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# Radiation exposure in whole-body computed tomography of multiple trauma patients: Bearing devices and patient positioning

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ABSTRACT

*Background:* Whole-body computed tomography (WBCT) plays an important role in the management of severely injured patients. We evaluated the radiation exposure of WBCT scans using different positioning boards and arm positions.

*Methods:* In this retrospective study, the radiation exposure of WBCT using a 16-slice multislice computed tomography scanner was evaluated. Individual effective doses ($E$, mSV) was calculated. Patients were assigned to two groups according to placement on a plastic transfer mat (PTM, group 1) or on the Trauma Transfer$^{TM}$-Board (TTB, group 2). Data were collected for each group with arm placement on the abdomen (a) or in raising position (b), respectively. The maximum ventro-dorsal diameter [VDD] at the trunk was measured.

*Results:* 100 patients with potentially life-threatening injuries were analysed. Patient demographics and VDD did not differ in the two groups. Radiation exposure in term of $E$ did not reveal any significant differences between the two positioning boards using same arm position [group 1a ($n = 26$) vs. 2a ($n = 24$) (mSV): $16.7 \pm 4.7$ vs. $17.1 \pm 4.4$, group 1b ($n = 26$) vs. 2b ($n = 24$) (mSV): $13.1 \pm 3.9$ vs. $14.3 \pm 1.5$]. The arm raising positioning showed a significant reduction in $E$ in comparison to the placement on abdomen position [group 1b vs. 1a (mSV): $13.1 \pm 3.9$ vs. $16.7 \pm 4.7$, $p < 0.05$, group 2b vs. 2a (mSV): $14.3 \pm 1.5$ vs. $17.1 \pm 4.4$, $p < 0.05$].

*Conclusions:* Patient arm positioning for WBCT has an important influence on radiation exposure. Effective dose was 16–22% lower when arms were raised. An individual placement algorithm may lead to a relevant reduction of radiation exposure of severely injured patients.



## Introduction

Within 24 h following hospital admission approximately half of the patients suffering from major trauma die because of their primary severe traumatic brain injury or multiple trauma with massive bleeding.[1,2] Providing an immediate and reliable diagnosis of life-threatening injuries to the head and body cavities is the goal of early in-hospital diagnostic imaging of multiple trauma patients. Whole-body computed tomography (WBCT) is increasingly gaining in importance for structured patient management in the resuscitation room and can improve the likelihood of survival.[3–8] According to data provided by the trauma registry of the German Society of Trauma Surgery the use of WBCT has risen from 5% in 2002 to 40% in 2008.[6]

WBCT is associated with considerable radiation exposure for this predominantly younger patient group.[9] For this reason, achieving a near-term and reliable diagnosis whilst keeping radiation exposure as low as possible even within an emergency situation must be of the utmost priority.

Different bearing devices geared towards a safe and fast transfer are employed to transfer the patient from the stretcher to the CT table. These transfer devices may lead to increased radiation exposure. Patients can also be positioned in different ways for their WBCT and patient positioning can have an impact on both radiation exposure and image quality.[21] The creation of the topogram and as such the setting of the necessary dose is influenced by all the structures (e.g. the arms) in the beam path. Whilst patients' arms are always elevated during routine CT scans

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of the trunk, this is not routinely feasible with severely injured patients. The arms of multiple injured trauma patients who have potentially suffered an injury to the upper extremity are positioned on or next to the trunk of the body.

The present study intends to evaluate the impact of two different bearing devices as well as different arm positions on radiation exposure. The potential dose saving effect of newest CT scanners was also evaluated.

## Material and method

In this retrospective single centre study we evaluated the radiation exposure of WBCT scans using different positioning boards and arm positions.

The data was collected in a full-service hospital of the maximum care level with a certified supra-regional trauma centre. The Department of Interdisciplinary Emergency Medicine has an integrated acute care unit for severely injured and critically ill patients. Two directly adjacent resuscitation rooms ensure simultaneous treatment of two casualties. There is immediate access to a 16-slice multi detector (MD) CT (Somatom Sensation 16, Siemens AG, Erlangen, Germany; gantry diameter: 70 cm, maximum rotational speed: 420 ms, minimum slice thickness: 0.75 mm) from both resuscitation rooms (Fig. 1).

