

# Tertiary survey in the management of patients with multiple injuries

SANDRA MONTMANY VIOQUE, SALVADOR NAVARRO SOTO, PERE REBASA CLADERA, ALEXIS LUNA AUFROY, CARLOS GÓMEZ DÍAZ, HEURA LLAQUET BAYO

Departamento de Cirugía General y del Aparato Digestivo, Hospital Universitario Parc Taulí, Barcelona, Spain.

## CORRESPONDENCE:

Sandra Montmany Vioque  
Dpto. Cirugía General  
Hospital Universitario Parc Taulí  
Parc del Taulí, 1  
08208 Sabadell,  
Barcelona, Spain  
E-mail:  
sandra.montmany@gmail.com

## RECEIVED:

13-5-2012

## ACCEPTED:

14-7-2012

## CONFLICT OF INTEREST:

The authors declare no conflict of interest in relation with the present article.

**Background:** Implementing tertiary trauma surveys can reduce the incidence of clinically significant missed injury, thereby reducing morbidity and mortality in patients with multiple injuries.

**Methods:** Prospective study of patients admitted to the critical care unit with multiple injuries. The patients were over the age of 16 years and survived at least 24 hours. Patients undergoing tertiary examination were compared to a historical control group that did not undergo additional assessment. We recorded missed injuries and clinically significant missed injuries in both groups. Also analyzed were the main errors associated with the appearance of missed injuries, avoidable risk factors, mortality, and complications in both groups.

**Results:** A total of 119 patients underwent tertiary examination and their data were compared to those of 117 in the historical control group. The incidence of missed injuries was lower in the test period (15.13%) than the control period (40.17%). The incidence of clinically significant missed injuries was also lower in the test period (3.36% vs 17.09 in the control period). Mortality fell to 4.25% with tertiary examination (vs 10.25% in the control period), and mortality due to multiorgan failure was 0% in the test period. Radiologic errors were fewer with implementation of tertiary trauma surveys and communication and surgical errors disappeared. The main risk factors for detecting clinically significant missed injuries were to blood pressure, the number of injuries and, particularly, the inclusion of a tertiary examination or not.

**Conclusion:** Tertiary trauma surveys should be considered an obligatory component of the initial management of patients with multiple injuries. [Emergencias 2013;25:105-110]

**Keywords:** Tertiary trauma survey. Multiple trauma. Missed injuries. Clinically significant missed injuries. Mortality. Morbidity.

## Introduction

The American College of Surgeons' guidelines on Advanced Trauma Life Support (ATLS), define two phases in the initial management of patients with multiple injuries: a primary survey, which aims to identify and treat injuries that endanger the patient's life; and secondary survey, which attempts to detect all the injuries and initiate definitive treatment<sup>1</sup>. Even after such a detailed and protocolized approach, some injuries are still not detected, and these are known as missed injuries. They are defined as injuries not identified on primary and secondary survey, or detected after admission to the critical care area<sup>2-16</sup>.

There is a subgroup of missed injuries that is

especially important, known as clinically significant missed injuries. These may involve serious complications, a change in treatment, or even death<sup>2-6,9,11,12,14,16</sup>. Missed and clinically significant injuries may delay the start of correct treatment and increase morbidity and mortality<sup>5,17,18</sup>, not to mention possible legal consequences<sup>19</sup>.

Different methods have been described to reduce the incidence of missed injuries<sup>5,17,18,20,26</sup>. One is the use of a tertiary trauma survey<sup>2,5,7,13-15,17,18,20,23,26</sup>. As described by Enderson et al<sup>17</sup> this involves a new whole-body examination, a new survey of complementary tests and further testing if necessary. This is done after the primary and secondary survey, but within the first 24 hours of trauma. Houshian et al<sup>11</sup> suggest that the com-

plexity of managing patients with multiple injuries makes the two initial surveys insufficient to detect all injuries. Similarly, Richards et al<sup>27</sup> define the objectives of different surveys: the aim of the primary survey is to save life, the second to detect all multiple injuries and the third trauma survey is to detect occult lesions, i.e. missed injuries. The literature contains few studies where a tertiary survey was performed<sup>2,7,13,15</sup>, so it is difficult to draw conclusions about whether it reduces the total number of missed injuries. Only Biffl et al<sup>13</sup> describe a reduction of 62.5% in the number of missed injuries on applying a tertiary trauma survey. No works address the incidence of clinically significant missed injuries on applying a tertiary survey.

