ASPECTS OF TREATMENT*

A burn formula in clinical practice

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Summary

In a retrospective review of the 10-year period 1969–78 the intravenous plasma loads given to patients admitted to one burn centre were studied and compared with the volumes predicted by the formula used at that centre. Of 1728 patients admitted 342 (19.8%) received intravenous resuscitation with plasma. The formula appeared to be a good empirical guide to transfusion needs in the 36 h after burning. Patients with burns in excess of 45% body surface area (BSA), and particularly children, were likely to require more fluid than that indicated by the formula estimate. However, as burns in excess of 50% BSA are uncommon (50/1728 admissions) it seems reasonable to use a formula which is a guide to the probable needs of most patients while accepting the clinical response as the best means of assessing the actual fluid need of each patient, especially those with extensive injury.

Introduction

Although many formulae exist to guide the clinician as to the likely fluid needs of the burned patient, there have been few reports relating the predicted formula volume to the actual amount of intravenous fluid given in the resuscitation period following burn injury.

While there is no doubt that the development of infusion regimens for correcting the hypovolaemia resulting from burn injury has been one of the most significant advances in burn care during the past four decades, there exists as yet no agreement as to the most appropriate volumes or types of fluid to be administered during the resuscitation period *(1–7)*. Ideally a fluid infusion regimen must restore the efficiency of the circulation, so avoiding secondary damage to other organ systems from poor perfusion but without giving rise to a debilitating and sometimes life-threatening fluid overload. In view of the obligatory antidiuresis and sodium retention that follow trauma *(8–10)* and the extensive alterations in vessel wall permeability which result from burn injury there is some doubt that the physiological mechanisms regulating the volumes of body fluid compartments will function normally. All the initial reactions to burn injury and fluid infusion will tend to promote interstitial tissue oedema.

The approach to burn resuscitation at the Wessex Burn Centre for more than 15 years has laid emphasis on avoiding the dangers of fluid overload. This has been achieved with a relatively low-volume, simple regimen derived from empirical observations of the clinical response of patients to intravenous plasma therapy. The concept of limiting intravenous fluid resuscitation in the immediate post-burn period is not new. Cope and Moore *(11)* considered fluid infusion up to 10% of body weight to be adequate for successful resuscitation while at the same time avoiding fluid overload, while Kyle and Wallace *(12)*, using plasma and saline, and Evans *(13)*, using dextran, set a ceiling figure of 10% of body weight for infused fluid in the 48 h following burning. Wilkinson *(14)* also advised limiting colloid therapy in burn treatment and emphasised that antidiuresis is to be expected after trauma, indicating that a low urine output per se in the early post-burn period cannot be reasonably equated with inadequate resuscitation. Since the assessment of response to fluid resuscitation at the Wessex Regional Burn Centre differs from other well-established regimens we have examined the fluid input and mortality records from this centre on a retrospective basis for a 10-year period to assess the value of the formula guide in practice.

Policy of treatment

This has been detailed previously *(7)*. Plasma transfusions are usually given to children (0–14

The Editor would welcome any observations on this paper by readers
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years) with burns exceeding 10% body surface area (BSA) and adults with burns exceeding 20% BSA. Initial guidance on the transfusion needs of individual patients is often given to the referring hospital by telephone so that infusion at an appropriate rate may proceed during transfer. Even from the farthest parts of the Region (population 2.7m) it is unusual for transfer to take more than 2 h, but despite this commencement of fluid therapy before transfer is advised. On admission the patient is weighed and his or her blood volume calculated as 7.5% of body weight. Empirical observations had initially suggested that for successful resuscitation patients rarely required more intravenous plasma than the equivalent of their own blood volume during the 36 h following injury. Therefore the individual's blood volume is considered the likely upper limit of transfusion needed during the resuscitation period. The calculated blood volume is divided into three equal parts, one third being allocated to the first 8 h after burning (given as plasma*), one third for the next 12 h, and the final third for the period 20–36 h. While these volumes are meant to represent the upper limit of transfusion in each period, in order to avoid the dangers of fluid overload (especially in those patients at the extremes of age) the actual amount administered is governed by *the clinical response of the patient*. An adequate response to therapy is seen as a falling pulse rate which becomes steady and with a good volume coupled with good cerebral orientation and lack of restlessness and a well-perfused peripheral circulation as judged by skin colour and temperature. Hourly urine volume and central venous pressure measurements are not considered vital for assessing response and because both pose infection hazards they are not used to monitor resuscitation. Renal function is gauged by estimation of urine osmolality and sodium concentration. In addition to intravenous fluid, patients are allowed to drink as thirst demands, usually from the time of admission.

