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Benefit of the Vittel criteria to determine the need for whole body scanning in a severe trauma patient

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CT scan;
Multiple trauma;
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Abstract
Objective: To evaluate the use of the Vittel criteria in addition to a clinical examination to determine the need for a whole body scan (WBS) in a severe trauma patient.
Materials and methods: Between December 2008 and November 2009, 339 severe trauma patients with at least one Vittel criterion were prospectively evaluated with a WBS. The following data were collected: the Vittel criteria present, circumstances of the accident, traumatic injury on the WBS, and irradiation. The original intent to prescribe a computed tomography (CT) scan (whole body or a targeted region), based solely on clinical signs, was specified.
Results: Injuries were diagnosed in 55.75% of the WBS ($n = 189$). The most common Vittel criteria were ''global assessment'' ($n = 266$), ''thrown, run over'' ($n = 116$), and ''ejected from vehicle'' ($n = 94$). The multivariate analysis used the following as independent criteria for predicting severe traumatic injury on the WBS: Glasgow score less than 13, penetrating trauma, and colloid resuscitation greater than 1 l. Based solely on clinical factors, 164 patients would not have had any scan or (only) a targeted scan. In that case, 15% of the severe injuries would have been missed.
Conclusion: Using the Vittel criteria to determine the need for a WBS in a severe trauma patient makes it possible to find serious injuries not suspected on the clinical examination, but at the cost of an increased number of normal scans.

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In France, severe trauma is the leading cause of death in adults under 40 years of age [1]. Its management is a real socioeconomic challenge. Usually performed by a trained, multidisciplinary medical and paramedical team, it requires a fast and thorough injury workup. Imaging is its foundation and consists of a whole body scan (WBS) [2—11]. However, the clinical criteria for performing a WBS have not been clearly established. For example, while it is mandatory for an unconscious patient with multiple trauma to undergo a WBS, a fully conscious patient with focal symptoms sometimes has only a targeted study of the symptomatic anatomical area, regardless of the severity of the trauma. This is all the more common when the patient is sent to a non-specialized department, where the initial workup may be incomplete or delayed.

Similarly, the pre-admission clinical evaluation of trauma patients is well established and relies on severity criteria based on a review of five categories of parameters: physiological variables, kinetic components, anatomical injuries, resuscitation prior to admission, and predisposition (Table 1) [12]. The existence of one or more of these criteria, known as Vittel criteria, defines a severe trauma patient. Our initial hypothesis was that these criteria could be used to determine the need for a WBS.

Thus the primary objective of your study was to assess the benefit of using the Vittel criteria in addition to a clinical examination to determine the need for a WBS in a severe trauma patient.

Table 1 List of the Vittel criteria.

Evaluation	Severity criteria
Physiological variables	Glasgow score < 13 Systolic blood pressure < 90 mmHg O_2 saturation < 90%
Kinetic elements	Ejection from a vehicle Other passenger died in the same accident Fall > 6 m Victim thrown or run over Global assessment (vehicle deformation, estimated speed, no helmet, no seat belt) Blast
Anatomical injuries	Penetrating trauma: head, neck, chest, abdomen, pelvis, arm, thigh Flail chest Severe burn, smoke inhalation Smashed pelvis Suspected spinal cord injury Amputation at the wrist, ankle, or above Acute ischemia of a limb
Resuscitation prior to admission	Assisted ventilation Colloid fluids > 1000 mL Catecholamines Inflated antishock trousers
Predisposition (to be determined)	Age > 65 years Heart or coronary failure Respiratory failure Pregnancy (second or third trimester) Dyscrasia

The presence of a single criterion is sufficient to characterize the severity of the trauma, except for predisposition, which must be evaluated case by case. Furthermore, extreme severity criteria were defined, since these are associated with very high mortality: systolic blood pressure less than 65 mmHg (mortality: 65%), Glasgow score —3 (mortality: 62%), and O_2 saturation less than 80% or unreadable (mortality 76%).

Materials and methods

Study design

This was a prospective, single-center study. Between December 2008 and November 2009, 339 severe trauma patients, referred either by the surgical resuscitation room or by the emergency department, were prospectively enrolled on an ongoing basis. The inclusion criteria were: trauma patient with at least one Vittel criterion (other than the predisposition factor). The exclusion criteria were: less than 15 years of age, pregnancy, and focal trauma without potential multiple trauma or severe kinetic component as defined in the Vittel criteria.