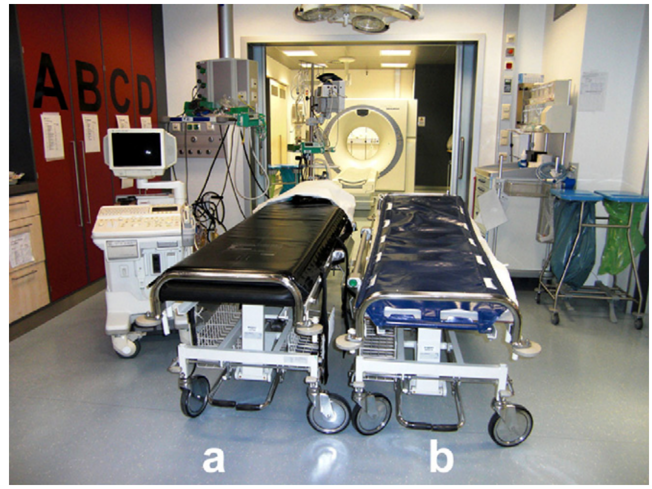


**Fig. 1.** Resuscitation room with integrated 16-slice CT in the background. Left (a): bearing device as used in the resuscitation room with Trauma Transfer$^{TM}$ Board (TTB, MedicalSCA, Vienna, Austria) on top. Right (b): bearing device as used in the resuscitation room with plastic transfer mat (PTM, B&W Schmidt GmbH, Garbsen, Germany) on top.

The authors' institution has a treatment algorithm for early management of trauma patients which provides for running a WBCT for ventilated patients and/or patients corresponding to established anamnestic and clinical criteria (e.g., fall from heights of ≥3 m, ejection from crashed motor vehicle, death of another vehicle passenger, pedestrian or cyclist hit, motorcycle or motorvehicle crash at high speed, major vehicle deformation, entrapment, accidental spillage, injuries resulting from explosion).[8,10] Its existence ensures that the indication for WBCT can be justified and correctly made in accordance with established algorithms.[10]

Fig. 2 shows the examination routine for a complete WBCT. In the following, we will focus on exposition data during MDCT of the trunk. The detailed examination routine applied for an MDCT of the trunk at our institution is shown in Table 1 and Fig. 2.

The CT scanners used have automatic modulation of the tube current depending on the tube position during rotation (CARE-Dose 4D, Siemens, Erlangen, Germany). The CT software uses the topogram and previous rotation in order to calculate the tube current required for each longitudinal rotation (*z*-axis) and irradiated section (*xy*-plane) (Fig. 3).[11]

At our institution patient's arms are positioned according to the following clinical criteria during the WBCT scan: the arms of intubated and ventilated patients are positioned on the body. The same is done in the case of injuries or suspected injuries of the upper extremity or thorax. The arms of all other patients are raised next to the head, as it is common practice for examinations of the trunk (Fig. 2).

The data collected for adult multiple trauma patients who were treated in the resuscitation rooms between September 2009 and November 2010 with the suspicion of major trauma and the indication for a WBCT in line with the institution's treatment algorithm were recorded retrospectively and assigned to one of two patient groups:

Group 1 included patients for whom a flexible plastic transfer mat (PTM, B&W Schmidt GmbH, Garbsen, Germany) was used during transfer (Fig. 1b). The patients' arms were placed on the abdomen in group 1a and raised above the head in group 1b. This

**Table 1**
Examination routine (trunk) during primary CT-diagnostic of polytraumatised patients (Siemens: Sensation 16/Definition AS64).

| Topogramm of the trunk a.p. | | |
|---|---|---|
| **Chest/abdomen/pelvis/vertebral column** | | |
| | **Siemens Somatom 16** | **Siemens Somatom Definition AS64** |
| Contrast medium (CM) amount (ml)/flow rate (ml/s) 300 mg J/ml | 120/3 | 70/4 + 50/3 |
| Saline solution-bolus (ml)/flow rate (ml/s) | 50/3 | 50/3 |
| Delay (s) post CM | 60 | 60 |
| Rotation time (s) | 0.75 | 0.5 |
| Collimation (mm) | 16 × 0.75 | 64 × 0.6 |
| Tube current (kV) | 120 | 120 |
| mAs-product (Care Dose 4D) | ~*170* | ~*170* |
| Pitch | 0.8 | 0.7 |
| Scantime (s) | 35–45 | 20–28 |
| Gantry tilt (°) | 0 | 0 |
| **Reconstruction whole-body MDCT** | | |
| Cranial-CT | Soft tissue- and bone kernel: 4.5 mm (infratentorial brain) + 9 mm (supratentorial brain) ⇒ PACS optional: soft tissue- and bone kernel: 1.5 mm | |
| Cervical spine | Axial: 1 mm bone-kernel ⇒ PACS coronal, sagittal: 1 mm bone-kernel | |
| Trunk (slice thickness mm/Increment mm) | Axial: 1/1 soft tissue ⇒ PACS axial, coronal, sagittal: 5/3 lung, soft tissue | |
| Vertebral column/pelvis | Axial, coronal, sagittal: 2/2 bone-kernel ⇒ PACS | |

mAs, milliampere seconds; kV, kilovolt; Pitch, table speed/rotation time/slice thickness; Collimation, number of detector rows, resolution of a single detector element; CareDose 4D, automatic modulation of the tube current; CM, contrast medium; Cranial CT; a.p., anterior-posterior.