Tropical parasitic nephropathies

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Introduction

Parasites constitute an important ally in the rich tropical and subtropical bioecology, mainly due to the prevailing climatic conditions, socio-economic standards and lack of adequate preventive health care programmes. Despite their general epidemiological significance, their impact on nephrological practice has been overlooked for many decades, largely as a result of the lagging standard of the specialty in endemic areas.

Nevertheless, parasites emerged in recent years as important agents that may cause opportunistic infections in the immunocompromised. Of particular importance in this respect are cryptosporidosis [1], toxoplasmosis [2], leishmaniasis [3], trypanosomiasis [4] strongyloidiasis [5], malaria [6] and schistosomiasis [7]. These infections may be either acquired *de novo* (e.g. toxoplasmosis, and malaria) or a dormant infection may be activated as a result of immunosuppression (e.g. cryptosporidosis and strongyloidiasis).

Parasites have also proven to be useful laboratory tools in experimental immunology, particularly when it comes to addressing the monocyte, the principal cell involved in the innate defence against parasitic infections. Parasites have been particularly useful in developing certain concepts such as the up-regulation of monocyte function by granulocyte–macrophage colony-stimulating factor (GM-CSF) (using trypanosomes) [8], their down-regulation by antigen (using *Leishmania* [9] and *Schistosoma* [10]), phospholipids (using *Ecchinococcus*) [11], interleukin-10 (IL-10) (using schistosomes [12]) and others. Despite their clinical and academic significance in nephrology, the mentioned aspects of parasitic disease are not the objective of this review. In the following pages, I focus on parasites as agents causing renal disease, an issue that may have considerable epidemiological importance in tropical and subtropical regions, but may also have some sporadic clinical relevance even in non-tropical territories.

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Epidemiological significance

It was only natural that the epidemiological impact of parasitic infections was recognized initially in acute renal failure. Not unexpectedly, the first reports came up from South East Asia [13], where up to 18.5% of acute renal failures (38.5% of those due to medical causes) are attributed to *Plasmodium falciparum* infection. Infection with the same parasite has been associated with acute renal failure in other parts of the world, such as India, Nigeria, Singapore and Brazil. Yet the incidence of this complication is much lower than in Thailand, which remains the leading country in this feature for reasons which are unclear.

The epidemiological significance of chronic parasitic infection is increasingly recognized [14], and has already established firm grounds in two diseases, namely malaria and schistosomiasis. That chronic malaria can lead to chronic renal disease was hinted at in the Hippocratic scripts, 400 years BC [15]. Bright's disease was attributed to chronic infection with *Plasmodium malariae* in 1884 [16]. The term 'malarial nephritis' was introduced ultimately by Giglioli in British Guyana [17], and its epidemiological significance among Nigerian children was appraised in the early 1960s [18]. The population density as well as the high prevalence of infection in endemic areas has resulted in the notion that malaria is the most common cause of secondary nephrotic syndrome worldwide (Figure 1). Although the exact contribution of quartan malarial nephropathy to the general prevalence of chronic renal failure is ill-defined, there has been considerable regression in this parameter following successful malarial control programmes in several African countries, most notably in Uganda [19].

The role of schistosomiasis in the prevalence of end-stage renal disease (ESRD) is species-dependent, and is geographically variable. *Schistosoma hematobium*, present only in Africa (Figure 1), is reported to lead to lower urinary tract morbidity, ranging from in 2% of infected subjects in Nigeria, to 52% in Tanzania [20]. Upper urinary tract pathology varies from 9.7% in the Niger to 48% in Cameroon [20]. Urinary schistosomiasis is blamed as the principal aetiology in 20% of patients on regular dialysis in Egypt [21]. *Schistosoma mansoni* is more widely spread (Figure 1),
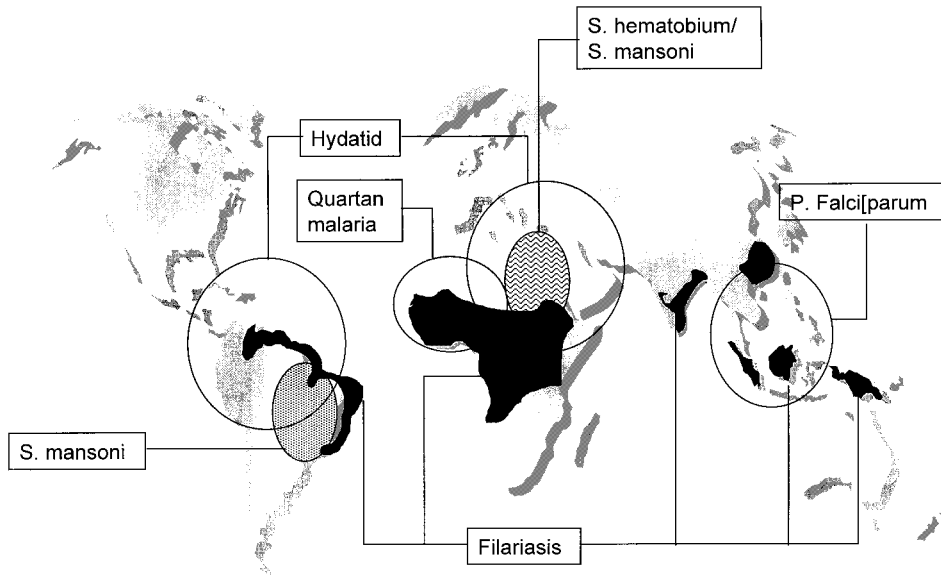
Fig. 1. Worldwide distribution of epidemiologically significant parasitic nephropathies.

