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Urinary bladder volume measured in whole-body CT scans is a useful marker for alcohol intoxication

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ABSTRACT

Purpose: The aim of this study was to investigate whether urinary bladder volume (UBV) and blood alcohol concentration (BAC) correlate in a cohort of emergency trauma patients. Furthermore, the feasibility of semi-automated 3D-CT volumetry for urinary bladder volumetry calculations in whole-body CT examinations was elucidated.

Material and methods: Whole-body CT scans of 831 individuals treated in the emergency department with suspected multiple injuries were included. Manual 3D-CT volumetry of the urinary bladder was performed and the mechanism of injury, patient demographics, BAC, serum creatinine, and hematocrit were retrospectively analyzed. Semi-automated calculation of UBV was performed in 30 patients. Statistical analysis included ROC analysis to calculate cut-off values, sensitivity, and specificity. The Mann-Whitney test and Spearman's correlation coefficient were used to detect significant correlations between UBV and BAC.

Results: Manual 3D-CT volumetry showed maximum sensitivity and specificity with a cut-off value for urinary bladder volume of 416.3 mL (sensitivity 50.9%; specificity 76.3%; AUC 0.678). With a cut-off value of 4.2 mL/μmol for the creatinine quotient (quotient of serum creatinine and UBV), the sensitivity was 64.2% (specificity 67.0%; AUC 0.681). Semi-automated 3D-CT volumetry resulted in lower UBV values compared to those obtained with manual 3D-CT volumetry.

Conclusion: Semi-automated 3D-CT volumetry is a reliable method to quantify UBV. UBV correlates with positive BAC results. A UBV above 416 mL seen on an initial whole-body CT must raise suspicion of alcohol intoxication. The creatinine quotient is an even more sensitive and specific parameter for the detection of alcohol intoxication.

Introduction

Alcohol consumption is a major public health concern associated with an increased risk for intentional and unintentional injuries (Maier, 2001; Rehm et al., 2009; Rivara et al., 1993; Shih et al., 2003; Taylor et al., 2010). Although it is rarely the primary reason for presentation, the prevalence of alcohol intoxication in patients admitted to the emergency department (ED) has been shown to average 35%, with regional differences ranging from 15% to 45% (Rivara et al., 1993).

Alcohol intoxication has legal implications, which complicates initial assessment of the severity and extent of injuries in trauma patients (Center for Substance Abuse Treatment, 1995). The legal implications may influence initial therapy, and intoxicated patients need to be identified and diagnosed appropriately at early stages (Jurkovich et al., 1992). Therefore, the American College of Surgeons recommends formal alcohol screening for multiple-trauma patients (Committee on Trauma American College of Surgeons, 2014).

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Clinical features of alcohol intoxication include the ingestion of alcohol in combination with psychological or behavioral alterations, e.g., slurred speech, lack of coordination, stupor, or coma (Vonghia et al., 2008). A previous study has shown that clinical suspicion of alcohol intoxication has a low sensitivity and specificity for detecting patients with alcohol intoxication and is biased based on patient characteristics (Gentilello et al., 1999).

In forensic medicine, volumetric measurements of post-mortem CT scans have gained wide acceptance for investigating premortal injury (Sogawa et al., 2014, 2015). A study by Rohner et al. has shown that urinary bladder distention as measured on post-mortem CT correlates with positive toxicological reports and may serve as an indicator for alcohol intoxication (Rohner et al., 2013). Because whole-body computed tomography (WBCT) is a conclusive and routinely used diagnostic tool in the assessment of injuries in multiple-trauma patients, findings on the use of WBCT in the field of forensic medicine may also have an impact on diagnostic algorithms in trauma patients (Stengel et al., 2009, 2012). The aim of the present study was to investigate whether UBV and BAC are correlated in a cohort of trauma patients. We additionally elucidated the feasibility of semi-automated 3D-CT volumetry for UBV calculations in WBCT examinations.