The study hypothesis was that a tertiary survey reduces the incidence of missed and clinically significant missed injuries. The main objective was to test this hypothesis.

## Method

We performed a prospective, epidemiological, descriptive study, comparing two groups of patients with multiple injuries; to one group we applied a tertiary trauma survey. We included all patients with multiple injuries over 16 years of age who were admitted to our critical care area. We excluded those under 16 years and patients who died of multiple injuries within the first 24 hours.

A missed injury was defined as one only detected after primary and secondary surveys, and within the first 24 hours after trauma. A clinically significant missed injury was defined as one that could cause complications, a change in treatment, or death.

A record of missed injuries and clinically significant missed injuries was kept until patient discharge. Patient autopsy was included in some cases. Tertiary surveys were performed in accordance with the definition established by Enderson et al<sup>17</sup>. The survey was considered properly conducted when, once completed, it was recorded on a data base (compliance).

The main dependent variables were missed and clinically significant missed injuries. Secondary dependent variables were completion of the tertiary survey, the distribution of missed injuries, the associated errors, complications and mortality. Confounding variables included age, sex, Charlson index<sup>28</sup>, history of coagulopathy and diabetes, mechanisms of trauma, the Injury Severity Score (ISS)<sup>29</sup>, time in days of stay, prehospital and hospi-

tal data: Glasgow coma score, blood pressure, heart and respiratory rates, temperature and oxygen saturation; laboratory tests, the record of injuries noted at the time of diagnosis and the treatment necessary, the complications and evolution of the case.

Data on the historical control group were collected between March 2006 and February 2007, based on a prospective descriptive study to describe the incidence of missed and clinically significant missed injuries without a tertiary trauma survey. The study met the same criteria for the selection of patients and the same definitions as the current study. We recorded the same dependent variables and confounders as in the current study except compliance with tertiary survey since this was not performed in any patients. The record was documented in the same way as in the current study.

Between February 2007 and July 2008 we conducted a pilot study where the tertiary survey protocol was initiated; the incidence of missed injury reduced by 50%. Based on these results it was not possible to conduct a randomized study according to the Ethics Committee. Therefore, the study group (with intervention) was not matched with controls.

The study performed was also presented to the Ethics Committee, and accepted before implementation, subject to the rules established by the committee. The registration of each participant was from admission and performed prospectively, and included all variables in a rational manner with data protection. Patients were recruited anonymously in accord with the Spanish Organic Law 15/1999 of December 13 on protection of personal data (LOPD). Statistical analyses were performed with SPSS.

Data are presented as mean and 95% confidence interval (CI) for continuous variables and as percentages for discrete variables. For comparisons, we assumed an alpha error of 0.05. To compare continuous variables we used Student's *t* test after establishing the normality of variable distribution. To compare discrete variables we used Fisher's exact test. For the identification of predisposing factors for missed injuries, we developed a predictive model which allowed early identification of patients with greater likelihood of having missed injuries. For this, we used logistic regression.

## Results

Between March 2006 and January 2007 we recruited 121 patients for the control group where

no tertiary survey was performed; 4 were excluded due to death within 24 hours of trauma. Between March 2009 and April 2010 we recruited 124 patients for the study group where tertiary trauma survey was performed in 90.8%; 5 were excluded due to death within 24 hours of trauma. The two groups were similar in age, sex and mechanism of trauma (Table 1). Mean ISS was higher in the study group than in the control group (25.6 vs. 18.9,  $P < 0.001$ ).

In the control group, 40.2% presented some missed injuries versus 15.1% in the study group, representing a reduction of 62.3% (Table 2). The main missed injury was bone fracture, which was reduced from 41.3% to 26.3% by the tertiary survey. The comparative distribution of missed injuries is shown in Table 3.

In the control group, 17.1% of patients presented some clinically significant missed injuries. This was reduced to 3.4% in the study group, representing a relative reduction of 80.2% (Table 2). The distribution of clinically significant missed injuries in both groups is shown in Table 3.