being encountered mainly in Africa, South America and East Asia. It eventually leads to periportal fibrosis and portal hypertension. About 15% of patients with this disease develop an immune-mediated glomerulopathy, usually referred to as 'schistosomal glomerulopathy', which often progresses to ESRD [22,23]. About 10% of patients on regular dialysis in Egypt attributed their condition to this syndrome [21].

Clinical profile

Parasitic nephropathies naturally fall into one or other of three categories: (i) acute renal injury caused by the systemic effects of severe infection; (ii) physical invasion of the urinary tract by the parasite; and (iii) renal injury caused by the host–parasite immune interaction.

Acute renal failure

Acute renal failure may be encountered in several parasitic infections, including those which lead to profound systemic illness, leading to acute tubular necrosis (e.g. falciparum malariae); those associated with acute interstitial nephritis (e.g. leishmaniasis) and occasionally those associated with the acute nephritic syndrome (e.g. trichinosis). The latter two categories are discussed under their individual headings.

Acute tubular necrosis

Falciparum malaria is associated with acute tubular necrosis in 1–4% of cases; the incidence being as high as 60% in 'malignant malaria' [24]. Intravascular red cell sludging, haemolysis and massive monocyte activation are the main pathogenetic mechanisms (Figure 2). Parasitized red cells show characteristic cell mem-

brane knobs [25] rich in sticky proteins such as PfEMP-1 (*P.falciparum* erythrocyte membrane protein) and the histidine-rich proteins HRP-1 and HRP-2 [26]. These bind to complementary sites on unparasitized red cells, platelets, monocytes and, most critically, the vascular endothelium. Such adhesion molecules, which are expressed as a consequence of antigen-induced monocyte activation, include P-selectins [27], intercellular cell adhesion molecule-1 (ICAM-1) [28], vascular cell adhesion molecule-1 (VCAM-1), thrombospondin, CD36 and chondroitin sulfate [26].

In addition, the effect of the parasitic agent on the monocytes leads to a cascade of mediator release very similar to that encountered in septic shock [29]. This leads to peripheral blood pooling, reduction of the effective blood volume and haemoconcentration. Diminished organ perfusion becomes exaggerated, including the kidneys, liver and lungs. The subsequent evolution of the morbid physiology is shown in Figure 3.

Acute renal failure in falciparum malaria is usually associated with the triad of jaundice, severe hyponatraemia and hypoglycaemia. Hyperkalaemia, hypocalcaemia, hypophosphataemia and severe acidosis are common features. Disseminated intravascular coagulation, coma and circulatory failure are terminal events [30].