Technique

Trauma patients were initially treated in the surgical resuscitation room or emergency department. Some patients who had no or few symptoms could be referred by another hospitalization department.

Hemodynamically unstable patients were treated in the resuscitation room. The team consisted of an anesthesia/critical care resident, a senior anesthesiologist/critical care specialist, and a nurse. An access port was always placed in the femoral veins and arteries, and a Focused Assessment with Sonography for Trauma (FAST) was always done to find any effusion in the pleura, pericardium, the pouch of Douglas, and Morrison's space, along with exploration of the splenorenal space. The radiological workup was completed by a standard x-ray of the chest and pelvis. Then, patients who had become hemodynamically stable were examined by WBS. Patients who were still hemodynamically unstable patients were transferred to the operating room for surgical exploration.

Patients who were initially hemodynamically stable patients could be treated in the resuscitation room or the emergency department. After clinical assessment and placement of venous access ports, they were explored by WBS.

All studies were performed with the same scanner, a PHMS Brilliance computed tomography (CT) 16-slice multidetector system (Philips Netherlands) using a standardized protocol that included several acquisitions.

Acquisitions without injection of contrast product, exploring the skull (120 kV, 300 mAs) reconstructed with bone and parenchymal windows, then the cervical spine (120 kV, 250 mAs) reconstructed with a bone window, and then the abdominal and pelvic cavity (AP) (120 kV, 220 mAs) reconstructed with an abdominal window.

After IV injection of iodinated contrast, acquisition focusing on the chest, abdomen, and pelvis (CAP) (120 kV, 240 mAs), reconstructed with a pulmonary window for the chest, and abdominal and bone windows for the entire CAP. The acquisition began with the chest and was performed 60 seconds after starting the injection of 130 mL of Xenetix® 350 mg/mL (Guerbet, Roissy, France) at a rate of 3 mL/sec.

Based on the clinical guidelines and interpreting data from the non-injected series exploring the abdominal and pelvic cavity, an additional spiral scan was done in the arterial phase for 25 to 30 seconds (depending on the patient's heart function) to look for active hemorrhaging and/or in the late secretory phase for at least 10 minutes (if the patient's condition allowed) if injuries to the urinary tract were suspected.

The supra-aortic vessels were explored based on the clinical and traumatic context, after reinjection of 40 mL of contrast at 3 mL/sec. The WBS series were immediately interpreted on the work station by the radiologist on duty or on call. A handwritten provisional report was issued after the study. A second reading was always done on a PACS work station by a radiologist specializing in emergency imaging after the first report was issued.

Criteria collected

Clinical criteria

The following were collected: the Vittel criterion or criteria present (Table 1), the circumstances of the accident, the patient's initial hemodynamic condition and any changes. Finally, clinicians were asked what they would have prescribed outside the context of this study, i.e., a whole body scan, a scan of a targeted anatomical area, or no scan. That item was called ''original prescribing intent''.

Scan criteria

The radiologist completed a reading chart for each study, classifying the injuries by system. Also entered were the time the WBS was performed, the time elapsed between the accident and the WBS, and the time of the reading. The DLP on the skull/spine and CAP were collected.

Endpoints

The injuries that would not have been found by the targeted scan prescribed by the clinician (item: original prescribing intent) were entered for each patient. Those injuries were called ''unsuspected injuries''.

For each unsuspected injury, we assessed its severity, rating as severe any potentially life-threatening or disabling injuries (immediate or delayed) and injuries whose existence affected the management or monitoring of the patient.

Statistical analysis

Firstly, we performed a descriptive analysis of the data. Distributions for categorical variables are presented in terms of numbers and percentages while quantitative variables are expressed as a mean ± standard deviation (minimum, maximum). Comparisons between patients with and without injuries (determined by an abnormal or normal whole body scan, respectively) were performed for categorical variables with a chi square test, or a Fisher's exact test when the conditions for using a chi square test were not met. Student's *t* test was used to test the mean age differences between the two groups.

We then determined the effectiveness of each Vittel criterion for diagnosing the presence of an injury. The following are reported for each Vittel criterion: diagnostic effectiveness, sensitivity, specificity, positive predictive value, negative predictive value, and positive and negative likelihood ratios. To determine which Vittel criteria were independently associated with the existence of an injury, we performed a multivariate logistic regression. All analyses were performed using SAS® software Version 9.2 (SAS Inc., Cary, NC). The significance threshold was set to 5%; all tests were two-tailed.

