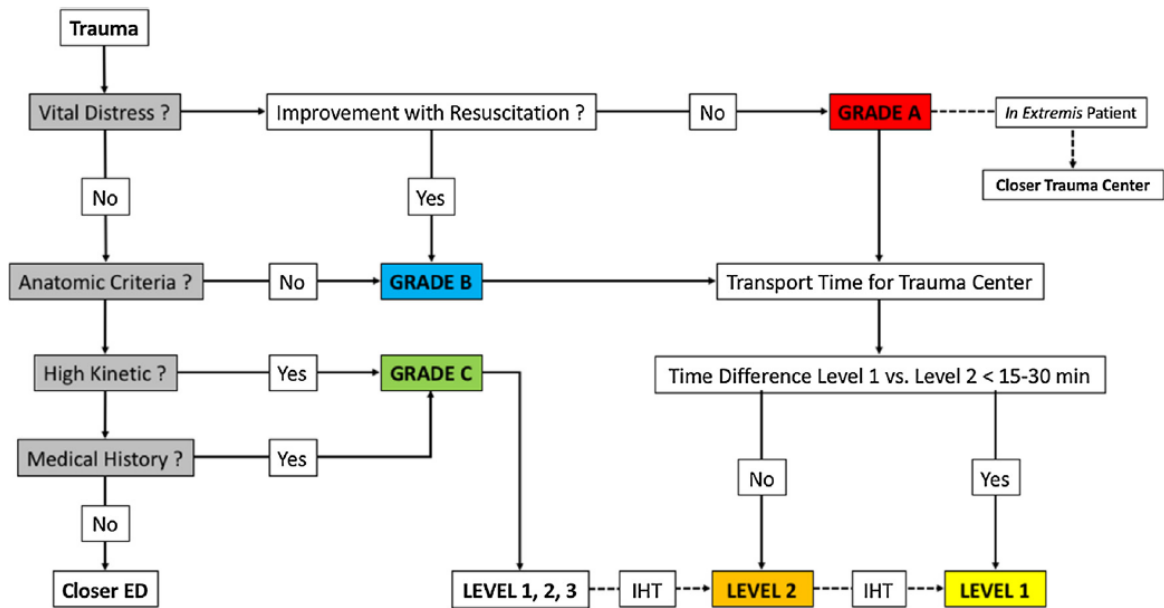


Hemodynamic instability is defined as a systolic arterial blood pressure of less than 90 mmHg despite the use of vasopressors and more than 1 L crystalloid fluids and/or a pre-hospital blood transfusion. Respiratory instability is defined as a SpO2 < 90% despite the use of mechanical ventilation and/or the use of a face mask with high-flow oxygen. GCS: Glasgow coma scale; SpO2, pulse oxygen saturation.

Source: Bouzat P et al. A regional trauma system to optimize the pre-hospital triage of trauma patients. Crit Care 2015;19



Figure 5 : Algorithm for triage of patients according to prehospital grade and level of hospitals in the RENAU (34):



Source : Gauss T et al. Strategic proposal for a national trauma system in France. *Anaesth Crit Care Pain Med*, avr 2019; 38(2):121-30

Figure N°6: Data collection triptych for the RENAU database:

**Observation Médicale Préhospitalière  
du Traumatisé sévère (Grades A, B, C)**

N° ID : \_\_\_\_\_

N° Patient : \_\_\_\_\_

SMUR de : \_\_\_\_\_ N° d'intervention : \_\_\_\_\_

<b>SAMU :</b> _____ <b>Origine de l'appel :</b> <input type="checkbox"/> 15 <input type="checkbox"/> 18 <input type="checkbox"/> 112 <input type="checkbox"/> Autre : _____	<b>Dr :</b> _____
<b>Date d'intervention :</b>  __ _  /  __ _  /  __ _ _ _	<b>IDE :</b> _____
<b>Adresse d'intervention :</b> _____	<b>ADE :</b> _____
<b>Code Postal</b>  __ _ _ _ _  <b>Ville :</b> _____	<b>Vecteur SMUR :</b>
<b>Type d'intervention :</b> <input type="checkbox"/> Primaire <input type="checkbox"/> Secondaire	<input type="checkbox"/> Terrestre : _____
<input type="checkbox"/> Jonction, SMUR de : _____ <input type="checkbox"/> Intra hospitalier	<input type="checkbox"/> Aérien : _____