Falciparum malarial ARF is a serious disease, which carries 15–30% mortality in most published series [30]. It is almost uniformly fatal when associated with 'black water fever', characterized by massive haemolysis that usually follows quinine therapy in patients with glucose-6-phosphate dehydrogenase (G6PD) deficiency. Haemodialysis is usually risky due to the associated circulatory insufficiency. Peritoneal dialysis is therefore used more frequently. The latter has the additional advantages of dealing more adequately with the hypercatabolic state, ameliorating hypoglycaemia, and being
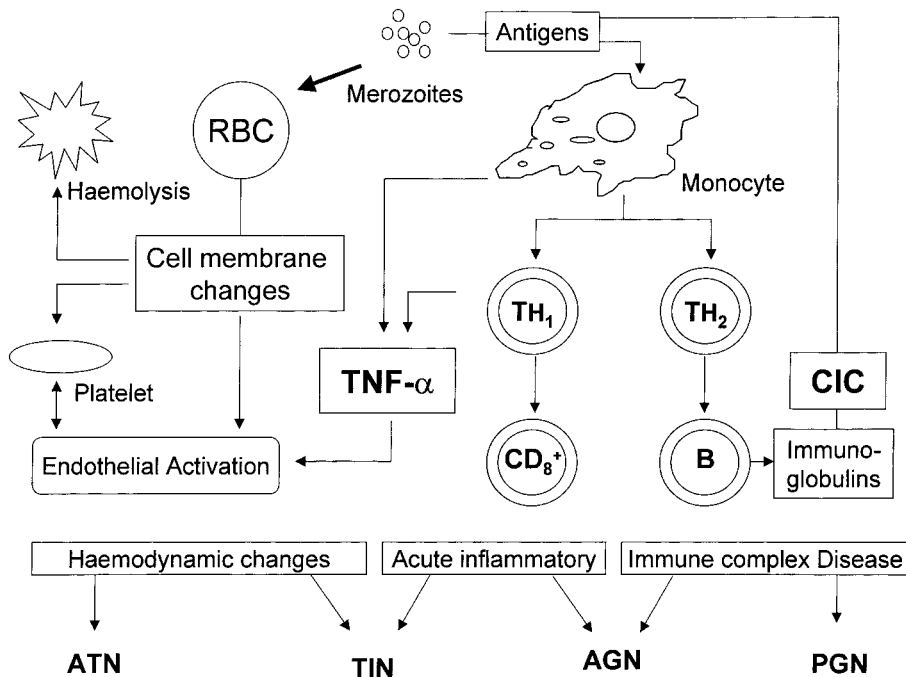
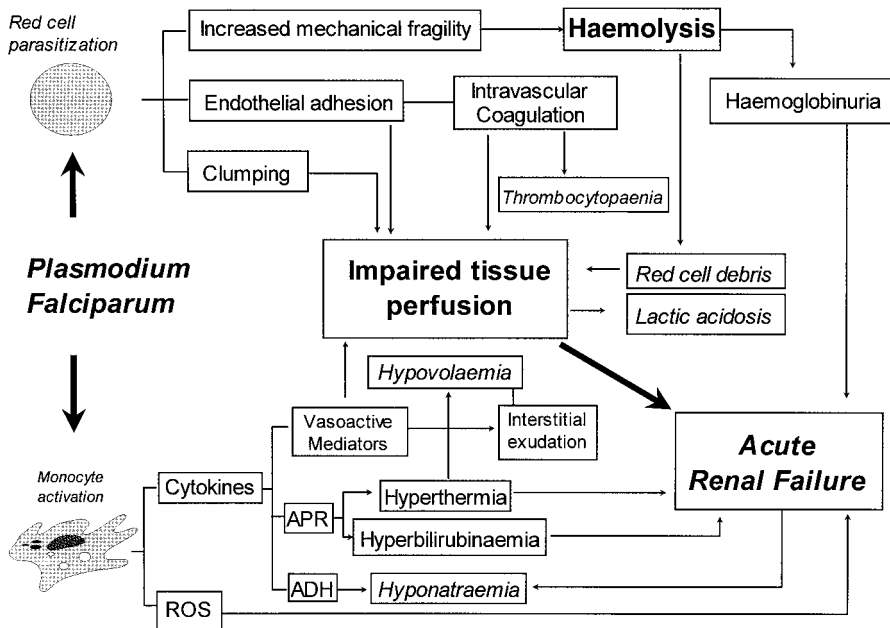**Fig. 2.** Mechanisms of *P.falciparum*-induced morbidity.

Fig. 3. Haemodynamic and metabolic abnormalities in malignant malaria. ARP = acute phase reactants; ROS = reactive oxygen substrate; ADH = antidiuretic hormone.

more readily available in endemic areas. Relatively good results have been reported with blood exchange and apharesis.

Another parasitic agent, *Babessia microfti*, morphologically similar to *P.falciparum*, is transmitted by a tick bite and exists mainly in Eastern Europe and South America. Infection with this parasite leads to fever, chills and malaise associated with nausea and arthralgias. A severe illness leading to acute renal

failure has been described in asplenic patients. It responds to clindamycin and in severe cases to quinine therapy [31].