Method of study

A retrospective review of acute burn admissions from 1969 to 1978 was carried out. Case notes and fluid charts were studied to determine the amount of fluid received by patients during the resuscitation period by both parenteral and oral routes. Postmortem reports for all patients who died were also studied.

*Reconstituted freeze-dried plasma was used initially but was replaced by plasma protein fraction (PPF) in the early 1970s. However, despite this the formula estimates have not required revision.

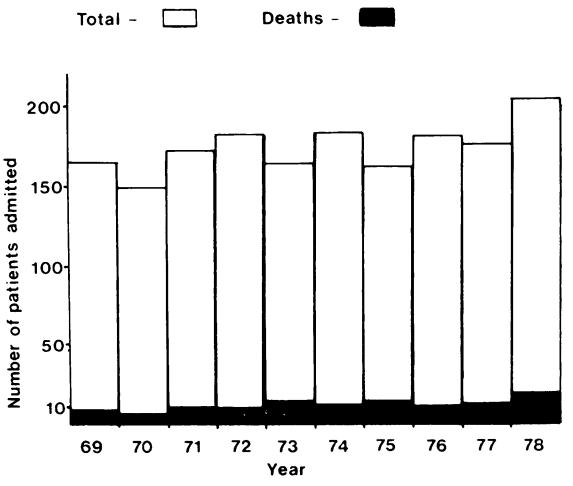

FIG. 1 *Annual admissions for acute burn injury, Wessex Regional Burn Centre, 1969–78*

Results

During the 10-year period there has been a gradual increase in the annual number of admissions to the centre (Fig. 1). Of 1728 patients admitted 119 (6.9%) died, most (80 (67%)) being over 60 years old even though patients in this age group accounted for only 16% of all admissions. Seventy-seven (64.7%) of the deaths occurred in patients requiring intravenous resuscitation, 32 of them within 3 days of injury (mean BSA burned 55%, mean age 54 years, over half (17) being over 60).

Four hundred and one patients (23.2%) were judged to have sustained a burn injury of a size likely to require transfusion (Table I), and of these patients 343 (85.5%) were admitted within 5 h of burning.

Fifty-nine patients in fact received no transfusion (48 were children with burns affecting 10–12% BSA who were adequately managed with oral fluids alone). Eighty-five patients had incomplete charts owing either to delayed admission, when the amount of fluid received was in doubt, or to the patient having died during the resuscitation period. Thus of 342 patients receiving plasma resuscitation 257 (75%) had complete fluid input records for study.

TABLE I *Patients judged to have sustained burns of a size requiring intravenous resuscitation—401 patients (23.2% of admissions).*

Age group	*Total*	*Deaths*	*Mortality*
0–14 years	247	12	4.9%
15–60 years	105	21	20.0%
Over 60 years	49	44	89.8%
Total	401	77	19.2%

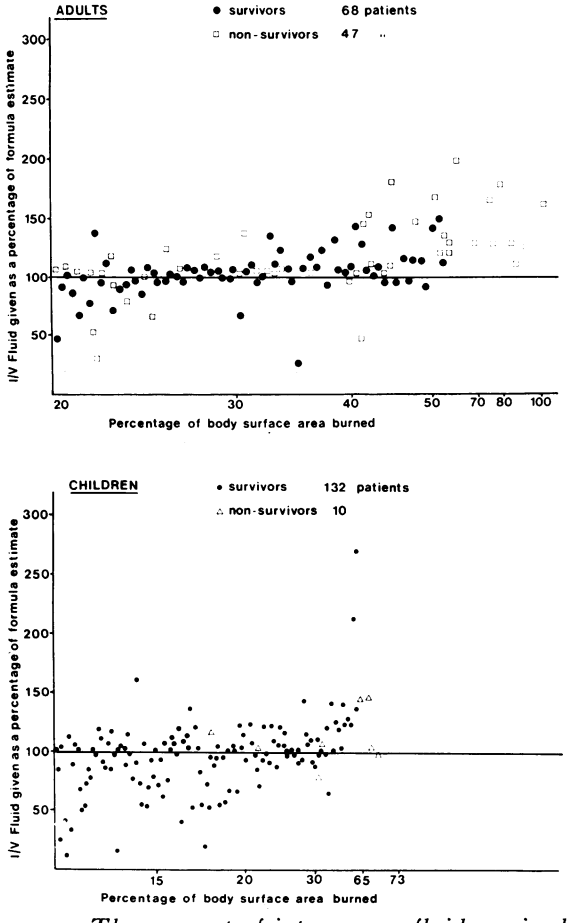

FIG. 2 *The amount of intravenous fluid received by adults (above) and children (below) during the resuscitation period expressed as a percentage of the formula maximum calculation (blood volume) represented by the 100 mark on the vertical axis. The relationship of fluid received to the percentage BSA burned is shown.*

