

# Effect of whole-body CT during trauma resuscitation on survival: a retrospective, multicentre study



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## Summary

**Background** The number of trauma centres using whole-body CT for early assessment of primary trauma is increasing. There is no evidence to suggest that use of whole-body CT has any effect on the outcome of patients with major trauma. We therefore compared the probability of survival in patients with blunt trauma who had whole-body CT during resuscitation with those who had not.

**Methods** In a retrospective, multicentre study, we used the data recorded in the trauma registry of the German Trauma Society to calculate the probability of survival according to the trauma and injury severity score (TRISS), revised injury severity classification (RISC) score, and standardised mortality ratio (SMR, ratio of recorded to expected mortality) for 4621 patients with blunt trauma given whole-body or non-whole-body CT.

**Findings** 1494 (32%) of 4621 patients were given whole-body CT. Mean age was 42.6 years (SD 20.7), 3364 (73%) were men, and mean injury-severity score was 29.7 (13.0). SMR based on TRISS was 0.745 (95% CI 0.633–0.859) for patients given whole-body CT versus 1.023 (0.909–1.137) for those given non-whole-body CT ( $p < 0.001$ ). SMR based on the RISC score was 0.865 (0.774–0.956) for patients given whole-body CT versus 1.034 (0.959–1.109) for those given non-whole-body CT ( $p = 0.017$ ). The relative reduction in mortality based on TRISS was 25% (14–37) versus 13% (4–23) based on RISC score. Multivariate adjustment for hospital level, year of trauma, and potential centre effects confirmed that whole-body CT is an independent predictor for survival ( $p \leq 0.002$ ). The number needed to scan was 17 based on TRISS and 32 based on RISC calculation.

**Interpretation** Integration of whole-body CT into early trauma care significantly increased the probability of survival in patients with polytrauma. Whole-body CT is recommended as a standard diagnostic method during the early resuscitation phase for patients with polytrauma.

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## Introduction

Improvements in technology have brought about a change in the use of CT in trauma treatment. The introduction of spiral CT into clinical routine in the early 1990s has revolutionised diagnostic radiology.<sup>1</sup> In 1998, the introduction of multislice CT, with up to eight-fold reduction in scan times (data acquisition time), made whole-body CT technically feasible,<sup>2,3</sup> leading to considerations of how to integrate it as a screening technique early in trauma-room treatment.<sup>4,7</sup> The process quality of whole-body CT has been proven in several studies<sup>4,6–14</sup> that confirm its feasibility, high diagnostic safety, and substantial reduction in scan time. Whether the advantages of this technique justify its use against cost and radiation exposure is controversial.<sup>15,16</sup> Nevertheless, an increasing number of trauma centres is using it during the early resuscitation phase, even in haemodynamically unstable patients, because it is thought to be an effective method. To the best of our knowledge, whole-body CT was first reported to be feasible during early trauma care in 1997 by Löw<sup>17</sup> and in 2001 by Ptak<sup>6</sup> and their colleagues. In five consecutive, haemodynamically stable patients with trauma, Ptak<sup>6</sup> showed that single-pass whole-body CT was safe. This

safety was also confirmed in other studies.<sup>4–8,10,13,18</sup> Multislice whole-body CT is time saving compared with conventional radiological diagnostic techniques, such as ultrasonography, radiography, or non-multislice CT.<sup>4,6,7,10,12</sup> However, to date, the benefit of whole-body CT on mortality in patients with major trauma has not yet been proven. We assessed whether whole-body CT during trauma-room treatment has an effect on the mortality of severely injured patients. We postulated that whole-body CT has a positive effect on mortality in patients with trauma.