Physical invasion

The urinary tract may be directly involved by deposition of parasitic products in only a few conditions,
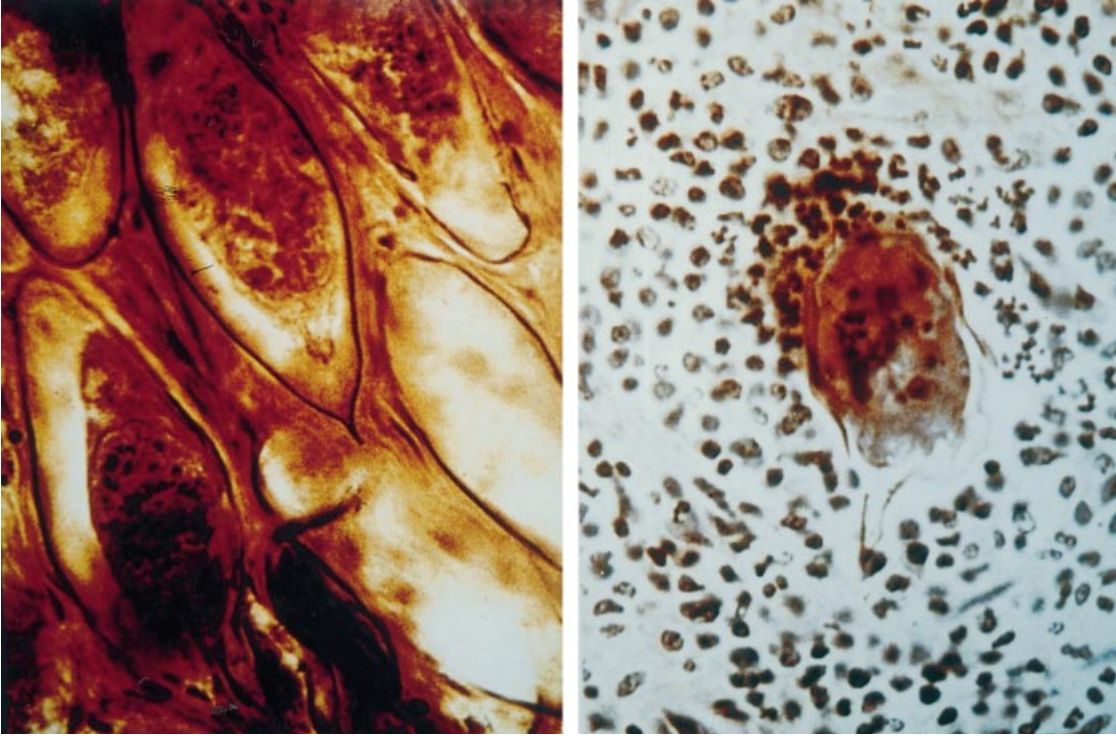
Fig. 4. *Schistosoma hematobium.* Left: cluster of ova with their characteristic terminal spikes. Right: typical schistosomal granuloma in the bladder submucosa, composed of monocytes, lymphocytes, granulocytes and fibroblasts around a distorted ovum.
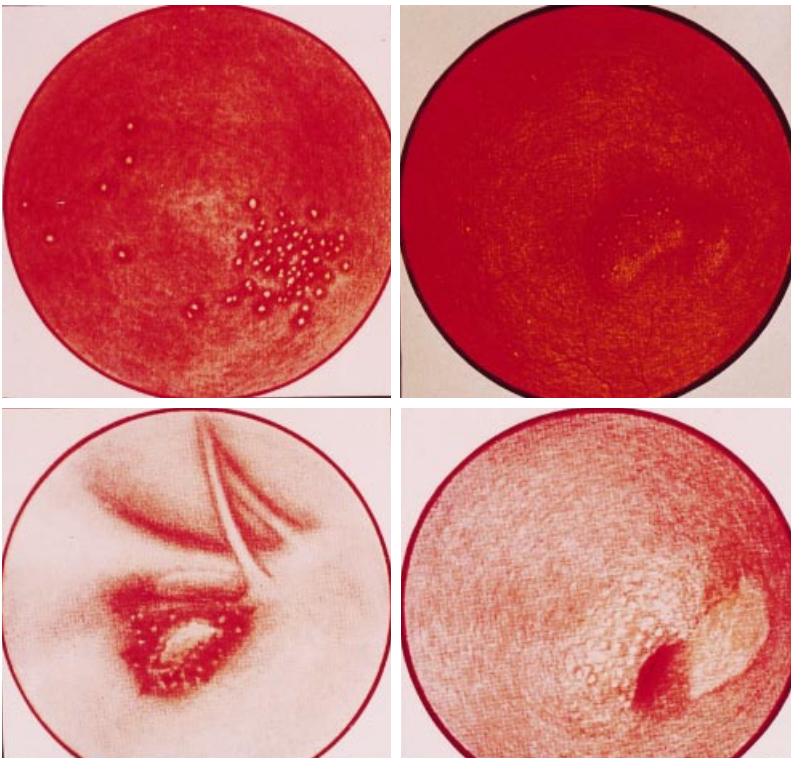

