THE RESUSCITATION OF BURNED CHILDREN*

BY

A. D. R. BATCHELOR

From the Royal Hospital for Sick Children, Edinburgh

Burns and scalds remain all too common injuries among children in this country. In any large series of burns in children two major groups are discernible: first the toddler of either sex who is particularly subject to scalds from hot water or tea; secondly, the 5-to-8-year-old, usually a girl, whose clothes catch fire from a naked flame. While the majority of these injuries fall into the 'minor' or 'moderate' categories, each year sees an appreciable number of children admitted with major burns. In the most severe cases, survival for a week or two may represent our present therapeutic limit. Many others will spend long weeks or months in hospital, to emerge once more with an intact skin covering after what can only have been, for a young child, an emotional and physical ordeal. If the coping stone of ultimate recovery is to be reached the foundations must be truly laid, and it is this early fundamental care that forms the subject matter of this presentation.

Burns Shock

Pathology. Rational therapy stems from an understanding of the pathological processes at work. The application of heat to a cutaneous surface damages or destroys the integument and the underlying vascular network. The permeability of the capillary wall is increased, or coagulation *in situ* of the capillary and its contents may result where the heat source is intense or its action prolonged. Through these damaged capillary linings a plasma-like fluid passes out into the extravascular space. The avenues of return to the bloodstream cannot cope with this flood and the fluid accumulates in and around the involved parts of the body. This process begins shortly after injury, is maximal in the first six to 12 hours, slowly diminishes up to 36 hours, and the oedema fluid is thereafter gradually reabsorbed. The protein content of this fluid is commonly of the order of 5 g. % and its electrolyte pattern is that of plasma. In deeper burns, where the vascular damage is greatest, red cells are destroyed either immediately at the site of injury or by

lysis of damaged erythrocytes in the reticulo-endothelial system.

Physiology. The protein-rich transudate acts like a leech upon the general circulating plasma volume. The larger the area of the body burned the greater will be the shift from the intravascular compartment to the interstitial space, and to the exterior through the burned surface. The reduction in plasma volume is thus directly related to the size of the burn wound. In children, a critical area can be roughly defined. Should the surface area involved exceed this, then the body's compensatory mechanisms, supplemented by oral fluids, are unable to maintain an adequate circulating volume and the clinical picture of oligæmic shock develops. This 'critical' area ranges from 8 % of the body surface in the infant, up to 15 % in the 12-year-old child. These figures are lowered by such additional factors as long journeys to hospital, careless or prolonged handling of the patient, or any coexisting illness.

Treatment

The aim of treatment must be to maintain, or restore, the circulating volume within, or close to, normal limits. If oligæmic shock is apparent on admission urgent intravenous therapy is imperative. Should the circulation be found adequate a more detailed assessment of the size of the injury is called for. In this latter group some will be found to have sustained a burn above the critical area, and intravenous therapy should be started to prevent the onset of shock.

Type of Fluid. Plasma or a plasma expander forms the basis of therapy. Reconstituted dried plasma has a protein concentration of approximately 5 g. %, closely comparable to the oedema fluid which it replaces. In extensive full-thickness burns, red cell destruction may diminish the red cell volume by 10 to 20 %, and early replacement of this deficit by whole blood transfusion is both rational and rewarding (Raker and Rovit, 1954).

Rate of Administration. During the early hours after injury, when the fluid loss is rapid, replacement

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must keep pace. The necessary rate of infusion slowly declines from this peak until, towards the end of the second 24 hours, no further colloid infusion will be found necessary. Should infusion be delayed by a lapse of several hours, a really fast rate of replacement must be obtained. For this purpose the veins of the upper extremity are superior to the more customary internal saphenous vein, and a polythene cannula provides the most reliable channel.

Volume of Infusion. No hard and fast figures can or should be given as to the volume of plasma necessary in any one case. The amount must vary according to the size of the patient and the extent of surface burned. The former is gauged by weighing on admission, the latter by reference to surface area charts (Lund and Browder, 1944). A rough estimate may be made that, throughout the whole shock period, up to 3 ml. of colloid solution may be required for each kilogram of body weight and each 1% of surface area burned. One half of this amount may be infused in the first 12 hours after injury. Oral fluids are only allowed when the circulatory state is satisfactory. Such fluids are given as sweetened water or tea, in amounts of from 30 to 60 ml. per hour according to the age of the child. Thirst is not an indication for increasing water intake and an excess water load after a major injury carries its own risk in view of the brake on renal water excretion exerted by the posterior pituitary gland.