Results

Population characteristics

Three hundred and thirty-nine patients were enrolled, 71.4% men ($n = 242$) and 28.6% women ($n = 97$). The mean age was 35.06 years (range: 15—88 years). Age and sex were not statistically predictive of traumatic injuries.

Injuries were diagnosed in 55.75% of the WBS ($n = 189$), with a relatively proportionate distribution over the main anatomical regions (Table 2).

The mean WBS reading time was estimated at 20.48 minutes (range: 8—60 minutes). The mean time between the accident and performance of the WBS was 4 hours and 15 minutes (range: 10 minutes to 24 hours).

Description of injuries by type of accident

Trauma circumstances were dominated by automobile (51.03%, $n = 173$) and motorcycle/bike (30.97%, $n = 105$) accidents. The existence of injuries (all combined) was not significantly different based on the type of accident ($P < 0.1138$) (Table 3).

The study of the anatomical regions affected by injuries by type of accident showed the following relationships (Table 3): injuries of the skull and/or cervical spine were more common with pedestrian and bicycle accidents and

Table 2 Number and percentage of injuries by location.

Injuries	*n*	Percentage based on No. of patients
Skull	63	18.6
Cervical spine	86	25.36
Chest	103	30.38
Abdomen-pelvis	74	21.82
Vascular	4	1.17
Bone	92	27.13

Table 3 Location of injuries by type of accident.

Injuries	Pedestrian n/%	Car n/%	Bicycle n/%	Motorcycle/bike n/%	Fall n/%	Other n/%	Fisher's test
All combined	15/75	87/50.29	7/70	53/55.21	18/69.23	6/75	0.1138
Skull/Cervical spine	10/50	39/22.54	5/50	18/18.75	10/38.46	2/25	0.0102
Chest	9/45	47/27.17	2/20	34/35.42	7/26.92	2/25	0.4643
Abdominal	5/25	35/20.23	2/20	27/28.13	3/11.54	2/25	0.5040
Vascular	0/0	2/1.16	0/0	2/2.08	0/0	0/0	0.8382
Bone	9/45	40/23.12	0/0	29/30.21	11/42.31	3/37.50	0.0239

falls; bone injuries (other than cervical spine) were less common with automobile and bicycle accidents.

Effectiveness of original intent to prescribe a computed tomography (CT) scan for detecting traumatic injuries

When clinicians were asked about their original intent to prescribe a CT scan (whole body or targeted anatomical region), a WBS would have been ordered in 50.74% of cases ($n = 172$), while the others were predominantly targeted brain and cervical spine scans. The distribution of scan type by anatomical region is reported in Table 4.

Of the 339 WBS performed, 44.2% were normal ($n = 150$). Of the 172 WBS that would have performed in the context of an original prescribing intent, 26.7% were normal ($n = 46$) and 73.3% were abnormal ($n = 126$). Of the 164 WBS performed based solely on the Vittel criteria, 32.3% were abnormal ($n = 53$) and 67.7% were normal ($n = 111$). The proportion of abnormal WBS was significantly higher in the original prescribing intent WBS group than in the Vittel criteria only WBS group ($P < 0.0001$).

Dosimetry study

The mean DLP was 1231.77 mGy.cm in the head-neck region, 476.92 mGy.cm in the chest, 1566 mGy.cm on the abdominopelvic region, and 2051.54 mGy.cm in the cumulative data on the chest/abdomen/pelvis region.

Table 4 Original prescribing intent.

Original prescribing intent	n	Percentage based on No. of patients
WBS	172	50.74
No scan	32	9.44
Skull-cervical spine	63	18.6
Chest	11	3.25
Abdomen-pelvis	18	5.3
Skull-cervical spine and chest	23	6.8
Skull-cervical spine and abdomen-pelvis	13	3.8
Chest and Abdomen-pelvis	4	1.17
Missing data	3	0.9

Analysis of the Vittel criteria based on traumatic injuries detected by WBS:

Distribution of the Vittel criteria

The proportion of the various Vittel criteria present is reported in Fig. 1. The most common criteria present were the ''global assessment'' criterion ($n = 266$), the ''thrown, run over'' criterion ($n = 116$), and the ''ejected from vehicle'' criterion ($n = 94$).

The effectiveness of the various criteria for diagnosis of traumatic injuries is reported in Table 5. The criteria with the best positive predictive value and sufficiently present in our severe trauma population were hemodynamic criteria and resuscitation prior to admission. However, these criteria often have low sensitivity. The ''global assessment'' criterion, which was the most common ($n = 266$), was the only Vittel criterion present in 117 patients. Injuries were found in 42 of the 117 WBS (35.9%) where the only Vittel criterion present was the ''global assessment'' criterion.