Fig. 5. Cystoscopic appearances in different stages of bladder schistosomiasis. Top left, bilharzial pseudotubercles; top right, tubercles and a sessile mass; bottom left, ulcer amidst pseudotubercles; bottom right, sandy patches.

the most significant being schistosomiasis (worms and ova), ecchinococcosis (cysts) and filariasis (adult worms).

Schistosomiasis

Schistosoma hematobium adult worms inhabit the perivesical venous plexus in couples. Females lay ova with terminal spikes, which excite a delayed hypersensitivity reaction leading to the formation of granulomata (Figure 4) mainly in the submucosa of the bladder, ureters, urethra and genital system. They coalesce to form 'pseudotubercles' that can be seen readily by cystoscopic examination (Figure 5). The overlying mucosa soon ulcerates, leading to the characteristic initial symptom of haematobiasis, painful terminal haematuria. Eventually, the granulomata heal by fibrosis and calcification, appearing as 'sandy patches' by cystoscopy, and as linear calcifications in plain radiograms. Healing may also generate small cystic lesions encrypting islands of bladder mucosa (cystitis glandularis) that may be almost totally atrophic (cystitis cystica). Cicatricial contraction of the healed lesions often encroaches on the ureteric orifices leading to partial obstruction, which may lead to upstream consequences including hydronephrosis, ascending infection and stone formation. Abnormalities of tubular function including salt loss and secondary tubular acidosis are fairly common, though frequently overlooked. End-stage renal failure eventually takes place as the interstitial and periglomerular fibrosis become sufficiently extensive.

One of the notorious complications of urinary schistosomiasis is the development of bladder malignancy. A causal relationship is established by an experimental model in the baboon [32] and by clear statistical correlation in humans [34]. Unlike the usual histological types, *Schistosoma*-associated bladder cancer is a squamous cell carcinoma, shows a distinct male predominance and is characterized by late and slow spreading, usually by local and/or lymphatic permeation [33]. Recent studies have shown oxidative stress-induced breakage of chromosome 1 in such patients [34], as well as mutation of the p53 suppressor gene [35], which suggests that impaired physiological apoptosis may be blamed.

Ecchinococcosis

The kidney may be the site of hydatid cyst formation in 2–3% of patients with ecchinococcosis [36]. Such cysts are often asymptomatic, unless they are located in critical sites leading to ureteric obstruction or vascular stretching.

Filariasis

Adult *Wuchereria bancrofti* worms, inhabiting the abdominal lymphatic system [37], may impair the renal lymphatic drainage ultimately leading to chyluria. This rare condition can be diagnosed readily by simple urine examination; the site of obstruction can be demonstrated by lymphangiography.

Immune-mediated parasitic nephropathies

The immune response to parasitic infections (Figure 6) is complex, involving natural host resistance, acquired host immunity and parasite-induced immunosuppression which is aimed at evading the host's response (concomitant immunity) [38].

The host tends to eliminate the parasite by innate mechanisms, which principally include monocyte phagocytosis, induction of natural killer cells and complement activation via the alternative pathways. Monocyte activation also leads to a cascade of acquired immune responses mainly initiated by activation of T-helper cells. The latter generally occurs in two phases: early Th_1- and late Th_2-dominated. The scenario is controlled by a number of monocyte-released interleukins including IL-1, IL-6 and IL-12 [39].

Th_1 activation represents a florid phase of the host's immune response. Thus, it provides a reaction amplification loop by enhancing the monocyte activity through the release of interferon-γ (IFN-γ). It also leads to activation of cytotoxic T-cells, eosinophils and basophils through several cytokines including Il-2, IL-13 and others. Th_2 cells, on the other hand, tend to suppress the immune response through the release of IL-4, IL-5 and IL-10 [40].