**Identité**

**Nom :** \_\_\_\_\_ **Date de naissance :** |\_\_|\_| / |\_\_|\_| / |\_\_|\_|\_|\_|

**Nom de jeune fille :** \_\_\_\_\_ **N° de SS :** |\_\_|\_|\_| |\_\_|\_|\_|\_| |\_\_|\_|\_|\_|\_|\_|\_|\_|\_|

**Prénom :** \_\_\_\_\_ **Sexe :**  M  F     carte vitale jointe     carte mutuelle jointe

**Adresse :** \_\_\_\_\_ **Téléphone :** \_\_\_\_\_

**Code Postal** |\_\_|\_|\_|\_|\_| **Ville :** \_\_\_\_\_ **Pays :** \_\_\_\_\_

**Médecin traitant :** Dr \_\_\_\_\_ **Personne à prévenir :** \_\_\_\_\_

**Horaires**    **Heure estimée de l'accident :** |\_\_|\_| h |\_\_|\_| min

<b>1<sup>er</sup> appel au « 15/18 » (=T0) :</b>  __ _  h  __ _  min	<b>Arrivée 1<sup>er</sup> secours (SP ou autre) :</b>  __ _  h  __ _  min
<b>Départ base SMUR :</b>  __ _  h  __ _  min	<b>Arrivée SMUR sur les lieux :</b>  __ _  h  __ _  min
<b>Bilan d'ambiance :</b>  __ _  h  __ _  min	<b>Départ SMUR des lieux :</b>  __ _  h  __ _  min
<b>Arrivée hôpital de destination :</b>  __ _  h  __ _  min	<b>Retour SMUR base :</b>  __ _  h  __ _  min

**Destination**

**Transport :**     SMUR terrestre     Heli-smur     VSAV     Ambulance     Autre : \_\_\_\_\_

Médicalisé     Non médicalisé     Laisse sur place

Décès date : |\_\_|\_|\_| / |\_\_|\_|\_| / |\_\_|\_|\_|\_|\_| | heure : |\_\_|\_| h |\_\_|\_| min    **Obstacle médico-légal**  O  N

**Etablissement :** \_\_\_\_\_ **Confié au Dr :** \_\_\_\_\_

Déchocage     SAUV     SAU     Réanimation     Bloc opératoire     Imagerie     Autre : \_\_\_\_\_

**Anamnèse - Contexte**

**Mécanisme:**     Trauma fermé     Brûlure     Trauma pénétrant     Arme blanche     Arme à feu

Autre : \_\_\_\_\_

**Intention :**     Accident     Auto-infligé     Agression / rixe

**Type d'accident :**  Travail     Domestique     Sport/ montagne     Cinétique élevée

<input type="checkbox"/> Route <input type="checkbox"/> AVP VL/PL/Bus <input type="checkbox"/> Conducteur <input type="checkbox"/> Passager <input type="checkbox"/> Désincar. > 15 min	<input type="checkbox"/> Absence de ceinture de sécurité <input type="checkbox"/> Airbag déclenché
<input type="checkbox"/> AVP Moto <input type="checkbox"/> Non casqué	
<input type="checkbox"/> AVP Vélo	
<input type="checkbox"/> AVP Piéton	

Obstacle : \_\_\_\_\_

**Autre :**     Chute d'un lieu élevé : \_\_\_\_\_mètres     Chute de faible hauteur     Ecrasement

**Détails :** \_\_\_\_\_

Âge : \_\_\_\_\_ Poids : \_\_\_\_\_ Taille : \_\_\_\_\_  Grossesse : \_\_\_\_\_ SA

**Antécédents**

-----  
 -----  
 -----  
 -----  
 -----  
 Allergies : -----

**Traitement en cours**

Aucun traitement  
 Inconnu  
 Anti-agrégant : -----  
 Anti-coagulant : -----  
 Autres : -----  
 ASA :  1     2     3     4     5     6

**Gestes pratiqués avant l'arrivée du SMUR**

MCS     MSP     ISP     Autre : -----

Aucun     Collier cervical     Ceinture pelvienne     Garrot     Coquille / plan dur     IOT     VVP     RCP/MCE     Autres : -----

Traitements reçus : -----

**Observation clinique SMUR :**

Arrêt cardiaque  Non  
 Oui, avant arrivée secours  
 Oui, après arrivée secours

TC PC  
 TC grave  
 Choc hémorragique  
 Détresse respiratoire  
 Trauma thoracique  
 Hémo/Pneumothorax  
 Trauma abdominal  
 Fracture membre  
 Fracture fémur  
 Bassin grave  
 Trauma rachis  
 Para/Tétraplégie

**Conclusion**

**Conditionnement**

<input type="checkbox"/> VS - O <sub>2</sub> Lunette / masque _____ l/min	<input type="checkbox"/> VVP Nombre : _____	<input type="checkbox"/> Geste d'hémostase : _____
<input type="checkbox"/> VNI   FR : _____ /min    VT : _____ ml	<input type="checkbox"/> KTIO	<input type="checkbox"/> Thoracostomie <input type="checkbox"/> D <input type="checkbox"/> G
<input type="checkbox"/> IOT   PEEP : _____ mmHg    FOI <sub>2</sub> : _____ %	<input type="checkbox"/> VVC	<input type="checkbox"/> Drainage thoracique <input type="checkbox"/> D <input type="checkbox"/> G
<input type="checkbox"/> Intubation difficile <input type="checkbox"/> Inhalation	<input type="checkbox"/> KT artériel	<input type="checkbox"/> Contention rachis : _____
	<input type="checkbox"/> Auto-transfusion	<input type="checkbox"/> Contention bassin : _____
		<input type="checkbox"/> Contention membre : _____

