CRITICAL CARE

LETTER

Substitution of exudative trace element losses in burned children

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We describe an intravenous copper-selenium-zinc substitution policy in children with major burns using adult doses adapted to total body surface area. Blood levels and clinical course confirm its safety, with a rapidly favourable clinical evolution.

Major burn injuries are associated with trace element deficiencies, which lead to impaired wound healing and infectious complications. Low plasma levels of zinc (Zn) and copper (Cu) are inadequately compensated for during hospitalization [1], and enteral supplements are unsuccessful in correcting the status [2]. Additionally, there are currently no clear recommendations regarding trace element requirements in children. The aim of the present study was to determine if our trace element supplementation policy for adults adapted to total body surface area would achieve normalization of plasma concentrations of trace elements in burned children.

Burned children admitted to the paediatric and adult ICU were enrolled after approval by the Institutional Ethics Committee and parental informed consent. Parkland formula was used for fluid resuscitation during the first 24 hours in addition to basal fluid requirements (1,800 ml/m^2). Target nutrition from 36 to 48 hours was: 3 to 5 year olds, 70 to 90 kcal/kg/day; over 5 year olds, 50 to 70 kcal/kg/day; teenagers, 40 kcal/kg/day. A normal saline solution containing Cu, selenium (Se), and Zn (Table 1) [3] was infused continuously first within 12 hours of injury and then over 8 hours per day for 7 to 15 days at a dose of 250 ml/1.70 m^2/day along with a standard parenteral multi-trace element preparation. In addition, children admitted to the paediatric ICU received vitamin C 30 mg/kg/day and vitamin E 1.5 mg/kg/day; teenagers managed in the adult ICU received vitamin C 10.8 mg/kg/day and vitamin E 8.3 mg/kg/day (Table 1). The length of mechanical ventilation, and ICU and hospital length of stay were recorded.

Table 1. Composition of the antioxidant micronutrient solutions used in the adult ICU

Micronutrient	Intravenous CHUV-TE-flex (250 ml)	Enteral antioxidant glutamine solution (500 ml; Intestamine®)
Copper (mg)	3.75	-
Selenium (µg)	375	300
Zinc (mg)	37.5	30
Phosphate (mg)	1,200	-
Vitamin E (mg)	-	500
Vitamin C (mg)	-	150
Beta-carotene (mg)	-	10
Glutamine (g)	-	30

TE, trace elements: copper gluconate, sodium selenite solution, and zinc gluconate (Laboratoires Aguettant, Lyon, France), plus a multi-trace element preparation (Decan®, Aguettant). Intestamin®, Fresenius Kabi AG, Stans, Switzerland.

The characteristics of all those enrolled, mean daily total trace element dose, per kilogram dose, and duration of supplementation are shown in Table 2. Figure 1 shows the individual plasma values of the four patients while in the ICU. Both teenagers (patients 3 and 4) who received additional enteral trace elements had the lowest values - although within normal ranges - probably reflecting higher requirements due to growth.

The present study is the first to show that large amounts of Cu, Se and Zn delivered intravenously are barely sufficient to normalize plasma concentrations in burned children. The amounts delivered are much larger than the usual nutritional per kilogram basis requirements [4], but are required to substitute cutaneous losses and normalize the activity of plasma glutathione peroxidase.

Our hypothesis that children may need somewhat larger amounts of trace elements than adults is supported by our results. These data, combined with two recent paediatric studies [1,5], suggest such a substitution policy is safe and should be considered in burn units.

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Competing interests
The authors declare that they have no competing interests.

Table 2. Patient characteristics and intervention details

Patient	Age (years)	Weight (kg)/ height (cm)	Body surface area (m^2)	PRISM	Burned surface %TBSA	Plasma albumin on D1, D5, D10 D20 (g/l)	Length of mechanical ventilation (days)	Length of ICU stay (days)	LOS (days)	Percentage of adult intravenous dose and duration	Daily dose	Daily dose per kilogram
1	8.5	20/110	0.78	4	Total 53% Surgical 21%	21/29/26/32	2	22	54	47%, 15 days	Cu 2.6 mg Se 177 µg Zn 27 mg	Cu 0.13 mg Se 8.9 µg Zn 1.4 mg
2	3	13/98	0.59	1	Total 14% Surgical 3.5%	27/31/32/-	11	12	23	21%, 7 days	Cu 0.9 mg Se 82 µg Zn 14 mg	Cu 0.07 mg Se 6.3 µg Zn 1.0 mg
3	12	63/165	1.69	7	Total 45% Surgical 45%	27/31/28/20	3	27	39	100%, 13 days + 10 days Intestamin*	Cu 3.0 mg Se 624 µg Zn 65 mg	Cu 0.05 mg Se 9.9 µg Zn 1.0 mg
4	15	60/173	1.69	6	Total 40% Surgical 20%	29/24/19/24	6	25	36	100%, 14 days + 10 days Intestamin*	Cu 2.47 mg Se 553 µg Zn 60 mg	Cu 0.04 mg Se 9.2 µg Zn 1.0 mg

