ELSEVIER

Burns 31 (2005) 986–990

BURNS

www.elsevier.com/locate/burns

Lactate: Early predictor of morbidity and mortality in patients with severe burns

L.-P. Kamolz [a,*], H. Andel [b], W. Schramm [b], G. Meissl [a], D.N. Herndon [c], M. Frey [a]

[a] *Division of Plastic and Reconstructive Surgery, Department of Surgery, Medical School, University of Vienna, Waehringer Guertel 18-20, A-1090 Vienna, Austria*

[b] *Department of Anesthesia and Intensive Care, Medical School, University of Vienna, Vienna, Austria*

[c] *Department of Surgery, Shriners Hospitals for Children, University of Texas Medical Branch, Galveston, TX, USA*

Accepted 30 June 2005

Abstract

A severe burn results in a devastating and unique derangement called burn shock. Historically, resuscitation has been guided by a combination of basic laboratory values, invasive monitoring and clinical findings, but the optimal guide to the endpoint of resuscitation remains controversial. One-hundred sixty-six patients, who were admitted to our Burn Unit, were enrolled in this prospective study. Resuscitation of these patients was undertaken according to the current standard of care. Parkland formula was used as a first approximation of acquired fluid administration rates and fluid administration was adapted in order to meet clinical needs. The aim of this study was to evaluate if plasma lactate is a useful parameter to estimate the severity of a burn shock. One of the main objectives was to evaluate, if the lactate clearance adds additional information. The results of this study indicate that the initial lactate level (Day 0) is a useful parameter to separate survivors from non-survivors.

Moreover, a significant marker of shock and resuscitation was observed in evaluating the lactate clearance on Day 1. A better chance of survival occurs when resuscitation results in a lactate clearance to normal values within 24 h (survival was 68% if the lactate reached normal values, compared to 32% if the lactate level remained supra-normal).

In summary, we believe that measuring lactate and lactate clearance may help to detect critically injured patients either for adequacy of treatment, or selection of other therapeutic options.

Keywords: Lactate; Resuscitation; Outcome; Morbidity; Mortality

1. Introduction

A severe burn results in a rapid loss of intravascular volume. Initially, burn shock is hypovolemic in nature and is characterized by hemodynamic changes including decreased plasma volume, cardiac output, urine output and an increased systemic vascular resistance with resultant decreased peripheral blood flow. Historically, resuscitation of trauma and surgical critical care patients has been guided by a combination of basic laboratory values, invasive monitoring and clinical findings, but still the optimal guide to the endpoint of resuscitation remains controversial. The ideal marker of adequate resuscitation should assess resolution of tissue hypoxia and should be predictive of patient mortality and outcome. Although not unanimously accepted, abnormal plasma lactate and delayed lactate clearance are felt to be precise markers of cellular hypoxia and shock [1–3]. The correlation between lactate and clinical outcome has been well accepted in hemorrhagic and septic shock [4]. In contrast to the existing evidence mentioned above there are no or almost no data dealing with lactate and lactate clearance in burn shock. The aim of this study was to evaluate if plasma lactate is also a useful parameter to estimate the morbidity of burn patients and thereby their outcome.

* Corresponding author. Tel.: +43 1 40400 6860; fax: +43 1 40400 6862.
E-mail address: lars-peter.kamolz@meduniwien.ac.at (L.-P. Kamolz).

0305-4179/$30.00
doi:10.1016/j.burns.2005.06.019

The further objective was to evaluate if a delayed lactate clearance (lactate clearance—the time it took for blood lactate level to return to normal values) adds additional information.

2. Material and methods

2.1. Clinical protocol

One-hundred sixty-six patients, admitted to our Burn Unit for severe burn were prospectively enrolled in this study. Initiation of the study protocol has begun as early after admission as possible. For each measurement, 1 ml of arterial blood was drawn into a heparin coated syringe. Plasma lactate levels were analyzed using the Radiometer Copenhagen ABL 700 Series (Bronshoj, Denmark) immediately after admission and on the following day. The study period was defined as the time interval between measurement one and two. Automatic quality controls were performed by the AutoCheck quality control module, which is included in the Radiometer. Moreover to guarantee exact results our lab has implemented and maintains a Quality Management System, which fulfills the requirements of the ISO 9001:2000 standards.

Resuscitation of these patients using only Ringer's solution was undertaken according to the current standard of care. Parkland formula was used as a first approximation of required fluid administration rates which is based on burn size and body weight [5]. Thereafter, fluid administration was adapted in order to meet clinical needs with target urinary output of 1 ml/kg body weight/h and target mean arterial pressure of 65 mmHg.

2.2. Data analysis

For the evaluation of lactate clearance, the median lactate levels of each patient over the first and second 24 h period (Day 0–1) were used. Based on the initial lactate level, patients were divided into two groups. Group A: subjects with a normal lactate value (<2 mmol/l). Group B: subjects with elevated levels (>2 mmol/l).

In order to evaluate the potential impact of using lactate measurements (after admission) for estimating outcome of burn patients, a linear discrimination function was devised to predict outcome for patients with acute burn injuries. The relationship between initial clinical parameters (ABSI parameters like age, TBSA, inhalation trauma, full thickness burn) and lactate value at the time of admission was studied using a Fisher linear discrimination analysis. According to previous data of our research group, the ABSI variable sex was excluded due the lack of importance in estimating outcome [6]. Survivors were coded as 0, non-survivors as 1; full thickness burn as 1; inhalation trauma as 1. A linear discrimination function was formulated by multivariate analysis to investigate the relationship between the above mentioned factors and the dependent variable mortality. The cut-off point was chosen retrospectively in order to guarantee a specificity of 100%. In order to demonstrate that the initial lactate value is not only a question of burn size, the correlation between the initial lactate level and TBSA was evaluated.

3. Results

The demographic data of the patients are presented in Table 1. The median interval between trauma and admission (first measurement) was 93 min (interquartile range: 44–118 min) and there was no difference between survivors and non-survivors. The median interval from measurement one to two was 16 h (interquartile range: 13–21 h) with no difference between survivors and non-survivors.

No subject died directly from ''burn-shock''. All non-survivors died after the initial postburn phase caused by sepsis, inhalation injury or complications due to pre-existing diseases. None of the subjects enrolled in the study received any kind of blood products during the study period. Moreover, no albumin was used within the first 24 h after injury (study period). In the following 24 h albumin 20% was administered to achieve a colloid osmotic pressure between 12 and 16 mmHg.

Patients with an initial lactate value of more then 2 mmol/l were divided into two groups depending on their lactate clearance. Patients in Group 1 clearing lactate levels within 24 h (below 2 mmol/l) had a mortality rate of 32%. Patients in Group 2, who were not able to clear the lactate levels within 1 day, had a corresponding mortality rate of 73% (Table 2).

The linear discriminant analysis produced a highly significant ($p < 0.001$) model to predict mortality. The initial lactate value had a significant impact ($p < 0.0001$) on the following formula. The formula to evaluate lactate

Table 1
Details (abbreviated burn severity index (ABSI) variables) of 166 patients

	F%	III°%	INHAL%	TBSA%	Age
Total patients	30	86	55	30 ± 23	50 ± 20
Survivor	29	80	40	20 ± 14	47 ± 20
Non-survivor	32	100	87	49 ± 24	56 ± 20

F%: percentage of female patients; III°%: percentage of patients with full thickness burns; INHAL%: percentage of patients with inhalation trauma; TBSA%: percentage of total body surface area burned; AGE: age in years. Where applicable, data are presented as mean ± standard deviation.