The ''thrown, run over'' criterion was the second most common criterion ($n = 116$). It was associated with a motorcycle accident in 50% of cases ($n = 54$), an automobile accident in 25.9% of cases ($n = 28$), and an accident involving a pedestrian in 16.6% of cases ($n = 18$). It was the only criterion present in 5 motorcyclists. As an original prescribing intent, only two motorcyclists would have had a WBS and a targeted scan. The presence of this criterion alone was the reason for performing a WBS in three cases, one of which had injuries. The injury that was found (peritoneal effusion with no associated parenchymal injury) was located in the area that would have been explored as part of the initial prescribing intent (targeted scan) and did not affect treatment.

The ''ejected from vehicle'' criterion was the third most common criterion ($n = 94$). It was the only criterion present in 13 motorcyclists. As an original prescribing intent, only five motorcyclists would have had a WBS. The presence of this criterion alone was the reason for performing a WBS in eight cases, three of which had injuries. In all three cases, no serious traumatic injury would have been missed, since a CT scan focusing on the area where the abnormality was discovered had been ordered as part of the original prescribing intent.

Multivariate analysis of the Vittel criteria for discovery of traumatic injuries

The ascending or descending step-wise multivariate logistic regression models resulted in three independent Vittel

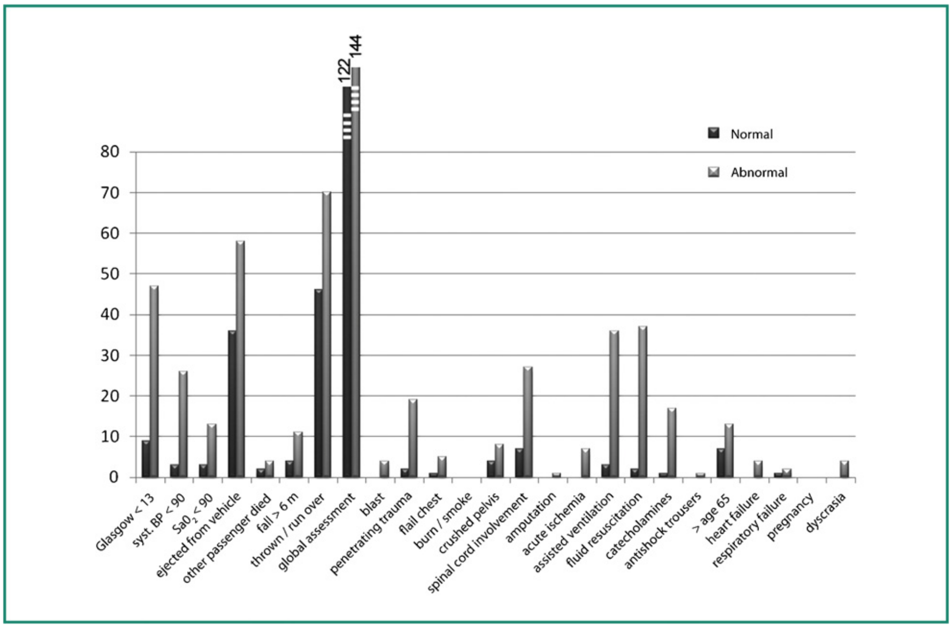

Figure 1. Vittel criteria present in patients included in the study and number of normal and abnormal whole body scan (WBS) per criterion.

Table 5 Effectiveness of the Vittel criteria for discovery of traumatic injury.

