RENAL FUNCTION AND RENAL FAILURE IN SEVERELY BURNT PATIENTS

J. S. CAMERON, C. M. H. MILLER-JONES and J. R. TROUNCE
Guy's Hospital, London, S. E. 1, Great Britain

Although most series report on one or two cases of renal failure in burnt patients (Shackman, Struthers & Milne, 1960; Lunding, Steiness & Thaysen, 1964) there are very few papers dealing with the topic exclusively (Graber & Sevitt, 1959; Dudley, Batchelor & Sutherland, 1957; Creyssel, Deleuze, Gate & Caillard, 1961; Proyard & Cuypers, 1963) and almost nothing on the role of dialysis (Goldsmith, Nakamoto & Kolff, 1960; Goldhahn 1960). The reported mortality in this group approaches 100%, only three cases, two electrical burns, having survived (Stephens & Stewart, 1965; Alwall & Kjellstrand, 1965). A few patients survive renal failure, only to die later of other complications.

628 Burns 1953 - 65

Fig. 1. All burns admitted to the Children's Burns Unit, Guy's Hospital, 1953/65, showing the percentage Body Surface Burnt (% B.S.B.) and deaths, with and without uraemia (blood urea above 100 mg/100 ml).

Fig. 2. Peak blood ureas in 22 fatal and 32 non-fatal burnt patients (some of the fatal cases were dialysed).
Fig. 3. Urine outputs of 26 children with more than 15% B.S.B. whose blood urea never exceeded 100 mg./100 ml. Data from adults is essentially the same.

Fig. 4. Urea outputs of 9 children with more than 15% B.S.B. whose blood urea never exceeded 100 mg./100 ml. Data from 6 adults is included for comparison.
The patients studied here were drawn from 628 burnt children admitted to the Children's Burns Unit at Guy's Hospital between October 1954 and January 1965 (Fig. 1). A number of cases of renal failure were studied retrospectively from before 1963, and for two years a study of all patients with more than 15% B.S.B. (body surface burnt), with or without renal complications has been conducted.

Of all burns, death in uraemia is uncommon (15 of 628 = 2.4%). But of burns exceeding 15% B.S.B. the proportion is quite high (15 of 94 = 16%). The peak blood urea reached in 22 fatal burns and 32 controls whose burns ranged from 15 to 65% are shown in Fig. 2. Virtually all patients whose urea did not exceed 100 mg % had other specific pathology, e.g. pulmonary burns due to inhalation of hot gases. Uraemia in burnt patients could arise from:

1. Overwhelming production of urea from breakdown of burnt and infected tissue.
2. A decrease in filtering surface.
3. Qualitative alterations in tubular function or
4. Combinations of these.

**RENAL FUNCTION IN NON-URAEMIC PATIENTS**

We set out to study the urine outputs, urea excreted and urea clearance, creatinine and P.A.H. clearances in these severely burnt patients, to define what renal abnormalities accounted for the uraemia.

![Graph](image)

*Fig. 5. Data from a patient with 17% B.S.B. flame burn whose course was entirely without incident. The course of the urine output (ml/day), urea clearance ($C_{\text{urea}}$), creatinine clearance ($C_{\text{cr}}$), blood urea and plasma $K^+$ are indicated. The 'expected' glomerular filtration rate in this and subsequent figures is derived from the data of Rubin, Bruck, and Rapoport (1949).*
Fig. 6. Data from a patient with 45% B.S.B. flame burn and greater constitutional disturbance. In this patient P.A.H. clearances were also measured during the period that the intravenous infusion was in place.

The urine outputs of 27 patients with more than 15% B.S.B. whose ureas never rose above 100 mg% are shown in Fig. 3. There is an initial oliguria which has also been noted by Batchelor, Kirk & Sutherland (1961) and others. This trend was also present in data from adult patients.

The urea outputs of 9 children whose ureas never rose above 100 mg% are shown in Fig. 4, compared with similar data from 6 adults. The urea excretions are very large, up to 100 g urea/70 kilos/day, but the kidneys of these patients were able to excrete this urea load successfully, with only transient mild rise in blood urea in some cases.

Fig. 5 shows data from an ‘uncomplicated’ patient (17% B.S.B.) with an ideal post burn progress. Even here the G.F.R. (creatinine clearance) and the urea clearance were initially depressed and rose slowly to normal levels.

Fig. 6 shows data from a more extensively burnt child (45% B.S.B.) who did not become uraemic. Again there is a rapid fall of G.F.R., urea clearance and P.A.H. clearance to very low levels. Neither of these patients was hypotensive or oliguric at any time. Microscopic haematuria has also been an almost constant feature of these severe burns, in addition to the occasional more familiar haemoglobinuria.
Fig. 7. Data from a very severely burnt patient with oliguric renal failure and spontaneous recovery.

THE URAEMIC PATIENTS

In 17 cases* the blood urea exceeded 100 mg.%, all but one died (see Clarkson, 1960). These fell into three groups:

1. Oliguric renal failure (5 cases)
   Two patients passed no urine at all from time of burn (60% and 95% B.S.B.) to death. The others showed varying degrees of oliguria (Fig. 7) immediately following the burn. This patient recovered from renal failure but died later of septicaemia.

2. Non-oliguric renal failure (6 cases)
   The existence of this type of renal failure has been emphasised by Graber and Sevitt (1959) and has been seen by other observers. This state consists of more than the inability of the kidneys to excrete a large urea load. An example is shown in Figs. 8 and 9. This child developed uraemia with a normal urine output. At that time also (i) the urine was dilute with respect to urea, (ii) was unaffected by intravenous mannitol, (iii) the G.F.R. was very low, (iv) the urine was loaded with granular casts and red blood cells. It seems reasonable to call this renal failure.

3. 'Delayed' renal failure (5 cases), Fig. 10
   Here there was usually transient early uraemia followed by apparent good renal function in terms of urine output and blood urea. G.F.R. and urea clearance, however, remained below normal or very low and death occurred after a week or longer with sudden deterioration into uraemia. This variety does not appear to have been noted before.

* One case since the analysis of 628 patients, 1953–1965.
Fig. 8. A patient (L.M.) with non-oliguric renal failure. Although a diuresis occurred on day 5, the urine output was in fact 'normal' on days 1-5, 'supranormal' subsequently (see Fig. 9).

Fig. 9. Urine output and urea excretion in the same patient (L.M.) compared with the normal values (± one standard deviation) established from control, non-uraemic burnt patients.
Fig. 10. Shows 'delayed' renal failure. The G.F.R. in this patient was not so depressed from day 1 to day 10 as in most other patients in this group. Note the close correspondence between \( C_{cr} \) and \( C_{urea} \).

**DIALYSIS**

Dialysis is difficult in burnt patients because of the burnt infected skin. With flammable burns, the hands and wrists are usually involved in attempts to put the flames out, and very extensive burns affect the groins and abdomen. We have only dialysed three patients, all of whom died. From experience with the most recent of these it is possible to control the blood urea even at the peak of urea production (9-14 days) by continuous peritoneal dialysis. Exchange transfusion (Fig. 8) may have a place in small children.

**CONCLUSIONS**

1. All patients with severe burns have a very reduced G.F.R.
2. The urea output, or better the urea clearance, are guides to early diagnosis of the renal failure; the urine output may mislead.
3. Renal failure in severely burnt patients is frequently not accompanied by oliguria.
4. Dialysis in burnt patients with renal failure is difficult and infrequently performed. From limited experience continuous peritoneal dialysis has much to offer.

5. Almost all patients who become uremic (100 mg.% and above) after burns, irrespective of renal function, will eventually die.

REFERENCES