The incidence of clinically significant missed injuries with important complications or leading to death or treatment change decreased dramatically from 6.0% in the control group to 1.7% in the tertiary survey group. In the control group, one patient died as a result of a clinically significant missed injury, with no such death occurring in the study group (Table 4).

The main errors associated with missed or clinically significant injury were clinical and radiological errors, but no surgical errors were identified in the current study. Implementation of the tertiary trauma survey reduced the number of errors and eliminated communication error completely. This reduction was greatest in radiological errors. Analysis of clinically significant missed injuries revealed a pattern of similar behavior (Table 5). Univariate analysis of unavoidable risk factors that determine the appearance of missed injury, a relationship was seen between them and the ISS, with a greater number of injuries and blood toxicity. This was not detected for age, hemodynamic stability, Glasgow Coma Scale score or endotracheal intubation. Multivariate analysis showed hemodynamic stability, the number of Injuries and performing a tertiary survey were predictors for

**Table 1.** Comparison between the two groups

	With tertiary survey	No tertiary survey	<i>p</i>
Age [mean (SD)]	44.9 (19.8)	43.8 (20.6)	0.67
Gender [n (%)]			1.00
Male	76.5%	76.9%	
Female	23.5%	23.1%	
Mechanism of action			0.25
Blunt	93.2%	93.1%	
Penetrating	6.8%	6.9%	
ISS [mean (SD)]	25.6 (15.5)	18.9 (14.3)	0.001

ISS: Injury Severity Score. SD: standard deviation.

missed injuries. Logistic regression based on the results of the multivariate analysis showed that the main risk factor for the occurrence of missed injury was performance of the tertiary trauma survey.

In the control group, mortality was 10.2% (12 patients) versus 4.2% (5 patients) in the study group, a reduction of 59%, but not of statistical significance. In both groups, the main cause of mortality was neurological. In the control group, 25% of deaths were due to multiple organ failure versus 0% in the study group (Table 6).

Over half (53%) of the controls had some type of complication versus 44.5% of the study group. Lung complications were the main type in both groups (Table 6).

## Discussion

In this prospective study we compared a group of patients who underwent a systematic tertiary trauma survey with a historical group of patients (controls) who did not. The two groups were homogeneous for all parameters except mean ISS which was higher in the study group (25.6 vs 18.9). This, in our opinion, increases the clinical relevance of our findings: the incidence of missed injuries in controls was 40.2% versus only 15.1% in the study group undergoing a tertiary trauma survey, representing a reduction of 62.3%. We can only compare our results with those of Biffi et al, authors of the only published comparative study on the incidence of missed injuries. They reported a reduction from 2.4% to 1.5%<sup>13</sup>, which is much lower than ours, probably because their study included all patients with multiple injuries admitted to both the critical care area and con-

**Table 2.** Incidence of missed injuries and clinically significant missed injuries

	With tertiary survey	No tertiary survey	<i>p</i>
Incidence of missed injuries	15.1% (18/119 patients)	40.2% (47/117 patients)	0.001
Incidence of clinically significant missed injuries	3.4% (4/119 patients)	17.1% (20/117 patients)	0.001

**Table 3.** Distribution of missed injuries and clinically significant missed injuries

	No tertiary survey	With tertiary survey
<b>Missed injuries</b>		
Chest	26.7%	10.5%
Extremities	20%	57.8%
Facial	17.3%	10.5%
Spinal	12%	–
Abdominal	10.7%	21%
Head	10.7%	–
Subcutaneous emphysema	5.3%	–
<b>Clinically significant missed injuries</b>		
Spinal	36%	–
Chest	20%	50%
Abdominal	20%	25%
Extremities	12%	25%
Head	12%	–

ventional hospital wards. Our incidence of missed injury after tertiary trauma survey (15.1%) is similar to that published by Howard et al<sup>7</sup> (14%) and Soundappan et al (15.8%)<sup>15</sup>.