B-lymphocytes are also activated in two phases through the interaction of several cytokines. This reflects on the antibody profiles associated with parasitic infections, characterized by an initial predominance of those with high complement-fixing properties and late supremacy of blocking, and poor complement-affinity immunoglobulins [38]. Of particular importance in most parasitic infections is IgE, which is necessary for the eosinophil-mediated parasite killing by a process of antibody-dependent cell-mediated cytotoxicity (ADCC). Although this process is maintained as long as the parasitic infection persists, its activity is maximal during the initial phase. IgG_1 and IgG_3 are also important during the early phase, since they interact with complement in catalysing another cellular mechanism, namely neutrophil-mediated cytotoxicity (antibody and complement-dependent cytotoxicity 'ACDC') [38].

Complement activation occurs via both the alternative (innate effect of parasitic toxins) and classical (immune complex-mediated) pathways [38]. Late complement components are involved in the final elimination of parasitic antigens, as well as in the parasiticidal activity of neutrophils by a complement-dependent cell-mediated cytotoxicity (CDCC) mechanism.

Evasive mechanisms in concomitant immunity also include antigen variability within the same (e.g. trypanosomiasis) or successive (e.g. malaria) generations. Some parasites tend to blind the host to their own antigens by acquisition of host antigens (e.g. blood
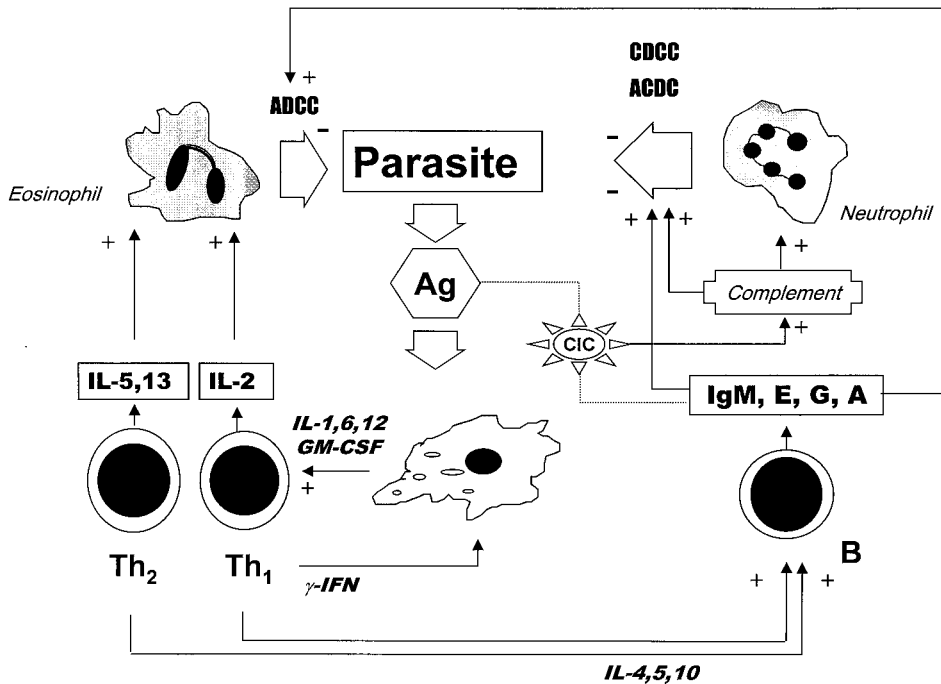
Fig. 6. Simplified diagram showing the principal immune mechanisms involved in parasitic infections. For explanation, see text.

group H substance or HLA antigens) within their tegument (e.g. schistosomiasis) [41]. Late and very late parasitic antigens have been shown to down-regulate the monocytes (e.g. leishmaniasis) [9]. Some recent data suggest that antigen excess may also be monocyte suppressive (schistosomiasis) [42]. Certain parasitic antigens tend to induce suppressor T-cell clones (schistosomiasis) by as yet poorly understood mechanisms.

The immune-mediated renal manifestations of parasitic infections closely reflect the whole scenario of concomitant immunity. They may be categorized into three distinct patterns, depending on the interaction between the florid immune activation dominated by Th$_1$ cells on one hand, and the modulated response dominated by Th$_2$ cells and other parasite's evasive mechanisms on the other.

