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Does increased prehospital replacement volume lead to a poor clinical course and an increased mortality? A matched-pair analysis of 1896 patients of the Trauma Registry of the German Society for Trauma Surgery who were managed by an emergency doctor at the accident site

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ABSTRACT

Introduction: Severe bleeding after trauma frequently leads to a poor outcome. Prehospital fluid replacement therapy is regarded as an important primary treatment option. Our study aimed to assess the influence of prehospital fluid replacement therapy on the post-traumatic course of severely injured patients in a retrospective analysis of matched pairs.

Patients and methods: The data of 51,425 patients of the Trauma Registry of the German Society for Trauma Surgery were analysed. The following patients were included: Injury Severity Score $\geq$ 16 points, primary admission, age $\geq$ 16 years, no isolated brain injury, transfusion of at least one unit of packed red blood cells (pRBC), systolic blood pressure $\geq$ 60 mm Hg at the accident site. The patients were divided into two groups according to the following matched-pair criteria (low-volume: 0–1500 ml prehospital volume replaced; high-volume: $\geq$1501 ml prehospital volume): intubation at the accident site (yes/no), time from injury to hospital $\pm$ 10 min., means of rescue (emergency helicopter, MICU), Abbreviated Injury Scale (body regions), injury year, systolic blood pressure and age (years). All patients were managed by an emergency doctor at the accident site.

Results: A total of 948 patients in each group met the inclusion criteria. Increasing replacement volume was associated with an increased need for transfusion (pRBCs: low-volume: 7 units, high-volume: 8.3 units; $p < 0.001$) and a reduced ability to coagulate (prothrombin ratio (PR): low-volume: 68%, high-volume: 61.5%; $p < 0.001$). Patients in shock (systolic BP < 90 mm Hg) upon admission to the hospital were equally in both groups (25.6%; $p = 0.98$). Significantly higher lethality was observed in cases of increasing volume (low-volume: 22.7%, high-volume: 27.6%; $p < 0.01$).

Conclusions: Excessive prehospital fluid replacement leads to an increased mortality rate. The results of this study support the concept of restrained volume replacement in the prehospital treatment of patients with severe trauma.

Introduction

Bleeding as a result of severe trauma is correlated with high rates of initial mortality and secondary complications.[1–4] Blunt trauma is the most frequent form of severe trauma in Europe (95% in Germany, according to the Trauma Registry 2010 annual report). Blunt trauma that causes bleeding into the large (thoracic and/or abdominal) body cavities is especially difficult to assess diagnostically. Furthermore, these injuries are related to increased mortality rates.[5–8]

At first glance, a reasonable course of action appears to be replacement of the lost blood by fluids as quickly as possible, i.e., at the accident site.[9] However, no studies have confirmed that the immediate administration of fluids is beneficial to trauma patients

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with internal bleeding. Unlike assessments of blunt trauma, the influence of prehospital fluid replacement on penetrating injuries has been more thoroughly investigated. Follow-up examinations of soldiers who were wounded in the Falklands War indicated that patients with hypotensive circulation and simultaneous hyperpyrexia prior to hospital treatment had better outcomes.[10] Further studies involving patients who suffered penetrating injuries showed that excessive replacement volume (>2000 ml), which also resulted in longer time from injury to hospital, was correlated with increased mortality rates after trauma in most cases.[11–13] Bickell et al. also showed positive results for moderate fluid replacement and permissive hypotension (90 mm Hg) in patients with penetrating injuries. This strategy also has the benefits that it reduces time from injury to hospital and is supported by several studies.[14–17]

To date, definitive evidence-based recommendations for the prehospital treatment of patients with haemorrhaging after blunt trauma do not exist. Anecdotal reports suggest that the benefit of a short time from injury to hospital and direct delivery to a level one trauma centre are the recommended course of action for penetrating injuries. In his systematic review, Butler presents a decision tree based on the Tactical Combat Casualty Care (TCCC) guidelines depending on the presence of haemorrhagic shock. However, this study concludes that it will not be possible to provide definite recommendations, since most of the results originate from animal experiments, and the evidence levels of investigations in humans will be too low.[18] This study did not particularly consider blunt trauma. Instead, it provides more general recommendations. With regard to blunt trauma, recent studies recommended keeping treatment at the accident site as minimal as possible, with the goal of maintaining a patient's vital signs and providing rapid transport to a higher-level trauma centre.[19–21] On the other hand, some reports continue to recommend extensive volume replacement as the best treatment option.[14,22,23] Turner et al. identified no relationship between mortality or outcome and the infused volume in patients with blunt trauma.[24] However, that study focused on less severely injured patients (>75% had ISS < 16).