In the control group, the incidence of clinically significant missed injury was 17.1% and this parameter decreased to 3.3% in those subjected to tertiary trauma survey (a reduction of 80.24%). This parameter was not reported in previous studies<sup>2,7,13,15</sup>. Analyzing the incidence of clinically significant missed injuries that led to clinical symptoms, change in treatment or even death, we found it decreased from 5.9% to 1.7% the after tertiary survey. The most frequent type of missed injury, bone fracture, also decreased from 41.3% to 26.3%, and clinically significant and missed injuries of the spine and head disappeared, as did subcutaneous emphysema. The importance of these improvements is indisputable.

Consistent with the literature, the errors most frequently associated with missed injuries and clinically significant missed injuries were clinical and radiological<sup>5,8,18,22,25,26</sup>.

Coinciding with Houshian et al<sup>11</sup>, when tertiary survey was not applied, the most frequent error was radiological, appearing in 65.7% of missed injuries and 80.8% of clinically significant missed injuries. On application of the tertiary survey, these decreased to 25% and 50% respectively. On decreasing radiological error, the main error asso-

**Table 4.** Clinically significant missed injuries with consequences

Injury	Consequence	Patient
<b>With tertiary survey</b>		
Ureteral injury	Pleural drainage	A
Hemothorax	Pleural drainage	B
<b>Without tertiary survey</b>		
Ureteral	Double-J	C
Hepatic	Surgery	D
Intestinal	Surgery	D
Spinal	Surgery	E
Spinal cord	Surgery	E
Spinal cord	Surgery	F
Knee	Surgery	G
Compartment Syndrome	Surgery	H
Heart	Death	I

ciated with missed injuries was clinical error, consistent with reports by Janjua et al<sup>2</sup>, Buduhan et al<sup>14</sup> and Soundappan et al<sup>15</sup>. The significant decrease in radiological error was due to the new survey of all laboratory tests performed by a top specialist in best conditions of physical rest, with support from expert radiologists in different areas (chest, abdomen musculoskeletal, skull, etc.). Something similar occurred with clinical errors, with re-examination by a physician in best conditions of physical rest which improved the results, but not as dramatically as with radiological error. Factors inevitably associated with risk (intubation, lower Glasgow Coma Scale scores, hemodynamic instability, spinal cord injury, etc.) remain a challenge for adequate physical examination of these patients. In our study no surgical errors were detected and communication errors disappeared on application of tertiary survey.

Univariate analysis in our study confirmed the association between the presence of missed injury and higher ISS, higher number of total injuries and positive toxic results<sup>5,7,9,12,14,15,17,18,20,24-26</sup>. Unlike other studies, we did not detect a relationship between missed injuries and age, hemodynamic stability, Glasgow Coma Scale scores or orotracheal intubation<sup>3,5,17,18,24,26</sup>, perhaps because of the limited sample size. We were unable to analyze the effect of patient care at night<sup>2</sup>, our center's experience in the care of patients with multiple injuries<sup>17,18,26</sup>, admission to an inappropriate department<sup>17,18,26</sup>, or

**Table 5.** Errors associated with missed injuries and clinically significant missed injuries

	Missed injuries		Clinically significant missed injuries	
	Tertiary survey	No tertiary survey	Tertiary survey	No tertiary survey
Clinical Error	75% (15 injuries)	30.1% (22 injuries)	50% (2 injuries)	15.4% (4 injuries)
Radiological Error	25% (5 injuries)	65.7% (48 injuries)	50% (2 injuries)	80.8% (21 injuries)
Communication	0%	4.1% (3 injuries)	0%	3.8% (1 injuries)
Surgical Error	0%	0%	0%	0%

**Tabla 6.** Mortality rates, causes of death and complications in patients with and without tertiary trauma survey

	With tertiary survey	Without tertiary survey	p
<b>Mortality</b>	4.2%	10.25%	0.082
<b>Causes of death</b>			
Neurological	80%	58.3%	
Multi-organ failure	0%	25%	
Respiratory	20%	16.7%	
<b>Complications</b>	44.5%	53%	0.241
<b>Complications</b>			
Lung	22.3%	41.5%	
Nephro-urological	20%	7.2%	
Surgical	15.4%	17.4%	
Neurological	11.5%	4.1%	
Catheter infection	3.8%	4.6%	
Abdominal	5.4%	3.1%	
Heart	3.1%	0.1%	
Embolism	2.3%	0.5%	
Pulmonary embolism	1.5%	0.5%	
Other	14.6%	17.9%	

mechanism of action<sup>5,9</sup> due to the characteristics of our hospital. Multivariate analysis showed that the major risk factors were systolic blood pressure, the number of injuries, and the most important factor was completion of the tertiary survey.