Acute glomerular lesions

Many parasitic infections lead to acute or subclinical, self-limited glomerulopathy during the early phase of florid immune stimulation. Such glomerular lesions have been reported with schistosomiasis [43,44], malaria [45], filariasis [46], leishmaniasis [47], trichinosis [48], ecchinococcosis [49], toxoplasmosis [50] and trypanosomiasis [51]. With the exception of infection by certain strains of the former three parasites, glomerular lesions are generally characterized by mesangial proliferation with little matrix expansion, associated with mesangial immune complex deposits, which are composed mainly of IgM, complement and, occasionally, IgG. Parasitic antigens have also been detected variably in the mesangial deposits in most of these infections (Figure 7). Renal involvement is usually

clinically irrelevant, being overlooked within the context of the more overt manifestations of the primary disease. In occasional circumstances, however, patients may develop a classical nephritic syndrome (e.g. falciparum malaria [52] and trichinosis [48]) and display overt urinary abnormalities including proteinuria, microhaematuria and casturia (e.g. schistosomiasis haematobium [44] and ecchinococcosis [49]) or even the nephrotic syndrome (schistosomiasis haematobium [53]). In all cases, though, the lesions are self-limited, and almost never progress to ESRD.

Acute interstitial lesions

The prototype parasite-associated interstitial nephritis is that of Kala-azar. In this infection, caused by *Leishmania donovani*, the renal interstitium is heavily infiltrated with monocytes and lymphocytes, which clearly display an acute cell-mediated inflammation [54]. Many patients remain asymptomatic, apart from the constitutional manifestations of the primary disease. Others may display urinary abnormalities such as proteinuria, lymphocyturia and pyuria. Occasionally, renal function is impaired even with acute oliguric renal failure [55].