Vittel criteria	*n*	%	PD	Se	Sp	RV+	RV−	PPV	NPV
Glasgow score < 13	56	16.5	55.5	24.9	94.0	4.14	0.80	83.9	49.8
Syst. BP < 90 mmHg	29	8.6	51.0	13.8	98.0	6.88	0.88	89.7	47.4
SaO_2 < 90%	16	4.7	47.2	6.9	98.0	3.44	0.95	81.3	45.5
Ejection from a vehicle	94	27.7	50.7	30.7	76	1.28	0.91	61.7	46.5
Other passenger died	6	1.8	44.8	2.1	98.7	1.59	0.99	66.7	44.4
Fall > 6 m	15	4.4	46.3	5.8	97.3	2.18	0.97	73.3	45.1
Victim thrown/run over	116	34.2	51.3	37.0	69.3	1.21	0.91	60.3	46.6
Global assessment of vehicle condition	266	78.5	50.7	76.2	18.7	0.94	1.28	54.1	38.4
Blast	4	1.2	45.4	2.1	100	—	0.98	100	44.8
Penetrating trauma	21	6.2	49.3	10.1	98.7	7.54	0.91	90.5	46.5
Flail chest	6	1.8	45.4	2.6	99.3	3.97	0.98	83.3	44.7
Severe burn/Smoke inhalation	0	0.0	—	—	—	—	—	—	—
Smashed pelvis	12	3.5	45.4	4.2	97.3	1.59	0.98	66.7	44.6
Suspected spinal cord injury	34	10.0	50.1	14.3	95.3	3.06	0.90	79.4	46.9
Amputation upper limb	1	0.3	44.5	0.5	100	—	0.99	100	44.4
Acute ischemia of a limb	7	2.1	46.3	3.7	100	—	0.96	100	45.2
Assisted ventilation	39	11.5	54.0	19.0	98.0	.52	0.83	92.3	49.0
Colloid fluids > 1000 mL	39	11.5	54.6	19.6	98.7	14.68	0.81	94.9	49.3
Catecholamines	18	5.3	49.0	9.0	99.3	13.49	0.92	94.4	46.4
Inflated antishock trousers	1	0.3	44.5	0.5	100	—	0.99	100	44.4
Age > 65 years	20	5.9	46.0	6.9	95.3	1.47	0.98	65	44.8
Heart or coronary failure	4	1.2	45.4	2.1	100	—	0.98	100	44.8
Respiratory failure	3	0.9	44.5	1.1	99.3	1.59	1.00	66.7	44.3
2nd or 3rd trimester of pregnancy	0	0.0	—	—	—	—	—	—	—
Dyscrasia	5	1.5	45.7	2.6	100	—	0.97	100	44.9

criteria for discovery of traumatic injuries. The three independent criteria were: a Glasgow score less than 13, penetrating trauma, and resuscitation with greater than 1000 mL of colloids. Interpretation of these results is limited by the weak representation of these criteria.

Analysis of unsuspected injuries (clinician original prescribing intent)

Based on clinical original prescribing intent, only 172 WBS would have been performed. Thus use of the Vittel criteria was responsible for the performance of 164 additional WBS. Of those 164 WBS, 49 unsuspected injuries, as defined in the Materials and Methods section, were discovered in 35 patients (Table 6 and Figs. 2—5).

These were: four skull injuries (one temporal fracture and three intraparenchymal hemorrhages); 18 chest injuries (one rupture of the diaphragmatic dome, two pneumothorax, eight costal fractures, and seven pulmonary contusions); 18 abdominopelvic injuries (one liver fracture, three renal injuries [one fracture, one venous wound, and one ischemia], four splenic injuries [one fracture, one contusion, and two hematomas], one contusion of the mesosigmoid with no associated GI perforation, one adrenal hematoma, one hemoperitoneum, and seven peritoneal effusions). In addition, three clavicular fractures, two sternal fractures, three vertebral fractures, and one scapular fracture were discovered. Of those 49 injuries, 29 injuries in 25 patients (excluding the eight costal fractures, seven peritoneal effusions, one adrenal hematoma, three clavicular fractures, and one scapular fracture) were considered severe, as defined in the Material and Methods section. This represented 15% of the 164 WBS whose only justification was the presence of a Vittel criterion.

Discussion

The Vittel criteria [12] are part of a triage algorithm used by SAMU (emergency medical service) physicians in France for managing trauma patients prior to admission. The trauma severity diagnosis is made based on the presence of a single criterion (other than predisposition), which allows the most critical patients to be directed toward a specialized traumatology center. The definition of severe trama patient reflects the Vittel criteria and corresponds to a patient with at least one potentially life-threatening or disabling injury, or who

Table 6 Number of injuries diagnosed in and outside of regions when a targeted scan (or no scan) would have been prescribed (original prescribing intent).

Prescribing intent Targeted region(s)	*n*	Injury(ies) in region(s)	Injury(ies) outside of region(s)
No scan	32	0	15
Skull-cervical spine	63	10	13
Chest	11	4	8
Abdomen-pelvis	18	4	2
Skull-cervical spine and chest	23	15	6
Skull-cervical spine and abdomen-pelvis	13	5	5
Chest and abdomen-pelvis	4	0	0

Figure 2. Clinically unsuspected sternal injury (original prescribing intent: no scan): axial slice (a) and sagittal reconstruction (b) of the chest in bone window showing a non-displaced manubrial fracture (white arrow). Discovery of such injuries systematically leads to performance of an echocardiogram to search for associated myocardial injuries.