Methods

Study design and population

For this retrospective analysis, all patients referred to our institute for suspected multiple trauma between October 2007 and June 2012 were identified. Inclusion criteria were positive vital signs, age $\geq$18 years, post-traumatic primary hospital admission to our ED, and diagnostic work-up by WBCT. Exclusion criteria were death prior to arrival at hospital, unknown trauma mechanism, secondary hospital admission from another institution, urinary catheterization, incomplete chart data, and poor image quality due to artefacts (e.g., caused by implants after hip arthroplasty, etc.).

The following parameters were reviewed from the hospital charts of the included patients: age, sex, mechanism of injury, intubation, blood parameters, and results of BAC testing.

Ethics approval

The study was approved by the local Ethics Committee (Int Reg. No. BB114/13).

Treatment algorithm

In accordance with the German Trauma Association's clinical practice guidelines for the management of multiple trauma, initial resuscitation according to the ATLS® algorithm was performed prior to the WBCT scan (American College of Surgeons, 2008; Deutsche Gesellschaft für Unfallchirurgie, 2011).

Computed tomography

All patients underwent WBCT scanning in a Somatom Sensation 16 (Siemens Medical Systems, Erlangen, Germany) according to a standardized protocol as described elsewhere (Langner, Fleck, Kirsch, Petrik, & Hosten, 2008).

3D-CT volumetry

Manual 3D-CT volumetry was performed using OSIRIX® software. The most cranial and most caudal axial slides were determined on axial images. The bladder circumference was manually assessed for every axial slide using the ROI tool “closed polygon” to mark the urinary bladder margin (Fig. 1). UBV was calculated automatically using OSIRIX® Software.

Additionally, semi-automated calculation of UBV was performed in a subgroup of 30 patients. In order to detect inaccuracies of measurements, 10 patients with intra-abdominal free fluid, 10 patients with intravesical contrast fluid, and 10 patients lacking these findings were randomly selected from the included

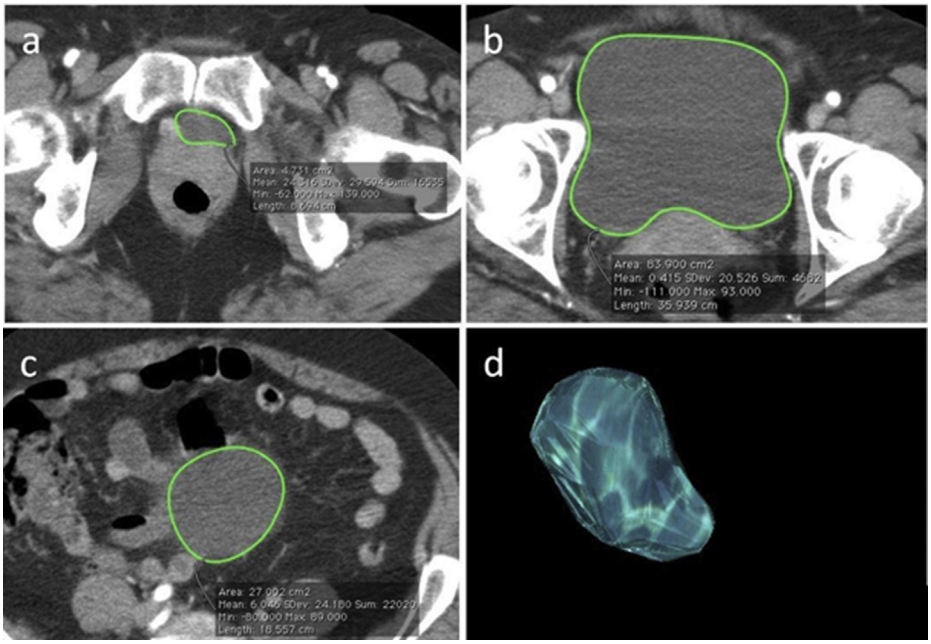

Fig. 1. Manual urinary bladder reconstruction. Urinary bladder wall was highlighted using the ROI tool “closed polygon” in basal (a), more cranial (b), and apical (c) slides. 3D bladder reconstruction using OSIRIX® Software prior to volumetric measurement (d).