Several questions arise after an examination of the current literature, including the following: does the quantity of volume replaced have consequences for haemorrhagic shock in the post-traumatic course, including multiple organ failure (MOF), sepsis, outcome and mortality? Thus, the hypothesis of this study was that the prehospital increased volume replacement has a negative impact on the outcome of the patients. We addressed these questions and the hypothesis in a patient cohort that was selected from the Trauma Registry of the German Society for Trauma Surgery (DGU) and had suffered severe injuries (Abbreviated Injury Scale (AIS) > 3) that resulted in haemorrhaging.

Patients and methods

The Trauma Registry of the German Society for Trauma Surgery was started in 1993. It contains prospectively collected data from 266 collaborating European trauma centres. Data were entered by hand from patient records until 2001, when data input was automated for central submission via online data entry software (beginning in 2002). Approximately 100 data points per patient were collected, including the coding of each injury according to the Abbreviated Injury Scale (AIS; revised version of 1998). Data were 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 both the patient and the participating hospital. Only patients from Germany and Austria were included in this study to minimise variations due to different rescue systems. All patients were attended by a physician prior to hospital admission. Records that were collected between 1993 and 2009 (51,425 patients) were considered for this study. The data of the Trauma Registry of the DGU have received the full approval of the Ethics Committee of the University of Witten/Herdecke, Cologne, Germany.

Patients were selected for this study according to the following criteria:

- Primary admission to the hospital (no transfers)
- Injury Severity Score (ISS) ≥ 16
- Age ≥ 16 years
- Infusion of at least one unit of packed red blood cells (pRBC)
- Systolic blood pressure at the accident site ≥ 60 mm Hg
- Data available for prehospitally administered fluid volume, haemoglobin concentration on hospital admission and blood pressure at the accident site and upon hospital admission

According to the pre-hospitally administered fluid volume (crystalloids plus colloids), patients were divided into a "low-volume" (≤1500 ml) and a "high-volume" (≥1501 ml) group. This classification was chosen according to the mean value of all patients that met the inclusion criteria (mean value: 1679 ml).

To evaluate the effect of pre-hospital volume administration, patients with high- and low-volume fluid replacement were matched according to the following criteria:

- Pattern of injury for the following five body regions: head, thorax, abdomen, face, and extremities, including the pelvis, where matching criteria were Abbreviated Injury Scale (AIS) severity ≥ or <3 points.
- In order to account for treatment changes that may have been established over the years, the date of injury was divided into four groups: (1) 1993–1997, (2) 1998–2001, (3) 2002–2005, (4) 2006–2009.
- Systolic blood pressure at the accident site had to be at least 60 mm Hg and was subdivided into three groups that matched the following values: (1) 60–89 mm Hg, (2) 90–99 mm Hg and (3) ≥100 mm Hg.
- Age categories were divided into three subgroups: (1) 16–54, (2) 55–69 and (3) ≥70 years.

Because the three following characteristics clearly depend on and correlate with the administered fluid volume, the patient cohort was also matched with respect to these characteristics[21]:

- Intubation (yes/no)
- Method of rescue transport (air vs. ground transport)
- Time from injury to hospital ± 10 min (differences in the time from injury to hospital in matched patients did not exceed 10 min)

Sepsis was defined according to the criteria of Bone, which are close to the American College of Chest Physicians/Society of Critical Care Medicine (ACCP-SCCM) consensus conference definition.[25] Single organ failure was defined as a value of ≥3 for the Sequential Organ Failure Assessment (SOFA) score.[26] The hospitals participating in the Trauma Registry entered this value as the total value in the registry. No conclusion about an individual patient management or intervention can be drawn. Multiple organ failure (MOF) was listed if simultaneous organ failure was recorded for at least two organs. Pre-hospital parameters, length of hospital stay and coagulation ability were examined separately in each group. For coagulation, the prothrombin ratio is a parameter that is commonly used in Germany and that corresponds to the International Normalised Ratio (INR). To evaluate the Injury