Assessment of Response to Therapy

The most valuable test of the response to treatment is a careful comprehensive examination of the patient, performed by an experienced clinician at frequent intervals. In the treatment of extensive burns it is neither advisable nor feasible to lay down a proposed schedule of intravenous fluids for more than an hour or two in advance. The response to treatment is satisfactory when the child is warm, pink and quiet, possesses a normal peripheral capillary return and venous filling, has a firm, stable pulse and a systolic blood pressure of 100 mm. of mercury or more. Where shock is well controlled the child should not vomit unless a meal has been eaten just before the injury.

Valuable confirmation of clinical judgment is obtained from hourly estimations of the urinary output, obtained with the aid of an indwelling urethral catheter. In the first 24 hours urine volumes of not less than 8 ml. per hour in the infant, and not less than 20 ml. per hour in the 12-year-old child are considered adequate. A fall in the urine output is often one of the earliest signs that the infusion is not keeping pace with the loss from the circulation.

Serial estimations of the peripheral haemoglobin and haematocrit suffer from two main disadvantages; representing, as they do, a ratio, these tests are difficult to interpret where there has been much red cell loss, as in deep burns, or where whole blood has been given; moreover, alterations in their values, such as a rise in haemoglobin concentration, represent a change that has already occurred, an existing deficit, with the result that treatment based on these findings must lag at least one step behind the changing situation.

Renal Damage

In many extensive deep burns a temporary pink discoloration of the plasma will be found, if looked for, in the first hour or two after injury. The pigment responsible is methaemoglobin derived from destroyed red cells. Haemoglobinuria, clearly apparent to the naked eye as a chocolate-brown discoloration of the urine, will follow not infrequently. Where kidney function is normal large quantities of pigment can be successfully excreted. In the severe burn, however, two factors predispose towards renal damage from pigment; first, low renal blood flow and, therefore, hypoxia of the tubules, and, secondly, the maximal concentration occurring in the tubules under posterior pituitary influence. Under the combined weight of these adverse factors renal failure with oliguria or anuria then becomes established, the process being similar to the renal damage of the 'crush syndrome'.

In all deep burns of over 20% surface area, an indwelling urethral catheter should be utilized to give early warning of the appearance of pigment. Established shock must be treated with great urgency and an adequate circulating volume restored in the shortest possible time. This alone, by improving renal oxygenation, may be all the help that the kidneys require. In most cases, however, further measures are needed. The promotion of a diuresis will lower the concentration of pigment in the tubules, and thus allow the kidneys to clear themselves. Such a diuresis can only be produced in the post-traumatic phase by the addition to the glomerular filtrate of a substance which passes along the nephron unchanged and unabsorbed, carrying an additional volume of water with it. For this purpose both 'plasmosan' (poly-vinyl-pyrrolidone) and 15% 'mannitol' have been found effective. In any case showing heavily pigmented urine and a declining urinary output, in spite of restoration of an adequate circulation, 8 ml. of 'plasmosan' or 1 g. of 'mannitol' per kilogram of body weight should be given intravenously over 10 to 15 minutes. Where treatment has been prompt a rapid response can be

expected. The urine output climbs sharply and serial specimens show progressive disappearance of pigment (Dudley, Batchelor and Sutherland, 1957).

Local Care

The treatment of the burned surface is beyond the scope of this short paper but reference must be made to the necessity for careful timing of such treatment. No definitive local care is permissible until the circulation has been stabilized at a satisfactory level for at least an hour. Failure to observe this simple rule

will predispose to the reappearance or intensification of shock.

In conclusion, it should be stressed that there is no area of surface involvement too great to permit successful resuscitation. In the absence of respiratory tract injury early, vigorous and meticulous treatment will ensure the survival of the child beyond the phase of oligæmic shock.

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