Figure 3. Clinically unsuspected renal injury (original prescribing intent: no abdominal scan): axial slice of abdomen in abdominal window, in portal phase, showing a fracture of the posterior lip of the right kidney (hollow arrow), associated with a right perirenal hematoma (short solid arrow) and peritoneal effusion (long solid arrow).

sustained trauma whose mechanism or violence suggests that such lesions may exist. Time to treatment of trauma patients is one of the main factors in preventable deaths of multiple trauma victims [13,14] and negatively correlates with patient survival [15,16]. At the same time, 12% of patient deaths due multiple traumas were preventable, either because justification for surgery was not established or because injuries went unnoticed on the clinical examination [17,18]. Numerous studies have shown that WBS should be the preferred method of exploring severe trauma [2—11]. However, the clinical examination can sometimes be insufficient to justify such a study [19] or the benefit of using probabilistic criteria, such as the Vittel criteria, for the presence of severe trauma.

In our study, 15% of 164 patients for whom the Vittel criteria led to performance of a WBS had unsuspected severe injuries. These results confirm our initial hypothesis, i.e., the benefit of using the Vittel criteria to determine

Figure 4. Clinically unsuspected hepatic injuries (original prescribing intent: no abdominal scan): axial slice of abdomen in abdominal window, in portal phase, showing hypodense lesions of hepatic segments VII and VIII, corresponding to multiple hepatic fractures of the right lobe (arrows).

Figure 5. Clinically unsuspected pulmonary injuries (original prescribing intent: no scan): axial slice of chest in parenchymal window showing right anterior pleural detachment corresponding to a right pneumothorax (long solid arrows), pulmonary condensation at site of air bronchograms corresponding to pulmonary contusions (short solid arrows), and subpleural air cysts corresponding to pneumatoceles (hollow arrow).

the need for a WBS in a severe trauma patient. However, this increased effectiveness is associated with a significant increase in the number of WBS performed, as well as an increase in the proportion of normal WBS. This has three implications:

- firstly, in order to decrease the proportion of normal WBS, it would be useful to identify the most pertinent Vittel criteria. Individually, the Vittel criteria are not very effective for discovery of serious injuries The most specific ones are the most rare and therefore have low sensitivity. Three criteria may give rise to comments:
  - the first, the ''global assessment'' criterion, is the most common. It results in the performance of a large number of normal WBS. This criterion is very subjective. While it is among the most sensitive criteria, it is the least specific. However, the goal of managing severe trauma patients is to not miss any injuries. In our study, injuries were found in 42 patients in whom the ''global assessment'' criterion was the only criterion present. It can therefore not be excluded. It could however be studied to isolate its most pertinent sub-criteria. For example, it is probable that rollovers and extraction are more significant accident severity factors than subjective interpretation of vehicle deformation. The notion of speed could also be a more selective element,
  - the two others are the ''Victim thrown or run over'' and ''Ejected from a vehicle'' criteria. These two criteria were often used for motorcycle/bike accidents, but did not identify serious injuries. In those accidents, the driver was always ''ejected from a vehicle'' or ''thrown or run over''. It therefore seems justified not to use those two criteria in motorcycle/bike accidents;
- the benefit of increasing the number of WBS performed cannot be expressed solely in positive diagnoses of unsuspected injuries. In fact, a normal WBS is a key element in managing trauma patients, who could either be observed in a non-specialized unit or discharged. This is therefore important information from a medical economic

perspective, which can reduce longer and more costly hospitalizations;
- finally, this increase in the number of WBS raises the problem of scanner utilization time. These are long studies (approximately 20 to 30 minutes per study in our center) in patients who are difficult to move. Interpreting these studies takes time (the mean interpretation time in our study was 20.48 minutes) and radiologists specializing in emergency imaging. All of these elements imply a need for trauma centers equipped with imaging units for emergency use.

Our study has certain limitations. Firstly, at our center, we were already using the Vittel criteria to determine the need for a WBS. The purpose of our study was to evaluate this practice. Due to this mode of operation, it was ethically difficult to change that approach and form two separate groups: a group where the WBS was justified by the Vittel criteria and a group where the WBS was justified by the clinical examination. In fact, in our study, all patients had at least one Vittel criterion, so it was not possible to calculate the effectiveness of the Vittel criteria as a whole. Finally, the very subjective nature of the ''global assessment'' criterion is a clear recruitment bias.