## Methods

### Data gathering

The trauma registry of the German Trauma Society was started in 1993 by the society's Working Group on Polytrauma to prospectively gather multicentre data about people with polytrauma living in German-speaking countries (Germany, Austria, and Switzerland). Parameters for prehospital and trauma-room treatments, and subsequent treatment in the intensive care unit, are continuously inputted into a web-based data server. Every patient admitted to one of the participating trauma hospitals with an injury severity score of at least 16 or

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who has been treated in the intensive care unit is recorded for the registry. Data are submitted to a central database that is hosted by the Institute for Research in Operative Medicine at the University of Witten/Herdecke, Cologne, Germany. Irreversible data anonymity is guaranteed for the patient and participating hospital. The registry records epidemiological, physiological, laboratory, diagnostic, operative, interventional, and intensive-care medical data, and injury-severity scores and outcome data.<sup>19</sup> The specific parameter whole-body CT has been recorded since 2002. We therefore analysed the database for 2002–04, containing information on 9259 patients.

Inclusion criteria were blunt trauma, injury-severity score of at least 16, and available information about whole-body CT during trauma-room treatment. Only those patients who were admitted directly from the incident scene, and not transferred from other hospitals, were included. 196 patients with penetrating trauma were excluded. This study has received the full approval of the ethics committee of the Ludwig-Maximilians-University of Munich, Germany.

Whole-body CT is an unenhanced CT of the head followed by contrast-enhanced CT of the chest, abdomen, and pelvis, including the complete spine. It can be done as single-pass or segmented whole-body CT. By contrast, no CT or only dedicated CT of one or combined body regions was done for non-whole-body CT.

Whether or not a patient received whole-body CT depended on the type of CT scanners and local emergency-department protocol. Participating hospitals were free to choose their own diagnostic algorithms. Information about the location of the CT scanner (in or near the trauma room or in the department of radiology) is not recorded in the trauma registry. Detailed information about the specific assessment protocols, such as collimation, slice thickness, and delay after injection of contrast material, were not available. The time to complete a whole-body CT is not recorded in the registry and can be estimated to take about 6–16 min, depending on the local conditions for each trauma centre.<sup>10,12</sup>

### Statistical analysis

We did a descriptive data analysis that included a comparison of patients given whole-body CT with those given non-whole-body CT using two-sided  $\chi^2$  test and Mann-Whitney *U* test. We then did an outcome analysis to calculate the trauma and injury-severity score (TRISS), revised injury severity classification (RISC) score, and standardised mortality ratio (SMR; ratio of recorded to expected mortality). For comparison of mortality in patients given whole-body CT with those given non-whole-body CT, we chose a risk-adjusted approach (TRISS and RISC calculation). Survival was defined as survival to discharge.

TRISS was first introduced in 1983. It is used to roughly predict the probability of survival of a patient; it combines physiological and anatomical derangements that arise after injury. This score combines the revised trauma score,<sup>20</sup> which consists of on-the-scene Glasgow coma scale, systolic blood pressure, and respiratory rate, with the discharge diagnoses, age, and mechanism of trauma (blunt vs penetrating) based on the injury-severity score.<sup>21,22</sup> TRISS is the most widely used method for measurement of expected outcome in patients with trauma, and the probability of survival after blunt trauma is calculated with the following formula:<sup>22</sup>

$$1/(1+e^{-x}); x=0.9544 \times \text{RTS} - 0.0768 \times \text{ISS} - 1.9052 \times (\text{AGE}) - 1.2470 \text{ (formula 1)}$$

*e* is 2.7182818 (base of the natural logarithm [Euler's number]), RTS is revised trauma score, ISS is injury-severity score, and age is 0 for patients younger than 55 years, and 1 for those 55 years or older. Although TRISS is widely used, it has limitations. The main limitation is the reduced applicability due to missing physiological parameters, particularly the respiratory rate. This rate is not recorded by the emergency teams at the scene of the trauma in about 33% of cases in the trauma registry. Other variables with proven effect on the outcome, like the base excess or coagulatory parameters, are not used for calculation of TRISS.<sup>23</sup> When applied to the data in the registry, the TRISS-calculated prognosis is about 4–5% greater than the recorded mortality rate; therefore use of this score might result in an overestimation of the probability of death.