Undoubtedly, the 58.5% reduction in mortality was the most clinically significant finding, although it was not of statistical significance. We would highlight that one patient in the control group died as a result of a clinically significant missed injury. On analyzing the causes of death, the main one was neurological injury in both groups. Any patients who died of hypovolemic shock were not included since that occurs in the first 24 hours of trauma and these patients were excluded from the study since the tertiary survey could not be performed. The difference between the two groups lies in the disappearance of deaths due to multi-organ failure on applying the tertiary survey versus 25% in the controls. Performing this survey probably results in optimal treatment of hypoxia and Initial hypoperfusion which reduces the probability of subsequent multiorgan failure.

The application of a tertiary survey also reduced the percentage of patients with complications, from 53% to 43.7%. This decrease of 17.5% is of relative clinical importance and a larger sample size is required to determine the significance of this difference. The major complications remain those of the lung, regardless of whether a tertiary survey is performed or not.

## References

- 1 ATLS. Soporte Vital Avanzado en Trauma para Médicos. Chicago: Comité de Trauma del Colegio Americano de Cirujanos, 8a. edición; 2008.
- 2 Janjua KJ, Sugrue M, Deane SA. Prospective evaluation of early missed injuries and the role of tertiary trauma survey. *J Trauma*. 1998;44:1000-7.
- 3 Montmany S, Navarro S, Rebas P, Hermoso J, Hidalgo JM, Cánovas G. A prospective study on the incidence of missed injuries in trauma patients. *Cir Esp*. 2008;84:32-6.
- 4 Pfeifer R, Pape HC. Missed injuries in trauma patients: A literature review. *Patient Safety in Surgery*. 2008;2:20.
- 5 Navarro-Soto S. Misread lesions in patients with multiple trauma. *Cir Esp*. 2005;78:281-2.
- 6 Jimenez LM, Amunategui I, Sánchez JM, Colón A, Pérez MD, Sanz M, et al. Missed injuries in patients with multiple trauma: analysis of a trauma registry. *Cir Esp*. 2005;78:303-7.
- 7 Howard J, Rajalashkmy S, Scott T, Mark W, Miel S. Reducing missed injuries at a level II trauma center. *J Trauma Nursing*. 2006;13:89-95.
- 8 Sung CK, Kim KH. Missed injuries in abdominal trauma. *J Trauma*. 1996;41:276-82.
- 9 Robertson R, Mattox R, Collins R, Parks-Miller C, Eidt J, Cone J. Missed injuries in a rural area trauma center. *Am J Surg*. 1996;172:564-8.
- 10 Hodgson NF, Stewart TC, Girotti MJ. Autopsies and death certification in deaths due to blunt trauma: what are we missing? *Can J Surg*. 2000;43:130-6.
- 11 Houshian S, Larsen MS, Holm C. Missed injuries in a level I trauma center. *J Trauma*. 2002;52:715-9.
- 12 Brooks A, Holroyd B, Riley B. Missed injury in major trauma patients. *Injury*. 2004;35:407-10.
- 13 Biffl WL, Harrington DT, Cioffi WG. Implementation of a tertiary trauma survey decreases missed injuries. *J Trauma*. 2003;54:38-44.
- 14 Buduhan G, McRitchie DL. Missed injuries in patients with multiple trauma. *J Trauma*. 2000;49:600-5.
- 15 Soundappan SV, Holland AJ, Cass DT. Role of an extended tertiary survey in detecting missed injuries in children. *J Trauma*. 2004;57:114-8.
- 16 Stephan PJ, McCarley M, Clifann RN, O'Keefe GE, Minei JP. 23-Hour observation solely for identification of missed injuries after trauma: is it justified? *J Trauma*. 2002;53:895-900.
- 17 Enderson BL, Maull KI. Missed injuries. The trauma surgeon's nemesis. *Surg Clin North Am*. 1991;71:399-418.
- 18 Sawyer MS. Missed injuries: a case of trauma hide and seek. *AACN clinical issues*. 1995;6:187-95.
- 19 Wilson H. Public and institutional responses to the 'missed' diagnosis in New Zealand. *New Zealand MJ*. 2006;119.
- 20 Frawley PA. Missed injuries in the multiply traumatized. *The Australian and New Zealand Journal of Surgery*. 1993;63:935-9.
- 21 Pehle B, Kuehne CA, Block J, Waydhas C, Taeger G, Nast-Kolb D, Ruchholtz S. The significance of delayed diagnosis of lesions in multiply traumatized patients. A study of 1187 shock room patients. *Unfallchirurg*. 2006;109:964-74.
- 22 Enderson BL, Reath B, Meadors J, Dallas W, DeBoo JM, Maull KI. The tertiary trauma survey: a prospective study of missed injury. *J Trauma*. 1990;30:666-70.
- 23 Sharma BR, Gupta M, Bangar S, Pal Singh V. Forensic considerations of missed diagnoses in trauma deaths. *Journal of Forensic and Legal Medicine*. 2007;14:195-202.
- 24 Sharma OP, Scala-Banett DM, Oswanski MF, Aton A, Raj SS. Clinical and autopsy analysis of delayed diagnosis and missed injuries in trauma patients. *Am Surg*. 2006;72:174-9.
- 25 Sharma BR, Gupta M, Harish D, Pal Singh V. Missed diagnoses in trauma patients vis-a-vis significance of autopsy. *Injury*. 2005;36:976-83.
- 26 Hollingsworth-Fridlund P, Stout P. Reasons why trauma patients have missed injuries or delays in diagnosis. *Trauma Nurs*. 2001;8:112-5.
- 27 Richards CF, Mayberry J. Initial management of the trauma patient. *Crit Care Clin*. 2004;20:1-11.
- 28 Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40:373-83.
- 29 Baker SP, O'Neill B, Haddon W, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma*. 1974;14:187-96.