The choice of an exploratory protocol remains open. Once the justification for performing a WBS is established, the exploratory protocol should be standardized to enable rapid management. It should also be brief while providing sufficient image quality for a thorough diagnosis. In our study, we used a standardized protocol comprising successive acquisitions of the skull, then the cervical spin, then the abdomen and pelvis all without contrast, followed by acquisition of the chest, performed 60 seconds after injection of iodinated contrast. Performance of a spiral scan of the abdomen and pelvis without contrast is discussed by some authors [20] who believe that the injuries diagnosed by that type of acquisition are best visualized on a late phase spiral scan performed 3 to 5 minutes after injection. According to some authors, eliminating that acquisition with spontaneous contrast enabled a 42.5% time saving with no difference in imaging effectiveness while maintaining high diagnostic quality [21]. However, from our point of view, certain hemorrhagic injuries of the mesenterium that appear spontaneously moderately hyperdense are sometimes difficult to see after injection of iodinated contrast.

Decreasing the radiation is also one of the challenges for exploring trauma patients. These are often patients who will have repeated radiological examinations [22]. In our study, radiation was consistent with the reference levels established by the French Radioprotection and Nuclear Safety Institute (IRSN), with a mean DLP of 1231.77 mGy.cm to the skull and neck, 476.92 mGy.cm to the chest, and 1566 mGy.cm to the AP, i.e., a mean cumulative dose of 2051.54 mGy.cm to the CAP. However, based on the ALARA (As Low As Reasonably Achievable) principal, the protocol should be adjusted to decrease the radiation. In a study using a protocol composed of a lateral scanogram followed by acquisition immediately after injection of contrast, Ptak et al. [23] found a 17% decrease in DLP compared with a protocol performing successive acquisitions in the different anatomical regions. That decrease in radiation was attributed to the elimination of redundant images acquired due to overlap between series [21,23—25]. Most current equipment allows the use of dose reducing techniques and software that should be used when available. Such software, which did not exist on our device at the time of the study, is now available and used systematically, providing a substantial dose reduction. Similarly, even though it was not its original purpose, this study led us to modify our acquisition protocols. A protocol was established limiting the number of acquisitions. It includes a single scanogram, a spiral scan of the skull without contrast, then an exploration of the neck, chest, abdomen and pelvis, immediately with IV contrast injection. However, the information supplied by the clinician is essential for adjusting the protocol, and a suspected abdominal injury can lead to an acquisition before contrast injection so as not to miss any hemorrhagic injuries to the mesenterium.

Conclusion

The use of probabilistic criteria such as the Vittel criteria to determine the need for a WBS makes it possible to detect injuries that would have initially been missed. However, the resulting increase in the number of scans requires reflection about the technical implementation of these examinations and about the infrastructure necessary to perform them. Finally, these criteria, diverted from their original function, need to be refined in order to decrease the number of normal examinations performed.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References

[1] Tentillier E, Masson F. Épidemiologie des traumatismes. In: Beydon L, Carli P, Riou B, editors. Traumatismes graves. Paris: Arnette; 2000. p. 1—15.

[2] Huber-Wagner S, Lefering R, Qvick LM, Korner M, Kay MV, Pfeifer KJ, et al. Effect of whole body CT during trauma resuscitation on survival: a retrospective, multicentre study. Lancet 2009;373(9673):1455—61.

[3] Wurmb TE, Fruhwald P, Hopfner W, Keil T, Kredel M, Brederlau J, et al. Whole body multislice computed tomography as the first line diagnostic tool in patients with multiple injuries: the focus on time. J Trauma 2009;66(3):658—65.

[4] Wurmb T, Balling H, Fruhwald P, Keil T, Kredel M, Meffert R, et al. Polytrauma management in a period of change: time analysis of new strategies for emergency room treatment. Unfallchirurg 2009;112(4):390—9.

[5] Rieger M, Sparr H, Esterhammer R, Fink C, Bale R, Czermak B, et al. Modern CT diagnosis of acute thoracic and abdominal trauma. Anaesthesist 2002;51(10):835—42.

[6] Deunk J, Brink M, Dekker HM, Kool DR, van Kuijk C, Blickman JG, et al. Routine versus selective computed tomography of the abdomen, pelvis, and lumbar spine in blunt trauma: a prospective evaluation. J Trauma 2009;66(4):1108—17.