To increase the applicability and predictive accuracy, the Institute for Research in Operative Medicine developed the RISC score for calculation of the probability of death in patients with trauma. This score was developed with data from 2009 patients in the trauma registry (1993–2000) and has been validated for 3475 patients (2001–03). It is calculated on the basis of more variables than is TRISS (table 1). Other variables are substituted when values are missing—eg, missing partial thromboplastin time is substituted for thromboplastin time. RISC-score-adjusted outcome comparisons have been routinely reported every year by the trauma registry since 2003.<sup>24</sup> The probability of death is calculated with the following formula:

$$1/(1+e^{-x}); x=5.0 + \text{coefficients (formula 2)}$$

Area under the curve of the receiver operator characteristic is 0.906 (95% CI 0.895–0.918) for the RISC score and 0.875 (0.863–0.887) for TRISS. Goodness of fit according to Hosmer and colleagues<sup>25</sup> is significantly better for the RISC score than for TRISS. Lefering's<sup>26</sup> calculations were based on valid data from about 5000 patients in the trauma registry that could be used

	Coefficient
<b>Age (years)</b>	
55–64	-1.0
65–74	-2.0
≥75	-2.3
<b>New ISS (points)</b>	
1–75 (per point)	-0.03
<b>Head injury (AIS points)</b>	
4	-0.5
5/6	-1.8
<b>Limb injury (AIS points)</b>	
5	-1.0
<b>GCS (points)</b>	
3–5	-0.9
<b>PTT (s)</b>	
40–49	-0.8
50–79	-1.0
≥80	-1.2
<b>Base excess (mmol/L)</b>	
-9.0 to -19.9	-0.8
≤-20	-2.7
<b>Cardiorespiratory arrest</b>	
Yes	-2.5
<b>Bleeding signs (n)*</b>	
1	-0.4
2	-0.8
3	-1.6
Constant	5.0

AIS=abbreviated injury scale. GCS=Glasgow coma scale. ISS=injury-severity score. PTT=partial thromboplastin time. \*Systolic blood pressure <90 mm Hg, or haemoglobin concentration <90 g/L or ≥ 10 units of packed red blood cells.

**Table 1: Revised injury severity classification (RISC) score**

for calculation of TRISS or RISC score, or both. Comparison of these two scores shows better precision, discrimination, and calibration for the RISC score than for TRISS.<sup>24–27</sup>

RISC and TRISS scores were used to deduce the expected mortality for inclusion in calculation of SMR. If SMR is 1, then the calculated mortality rate is identical to the recorded rate; less than 1 means that more patients than expected survive; and a ratio greater than 1 means fewer patients than predicted survive. We calculated 95% CIs when appropriate. Significance was assessed at  $p < 0.05$ . We did the statistical analysis using SPSS (version 15.0).

To find out whether whole-body CT is significantly associated with the risk of death, we calculated logistic regression models in which this CT had been tested with the well known prognostic indices of TRISS, RISC score (models 1 and 2), and other potential interfering factors like hospital level (I, II, or III) or year of the trauma (models 3 and 4). We did sensitivity analysis for potential centre effects by assessing whole-body CT×hospital interaction terms, with inclusion of the term hospital as an independent predictor in the logistic regression