Mean age was 12 years and mean percentage of total body surface area burned was 38%. The daily delivered trace element dose is the sum of all intakes, including micronutrient supplements by intravenous and enteral routes (the trace elements in the feeding solutions were minimal and are not included). *Patients received the intravenous supplements for x days, with Intestamin being delivered by the enteral route for 10 days from admission in both teenagers in addition to the intravenous supplement. D, day; LOS, length of hospital stay; PRISM, pediatric risk of mortality; TBSA, total body surface area.

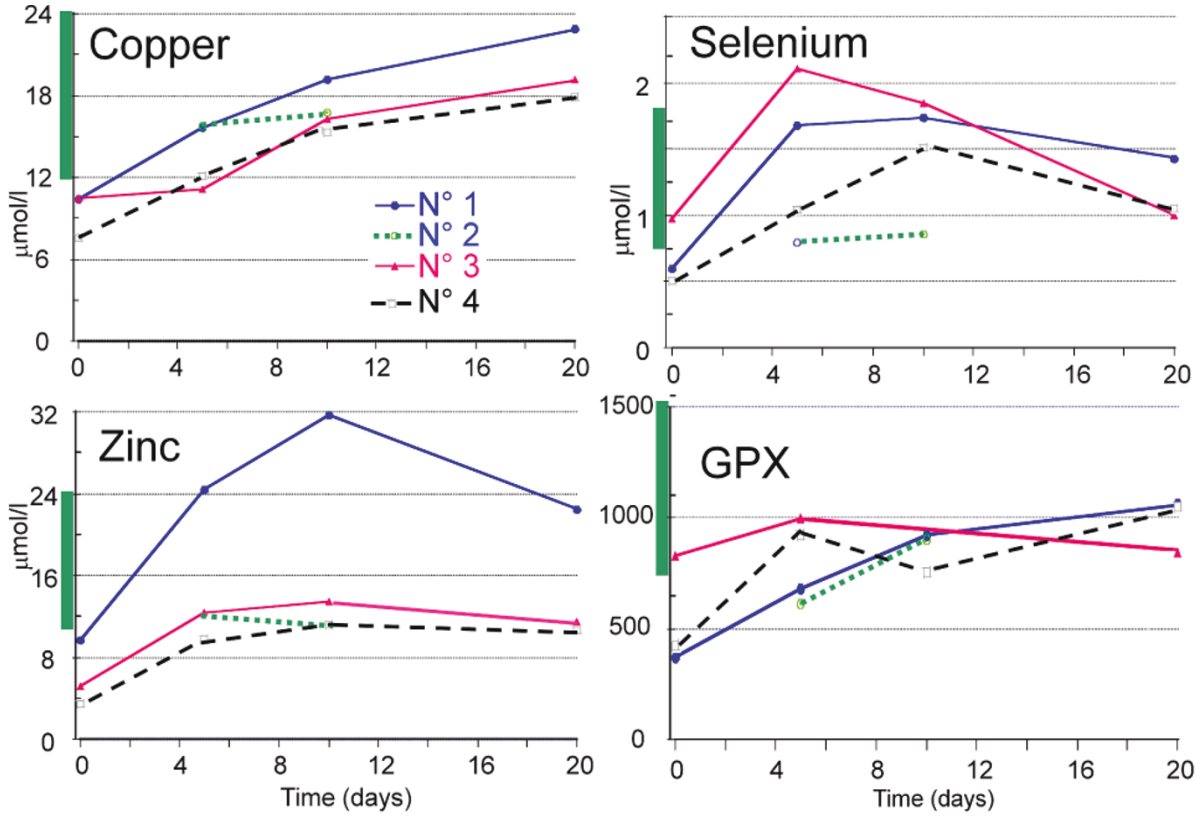

Figure 1. Evolution of copper, zinc, selenium and glutathione peroxidase (GPX) plasma concentrations over time. Low on admission, normalization was achieved by day 5 of the ICU stay. The green bars on the left side of the y-axis show the respective reference values.

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