## Aplicación de la revisión terciaria en el manejo inicial del paciente politraumatizado

Montmany Vioque S, Navarro Soto S, Rebas Cladera P, Luna Aufroy A, Gómez Díaz C, Llaquet Bayo H

**Objetivo:** La revisión terciaria puede disminuir la incidencia de lesiones inadvertidas y de lesiones inadvertidas clínicamente relevantes y puede reducir la morbi-mortalidad de los pacientes politraumatizados.

**Método:** Estudio prospectivo que incluye pacientes politraumatizados mayores de 16 años ingresados en una área de pacientes críticos, excluidos los que murieron en las primeras 24 h. Comparación de un grupo a quien se aplicó la revisión terciaria, con un grupo control a quien no se aplicó. Hemos registrado la incidencia de lesiones inadvertidas y de lesiones inadvertidas clínicamente relevantes. Hemos analizado los principales errores asociados a la aparición de lesiones inadvertidas y los factores de riesgo inevitables. Se estudió la mortalidad de ambos grupos y sus complicaciones.

**Resultados:** Se ha protocolizado la revisión terciaria en 119 pacientes frente a 117 en los que no se realizó. Con la aplicación de la revisión terciaria, la incidencia de lesiones inadvertidas se ha reducido de un 40,2% a un 15,1%, y la incidencia de lesiones inadvertidas clínicamente relevantes de un 17,1% a un 3,4%. La mortalidad ha disminuido de un 10,2% a un 4,2%, y desaparecieron las muertes causadas por fracaso multiorgánico. Ha disminuido el error radiológico han desaparecido los errores de comunicación y quirúrgicos. Los principales factores asociados a la detección de lesiones inadvertidas y de lesiones inadvertidas clínicamente relevantes son la presión arterial, el número de lesiones y, como factor más relevante, la aplicación de la revisión terciaria.

**Conclusiones:** La aplicación de la revisión terciaria debería ser obligada en el manejo inicial de los pacientes politraumatizados. [Emergencias 2013;25:105-110]

**Palabras clave:** Revisión terciaria. Politraumatismo. Lesiones inadvertidas. Lesiones inadvertidas clínicamente relevantes. Mortalidad. Morbilidad.