	Total (n=4621)	Whole-body CT (n=1494)	Non-whole-body CT (n=3127)	p value
Age (years)	42.6 (20.7)	42.5 (20.3)	42.7 (20.8)	0.85
Men	3364 (73%)	1098 (74%)	2267 (73%)	0.49
<b>Prehospital</b>				
Shock on scene (SBP <90 mm Hg)	970 (21%)	353 (24%)	616 (20%)	0.004
Intubation	2740 (59%)	1035 (69%)	1704 (55%)	<0.001
GCS on scene (points)	10.3 (4.8)	9.9 (4.8)	10.4 (4.8)	0.002
<b>Trauma room/in hospital</b>				
Shock on admission (SBP <90 mm Hg)	707 (15%)	260 (17%)	444 (14%)	0.005
Haemoglobin concentration (g/L)	113 (30)	110 (28)	114 (30)	<0.001
Thromboplastin time (%)	74.9 (23.3)	73.1 (22.3)	75.9 (23.8)	<0.001
Base excess (mmol/L)	-3.7 (5.0)	-4.1 (4.8)	-3.5 (5.1)	<0.001
Time from trauma-room admission to CT (min)	41.7 (33.9)	35.5 (26.5)	46.6 (37.5)	<0.001
Operation	3581 (78%)	1264 (85%)	2258 (72%)	<0.001
Massive blood transfusion until ICU (≥10 PRBC transfused)	425 (9%)	160 (11%)	266 (9%)	0.015
Multiorgan failure*	1229 (27%)	569 (38%)	644 (21%)	<0.001
Ventilation time (days)	8.7 (12.8)	10.2 (14.1)	7.9 (12.1)	<0.001
ICU stay (days)	12.5 (14.7)	14.2 (15.6)	11.7 (14.2)	<0.001
Hospital stay (days)	26.0 (30.2)	28.2 (33.4)	25.0 (28.4)	0.002
<b>Abbreviated injury scale (≥3)</b>				
Head	2768 (60%)	884 (59%)	1882 (60%)	0.51
Thorax	2625 (57%)	1035 (69%)	1589 (51%)	<0.001
Abdomen	1049 (23%)	390 (26%)	660 (21%)	<0.001
Extremities	1687 (37%)	614 (41%)	1073 (34%)	<0.001
<b>Injury-severity score (points)</b>	<b>29.7 (13.0)</b>	<b>32.4 (13.6)</b>	<b>28.4 (12.4)</b>	<b>&lt;0.001</b>
<b>Mortality rate</b>				
24 h	518 (11%)	146 (10%)	372 (12%)	0.038
Overall	998 (22%)	306 (21%)	691 (22%)	0.21

Data are number (%) or mean (SD), unless otherwise indicated. GCS=Glasgow Coma Scale. ICU=intensive care unit. PRBC=packed red blood cells. SBP=systolic blood pressure. \*Defined as organ failure of two systems of >2 sepsis-related organ-failure assessment-score points for at least 2 days.<sup>28</sup>

**Table 2: Characteristics of patients with polytrauma with information about CT during trauma-room treatment**

models. The dependent (target) variable was hospital-related mortality. To correctly include these probabilities into the logistic model, we transformed them with the inverse logistic function:

$$x = \ln[1/p - 1]$$

in which  $p$  is the score probability and  $x$  is identical to that in formulas 1 and 2 into values that were appropriate for logistic modelling. We analysed each prognostic score separately.

#### Role of the funding source

There was no funding for this study. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

**Results**

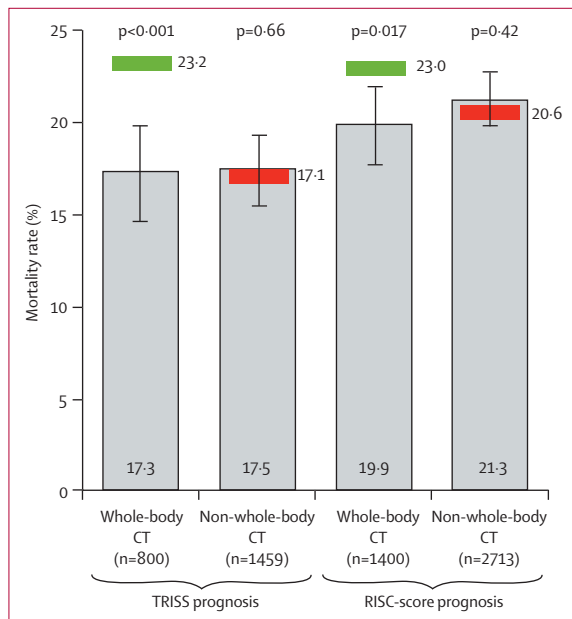
4621 of 9259 patients met the inclusion criteria. 1494 (32%) of 4621 patients underwent whole-body CT during early resuscitation phase, 3127 (68%) did not. 697 (22%) of 3127 patients assigned to non-whole-body CT did not undergo any kind of CT and 2430 (78%) were given selective organ CTs (2024 [83%] head, 863 [36%] thorax, 627 [26%] abdomen, 416 [17%] pelvis, and 960 [40%] spine).