**Fast Echo**

Non réalisée     Réalisée :     Epanchement non vu  
 Epanchement vu :     Péritoine     Péricarde     Plèvre

**Grade au départ des lieux**

<input type="checkbox"/> Grade A	<input type="checkbox"/> Grade B	<input type="checkbox"/> Grade C
----------------------------------	----------------------------------	----------------------------------

Heure	T0 HH:00	HH:00	HH:00	HH:00	HH:00	T Hôpital HH:00
<b>Constantes (indiquer obligatoirement les 1<sup>eres</sup> constantes sur les lieux et les 1<sup>eres</sup> constantes au déhocage)</b>						
FC / min						
PAS / PAD mmHg	/	/	/	/	/	/
PAM mmHg						
FR / min						
SpO <sub>2</sub>						
EtCO <sub>2</sub>						
EN - EVA						
Glasgow (à détailler)	Y   M   V	Y   M   V	Y   M   V	Y   M   V	Y   M   V	Y   M   V
	Total	Total	Total	Total	Total	Total
Température °C						
Glycémie (g/l ou mmol/l)						
Hémocue g/dl	N°1					
	N°2					
Pupilles	Réactives	<input type="checkbox"/> D <input type="checkbox"/> G	<input type="checkbox"/> D <input type="checkbox"/> G	<input type="checkbox"/> D <input type="checkbox"/> G	<input type="checkbox"/> D <input type="checkbox"/> G	<input type="checkbox"/> D <input type="checkbox"/> G
	Mydriase	<input type="checkbox"/> D <input type="checkbox"/> G	<input type="checkbox"/> D <input type="checkbox"/> G	<input type="checkbox"/> D <input type="checkbox"/> G	<input type="checkbox"/> D <input type="checkbox"/> G	<input type="checkbox"/> D <input type="checkbox"/> G
<b>Traitements (Indiquer le nom du produit et la dose réalisée)</b>						
Cristalloïde (NaCl/Ringer)						
Colloïde (HEA/Voluvén/...)						
Analgésie						
Induction						
Sédation						
Ac. tranéxamique (Exacyl) gr						
Amines						
Osmothérapie						
Produits sanguins						
Antibiotiques						

**Evolution :**

Diagnostic principal : \_\_\_\_\_

CIM 10 : \_\_\_\_\_ CCMS/U : \_\_\_\_\_

Signature médecin SMUR

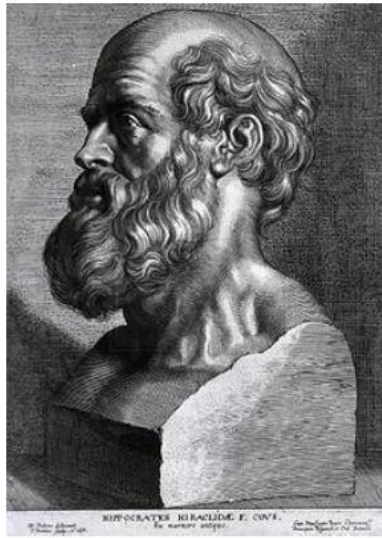
**Deux premiers feuillets -> service receveur // 3e feuillet -> SMUR**

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## **SERMENT D'HIPPOCRATE**

*En présence des Maîtres de cette Faculté, de mes chers condisciples et devant l'effigie d'HIPPOCRATE,*

*Je promets et je jure d'être fidèle aux lois de l'honneur et de la probité dans l'exercice de la Médecine.*

*Je donnerai mes soins gratuitement à l'indigent et n'exigerai jamais un salaire au dessus de mon travail. Je ne participerai à aucun partage clandestin d'honoraires.*

*Admis dans l'intimité des maisons, mes yeux n'y verront pas ce qui s'y passe ; ma langue taira les secrets qui me seront confiés et mon état ne servira pas à corrompre les mœurs, ni à favoriser le crime.*

*Je ne permettrai pas que des considérations de religion, de nation, de race, de parti ou de classe sociale viennent s'interposer entre mon devoir et mon patient.*

*Je garderai le respect absolu de la vie humaine.*

*Même sous la menace, je n'admettrai pas de faire usage de mes connaissances médicales contre les lois de l'humanité.*

*Respectueux et reconnaissant envers mes Maîtres, je rendrai à leurs enfants l'instruction que j'ai reçue de leurs pères.*

*Que les hommes m'accordent leur estime si je suis fidèle à mes promesses.*

*Que je sois couvert d'opprobre et méprisé de mes confrères si j'y manque.*