[7] Self ML, Blake AM, Whitley M, Nadalo L, Dunn E. The benefit of routine thoracic, abdominal, and pelvic computed tomography

to evaluate trauma patients with closed head injuries. Am J Surg 2003;186(6):609—13 [discussion 13—4].
[8] Tillou A, Gupta M, Baraff LJ, Schriger DL, Hoffman JR, Hiatt JR, et al. Is the use of pan-computed tomography for blunt trauma justified? A prospective evaluation. J Trauma 2009;67(4):779—87.
[9] Holmes JF, Akkinepalli R. Computed tomography versus plain radiography to screen for cervical spine injury: a meta-analysis. J Trauma 2005;58(5):902—5.
[10] Griffen MM, Frykberg ER, Kerwin AJ, Schinco MA, Tepas JJ, Rowe K, et al. Radiographic clearance of blunt cervical spine injury: plain radiograph or computed tomography scan? J Trauma 2003;55(2):222—6 [discussion 6—7].
[11] Brown CV, Antevil JL, Sise MJ, Sack DI. Spiral computed tomography for the diagnosis of cervical, thoracic, and lumbar spine fractures: its time has come. J Trauma 2005;58(5):890—5 [discussion 5—6].
[12] Riou B, Thicoïpe M, Atain-Kouadio P, Carli P. Le traumatisé grave. Actualités en réanimation préhospitalière. Journées scientifiques des SAMU de France Société française d'éditions médicales 2002.
[13] Teixeira PG, Inaba K, Hadjizacharia P, Brown C, Salim A, Rhee P, et al. Preventable or potentially preventable mortality at a mature trauma center. J Trauma 2007;63(6):1338—46 [discussion 46—7].
[14] Cayten CG, Stahl WM, Agarwal N, Murphy JG. Analyses of preventable deaths by mechanism of injury among 13,500 trauma admissions. Ann Surg 1991;214(4):510—20 [discussion 20—1].
[15] Driscoll PA, Vincent CA. Variation in trauma resuscitation and its effect on patient outcome. Injury 1992;23(2):111—5.
[16] Clarke JR, Trooskin SZ, Doshi PJ, Greenwald L, Mode CJ. Time to laparotomy for intra-abdominal bleeding from trauma does affect survival for delays up to 90 minutes. J Trauma 2002;52(3):420—5.
[17] Kreis Jr DJ, Plasencia G, Augenstein D, Davis JH, Echenique M, Vopal J, et al. Preventable trauma deaths: Dade County, Florida. J Trauma 1986;26(7):649—54.
[18] Buduhan G, McRitchie DI. Missed injuries in patients with multiple trauma. J Trauma 2000;49(4):600—5.
[19] Schurink GW, Bode PJ, van Luijt PA, van Vugt AB. The value of physical examination in the diagnosis of patients with blunt abdominal trauma: a retrospective study. Injury 1997;28(4):261—5.
[20] Millet-Cénac I, Taourel P. TDM en traumatologie. Imagerie médicale. Issy-les-Moulineaux: Elsevier Masson; 2009, ISBN 978-2-294-70846-6.
[21] Nguyen D, Platon A, Shanmuganathan K, Mirvis SE, Becker CD, Poletti PA. Evaluation of a single-pass continuous whole body 16-MDCT protocol for patients with polytrauma. AJR Am J Roentgenol 2009;192(1):3—10.
[22] Griffey RT, Sodickson A. Cumulative radiation exposure and cancer risk estimates in emergency department patients undergoing repeat or multiple CT. AJR Am J Roentgenol 2009;192(4):887—92.
[23] Ptak T, Rhea JT, Novelline RA. Radiation dose is reduced with a single-pass whole body multidetector row CT trauma protocol compared with a conventional segmented method: initial experience. Radiology 2003;229(3): 902—5.
[24] Fanucci E, Fiaschetti V, Rotili A, Floris R, Simonetti G. Whole body 16-row multislice CT in emergency room: effects of different protocols on scanning time, image quality and radiation exposure. Emerg Radiol 2007;13(5): 251—7.
[25] Heyer CM, Rduch G, Kagel T, Lemburg SP, Theisinger A, Bauer TT, et al. Prospective randomized trial of a modified standard multislice CT protocol for the evaluation of multiple trauma patients. Rofo 2005;177(2):242—9.