ADULTS

In the adult group 47 non-survivors (mean BSA burned 44%, mean age 65 years) received on average 18% more plasma than the formula estimate compared with 68 survivors (mean BSA burned 33%, mean age 34 years) who received 2% more fluid on average than the formula estimate (Fig. 2). Mean oral fluid intake for the non-survivors was 1.1 l/24 h compared with 2.1 l/24 h for survivors. Vomiting occurred in 33% (38/115).

CHILDREN

Ten non-survivors (mean BSA burned 55%, mean age 5 years) received on average 20% more plasma than the formula estimate, whereas 132 survivors (mean BSA burned 20%, mean age 3 years) received on average 4% less plasma than the formula maximum calculation (Fig. 2). Mean oral fluid intake was 1.0 l/24 h for children in both groups. Vomiting affected 13.4% (19/142).

In both adults and children the episodes of vomiting were often single and the fluid loss small. Only 4 patients required fluid replacement specifically to compensate for loss from vomiting.

In the 10-year period only 50 (2.9%) of the patients admitted had suffered a burn injury of more than 50% BSA and of these 32 (64%) died.

Acute renal failure and pulmonary oedema are usually considered major complications of burn injury. In this series only 4 patients developed acute renal failure (Table II), while acute pulmonary oedema was considered to be the cause of death in 3 patients (2.5% of deaths).

Discussion

The various formulae available provide valuable guides to the possible intravenous fluid needs of burned patients. However, the recommended volumes and types of fluid vary widely *(1–7)*. Many formulae initially assess intravenous fluid needs on the basis of body weight and % BSA burned and therefore the amount of fluid considered necessary for resuscitation will tend to rise in proportion with the extent of the burn. However, once the initial guide has been calculated the amount of fluid given to the patient is judged on the response to treatment. Reports from centres using measurements such as hourly urine output and central venous pressure in addition to the clinical response of the patient have shown that the Brooke formula (Ringer lactate, 2 ml/kg/%BSA/24 h) may be exceeded by 40% *(15)* and the Muir and Bar-

TABLE II *Acute renal failure in 4 patients*

% BSA burned	*Sex*	*Age (years)*	*Type*	*Interval: burn–death*	*Existing disease*
18%	M	49	Oliguric	28 days	Cirrhosis
36%	F	78	Non-oliguric	7 days	Haemolytic anaemia
45%	M	60	Oliguric	7 days	—
95%	M	19	Non-oliguric	6 days	—

clay formula (PPF, 2.5 ml/kg/%BSA/24 h) may be exceeded by 33% *(16)*.

In this series, in which the calculated blood volume was considered to be the likely maximum plasma transfusion need in the 36 h after burning and the actual amount of colloid administered was determined by the clinical response of the patient alone, it seemed that, for adults and children who survived, the mean volume of plasma actually required approximated closely to the estimate. The 18–20% more plasma required by the non-survivors is in part a reflection of the larger fluid needs of patients with more extensive burns—44% BSA in adults, and 55% BSA in children. Although 44% BSA may be regarded as a burn from which recovery should be expected in the majority of otherwise fit younger patients, it should be noted that here the mean age for the adult non-survivors with a mean burn area of 44% was 65 years. Indeed, several series have shown that once patients reach the age of 65 the chances of surviving a burn of even 13–17% BSA are only 50:50 *(17–19)*. The figures from this survey show that some children with burns of over 50% BSA seem to require 2–3 times their blood volume as plasma in the resuscitation phase.

Because patients with more than 50% BSA burned made up only 2.9% of all admissions and 14.6% of all patients receiving transfusions in this series it seems reasonable to use a formula which assesses fairly accurately the needs of the majority of patients, who will have sustained lesser burns. It is equally important that the large fluid needs of patients with extensive burns are appreciated and that resuscitation should be based closely on the clinical response; this is of paramount importance in the very young and the very old, who will constitute a substantial proportion of admissions.

The work presented here reflects 10 years of burn care and we wish to acknowledge the work of the medical and nursing staff of the Burn Centre over that period. It is a pleasure to thank Dr P G Shakespeare for his constructive criticism and Mr R Conroy and the staff of the Photographic Department at Odstock Hospital for the photography of the illustrations.

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