The mean time from trauma-room admission to starting whole-body CT was significantly shorter than that for non-whole-body CT (table 2). We did not note any adverse effects that could be attributed to whole-body CT. The TRISS method could be applied to 2259 of 4621 patients meeting the inclusion criteria. 800 patients with TRISS prognosis received whole-body CT, 1459 did

not. The recorded mortality rate for patients given whole-body CT was 138 (17%) and was significantly lower than the 186 (23%) predicted with TRISS ( $p < 0.001$ ). The absolute risk reduction was 5.9%, representing a relative reduction of 25% (95% CI 14–37). For 1459 patients given non-whole-body CT, the recorded mortality rate was 255 (18%) and higher than 250 (17%) predicted with TRISS ( $p = 0.66$ ). The SMR for 800 patients given whole-body CT was 0.745 (0.633–0.859), which meant that the recorded mortality rate was significantly lower than that predicted with TRISS. The SMR for 1459 patients given non-whole-body CT was 1.023 (0.909–1.137) with a recorded mortality rate higher than predicted with TRISS (figure). The number needed to treat or, better, the number needed to scan based on TRISS was 17 for whole-body CT.

The RISC calculation could be done in 4113 patients. 1400 patients with RISC prognosis received whole-body CT, 2713 did not. The recorded mortality rate for patients given whole-body CT was 279 (20%) and thus significantly lower than 322 (23%) predicted with the RISC score ( $p = 0.017$ ). The absolute risk reduction was 3.1%, representing a relative reduction in mortality of 13% (95% CI 4–23). The recorded mortality rate was 578 (21%) of 2713 patients given non-whole-body CT and higher than 559 (21%) predicted with the RISC score ( $p = 0.42$ ). The SMR for 1400 patients given whole-body CT was 0.865 (0.774–0.956), which meant that the recorded mortality rate was significantly lower than that predicted with the RISC score. The SMR for the 2713 patients given non-whole-body CT was 1.034 (0.959–1.109); therefore, the recorded mortality rate was higher than predicted with the RISC score (figure). The number needed to scan based on the RISC score was 32 for whole-body CT. The non-overlapping CIs of SMR for TRISS and RISC-score calculations show that the recorded differences are significant.

Logistic regression analysis of whole-body CT with the well known prognostic indices of TRISS or RISC score showed that this CT is an independent predictor for survival that significantly adds predictive power to the model ( $p \leq 0.002$ ). Table 3 shows the results of models 1 (TRISS+whole-body CT) and 2 (RISC score+whole-body CT). The size of the effect suggests that the odds of survival could be increased by about a third if whole-body CT is done. The same effect was noted with models 3 and 4 for logistic regression analysis (table 4; table 5) even with additional adjustment for hospital level and year of trauma. The findings remained stable and robust even after adjustment for potential centre effects.



**Figure: Effect of whole-body CT on outcome**  
 Grey columns represent the recorded mortality rates. Error bars represent 95% CI. Green bars show that the recorded mortality rates are lower than the predicted rates. Red bars show that the recorded mortality rates are higher than the predicted rates. RISC=revised injury severity classification. TRISS=trauma and injury severity score.

	Regression coefficient $\beta$	p value	Odds ratio ( $e^{\beta}$ ; 95% CI)
<b>Model 1: TRISS+whole-body CT (n=2259)</b>			
TRISS*	-0.62	<0.001	0.54 (0.51-0.58)
Whole-body CT	-0.42	0.002	0.66 (0.50-0.86)
Constant	-0.34	<0.001	..
<b>Model 2: RISC+whole-body CT (n=4113)</b>			
RISC score*	0.92	<0.001	2.50 (2.35-2.66)
Whole-body CT	-0.37	<0.001	0.69 (0.58-0.85)
Constant	-0.02	<0.81	..

RISC=revised injury severity classification. TRISS=trauma and injury severity score. \*Inverse logistic transformation of the predicted outcome probability of TRISS (survival) or RISC score (mortality).

**Table 3: Logistic regression models 1 (TRISS+whole-body CT) and 2 (RISC score+whole-body CT)**

**Discussion**

The probability of survival, based on TRISS, RISC-score, and SMR, increased significantly for patients given whole-body CT compared with non-whole-body CT. The mean injury-severity score for patients with severe blunt trauma in our study was similar to that in other studies on

	Regression coefficient $\beta$	p value	Odds ratio (e <sup><math>\beta</math></sup> ; 95% CI)
TRISS*	-0.62	<0.001	0.54 (0.51-0.58)
Whole-body CT	-0.42	0.002	0.66 (0.50-0.86)
Level			
I (reference)	..	0.67	..
II	0.08	0.62	1.08 (0.80-1.47)
III	0.38	0.44	1.46 (0.57-3.76)
Year			
2002 (reference)	..	0.73	..
2003	0.11	0.50	1.12 (0.82-1.52)
2004	-0.01	0.99	1.00 (0.74-1.35)
Constant	-0.39	0.002	..

TRISS=trauma and injury severity score. \*Inverse logistic transformation of the TRISS-predicted probability of survival.

**Table 4: Logistic regression model 3 (TRISS+whole-body CT+level of hospital+year) based on data from 2259 patients**

	Regression coefficient $\beta$	p value	Odds ratio (e <sup><math>\beta</math></sup> ; 95% CI)
RISC score*	0.92	<0.001	2.50 (2.35-2.66)
Whole-body CT	-0.38	0.001	0.69 (0.55-0.85)
Level			
I (reference)	..	0.96	..
II	0.11	0.93	1.01 (0.79-1.30)
III	-0.12	0.81	0.89 (0.35-2.29)
Year			
2002 (reference)	..	0.68	..
2003	0.06	0.62	1.06 (0.84-1.35)
2004	-0.05	0.70	0.95 (0.75-1.22)
Constant	-0.02	0.82	..

RISC=revised injury severity classification. \*Inverse logistic transformation of the RISC-score-predicted probability of death.

**Table 5: Logistic regression model 4 (RISC+whole-body CT+level of hospital+year) based on data from 4113 patients**

whole-body CT.<sup>7,12</sup> Patients given whole-body CT had a significantly higher injury-severity score than did those given non-whole-body CT (table 2). Furthermore, the mean time from trauma-room admission to beginning whole-body CT was significantly shorter than for an organ-selective CT. This difference could be explained by the fact that more CT scanners are located inside or near the trauma room and an increasing number of trauma centres do whole-body CT during the early resuscitation phase. Of note, every fifth patient who underwent whole-body CT was in shock at the scene of the trauma and every sixth patient at the time of trauma-room admission.

To estimate radiation exposure, an effective radiation dose is assumed to be 10–20 mSv for a whole-body CT, 5–16 mSv for a selective-organ CT, and 2 mSv for a conventional radiography series (chest, vertebral column, pelvis).<sup>29</sup> However, the effective dose for particular organs can accumulate and thereby potentially increase an individual's risk of cancer.<sup>30</sup> Despite the patient's size, the dose is strongly dependent on parameters and protocols used for CT.<sup>14,31</sup> Comparison of different protocols for whole-body CT shows that those for single-pass acquisition result in lower radiation exposure than do segmented, partially overlapping protocols.<sup>14,31</sup>

Whole-body CT is associated with greater radiation exposure than is CT targeted to a particular organ and anatomical area. The potentially harmful effects of increased radiation exposure have to be weighed against the better diagnostic accuracy of the whole-body technique. Even if increased risk of developing cancer years or decades later cannot be neglected, a swift, accurate, and comprehensive diagnosis is mandatory in critically injured patients. To justify the increased radiation exposure, the potential gain in diagnostic safety should ideally result in an increased probability of survival. Salim and colleagues<sup>13</sup> showed that whole-body

CT resulted in a change of treatment in 19% of 1000 patients without obvious external signs of injuries. Deunk and co-workers<sup>32</sup> reported that chest or abdominal CT resulted in a change of treatment in up to 34% of patients with blunt trauma.

We chose a risk adjustment method by calculating TRISS, RISC score, and SMR to compare patients given whole-body CT with those given the non-whole-body technique. However, score-based prognosis can only adjust for injury severity. Additional confounding factors could be the dedication of a centre to trauma care, level of hospital, experience of surgeons, or therapeutic improvements over time. Not all of these factors could be measured validly and thus could not be accounted for. But multivariate analysis that takes into account the hospital level and year of trauma showed that the association of whole-body CT with improved outcome is still substantial. We are aware that our findings show associations rather than causalities. Our findings suggest that integration of whole-body CT into the early trauma resuscitation phase has an advantage on the endpoint of survival.

The crucial factor in whole-body CT is not the exposure of radiation but the early realisation and implementation of the findings to the critically injured patient. We postulate that the earlier the emergency team knows the definitive pattern of injury, the sooner a prioritised therapeutic plan can be developed and realised for the benefit of the patient. Therefore whole-body CT, if done early, can replace conventional radiography with a considerable amount of time saved.<sup>33</sup>

Use of whole-body CT does not mean that use of standard techniques, such as ultrasonography and conventional radiography, will decrease. These techniques are well established and reasonable, and should be used as adjuncts to whole-body CT or as a backup in case of CT failure (ie, complete shutdown or breakdown of CT before or during the procedure). In our opinion whole-body CT

is the most comprehensive diagnostic method and should be part of a modified advanced trauma life-support-based treatment.

To achieve a synergistic effect that increases the probability of survival in major trauma, an existing, functional, and structured trauma room work flow is needed in which early whole-body CT is an integral part. Whole-body CT without an effective, structured, and targeted resuscitative treatment will not increase the survival rate.

Our results show the importance of having a CT scanner near the trauma room. In our opinion, when planning or rebuilding emergency departments, CT scanners should be placed close to or, at best, in the trauma room.

Our study has several limitations that might bias the results. It was not done prospectively. Because of missing data in the trauma registry, calculations of TRISS could be done in only 2259 (49%) and RISC score in 4113 (89%) of 4621 patients. Since the participating hospitals choose their own diagnostic workup, indications for or against whole-body CT were not clearly defined. The registry does not have information about structural differences of the participating hospitals, such as the location of the CT scanner and transportation times between the trauma room and CT suite. We also do not have information about CT protocols, type of contrast enhancement, or any data about radiation doses for the hospitals. Furthermore we do not know which hospital, and to what extent, has implemented the principles of advanced trauma life support. Potentially different intercentre consistency in grading injuries (abbreviated injury scale or injury-severity score) might also bias our results. The substantial geographic and structural differences between regions and federal states in Germany might have additional and unquantifiable effects on our results. Furthermore, residual confounding could be caused by preferential selection of likely survivors in centres with better equipment or highly developed protocols to select and undertake whole-body CT in patients who might benefit, or by the level of experience of the attending doctors within a centre to prefer whole-body CT and hence provide better care to those patients given this CT.

The results of our study need to be confirmed in a randomised controlled trial in which the safety issues (radiation doses), treatments as a consequence of whole-body CT, and the costs and benefits are rigorously and prospectively assessed.

Despite these limitations, our results indicate that the probability of survival for patients with major trauma can be significantly increased by use of whole-body CT. On the basis of our findings, we recommend that whole-body CT should be integrated into the early resuscitation phase of severely injured patients as a standard and basic diagnostic method.

#### Contributors

SHW and KGK participated in the idea, planning, data analysis and interpretation, statistical analysis, and writing the report. RL participated

in the planning, data analysis and interpretation, statistical analysis, and writing the report (methods, results, and discussion). LMQ participated in the data analysis and interpretation, searching for publications, and writing the report. MK participated in data interpretation, searching for publications, and writing the report (radiological part). MVK participated in data interpretation, language support, and writing the report. KJP and MR participated in data interpretation and writing the report (radiological part). WM participated in data analysis and interpretation, statistical analysis, and writing the report. All authors have seen and approved the final version of the report.

#### Working Group on Polytrauma—German Trauma Society (Deutsche Gesellschaft für Unfallchirurgie, DGU, Sektion Notfall-, Intensivmedizin und Schwerverletztenversorgung, NIS)

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#### Participating hospitals

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#### Conflict of interest statement

We declare that we have no conflict of interest.

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