Interestingly, the infiltrating monocytes contain plenty of amastigotes which seem to survive happily within such potentially lethal cells. This kind of symbiosis animates the concept of concomitant immunity within the same cell. It is attributed to down-regulation of the monocyte function by leishmanial antigens [9], and is IL-10 mediated [56]. Lymphoid proliferation is impaired [57] and natural killer cells are inhibited [58]. It is this immune modulation that checks the progres-
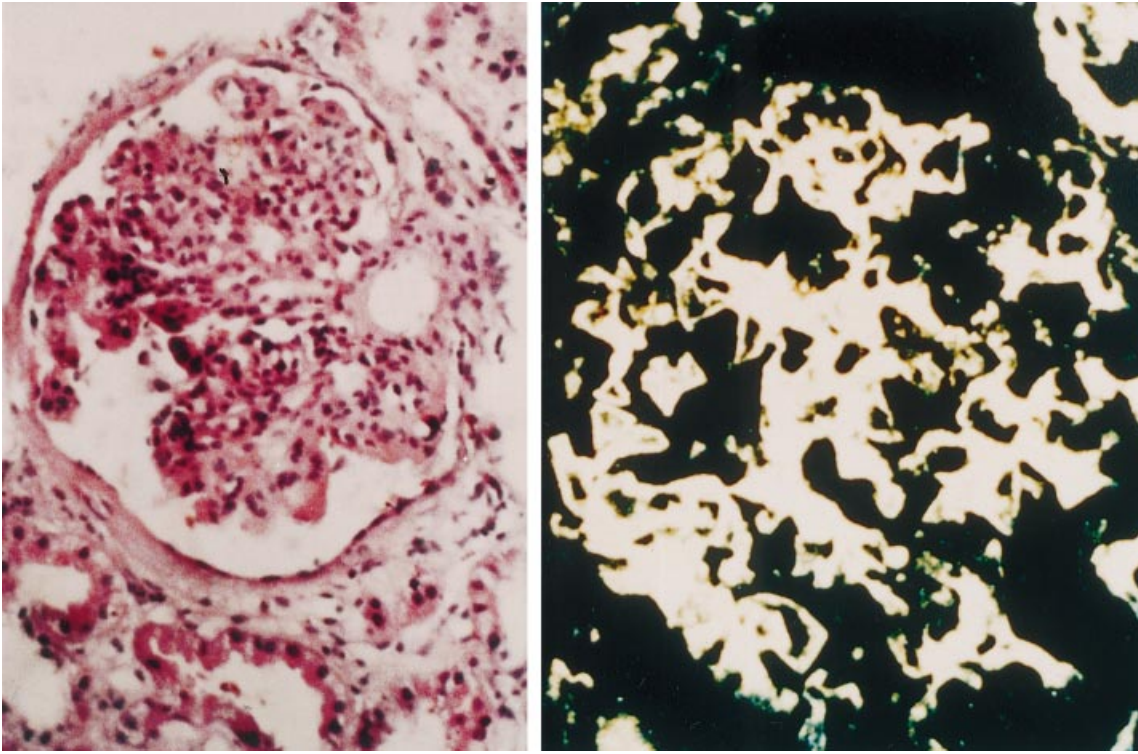
Fig. 7. Mesangial proliferative glomerulonephritis in *S.mansoni* infection. Schistosomal gut antigen deposits are shown by immuno-fluorescence.
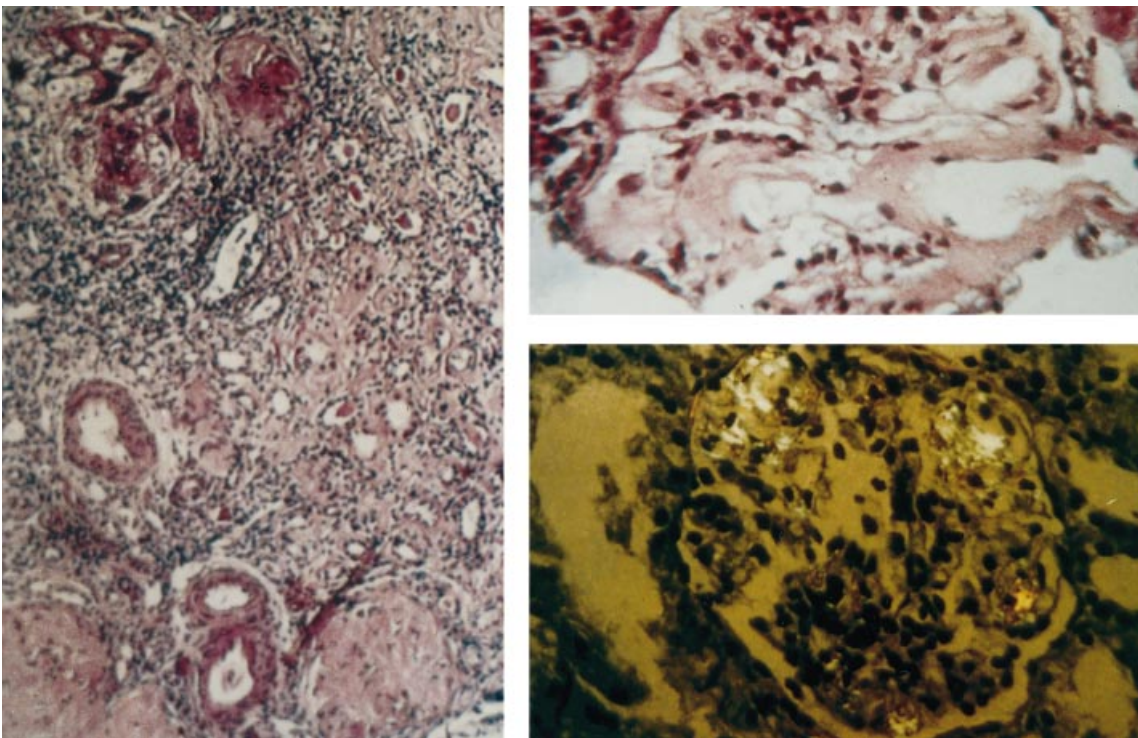

Fig. 8. Renal amyloidosis in schistosomiasis. Left: schistosomal granuloma (top), three glomeruli with extensive amyloid deposits (bottom) and dense interstitial infiltration and fibrosis (H&E stain). Top right: amyloid deposition in the mesangium associated with mild mesangial cellular proliferation (H&E stain). Bottom right: early amyloid deposits (seen as green birefringence) in the glomerulus with mesangial proliferation. (Congo Red stain—polarized light).

sion of Kala-azar interstitial nephropathy any further, and leads to spontaneous regression in almost all cases [58, 59].

Interstitial nephritis has also been described in experimental infection with *Schistosoma mekongi* [60]. Little is known about the natural history of this disease in humans.

Amyloidosis

Amyloidosis has been reported in a number of parasitic infections including shistosomiasis [61,62], filariasis [63], leishmaniasis [64] and ecchinococcosis [65]. The renal lesions vary from a few vascular or glomerular deposits seen only when searched for by special stains [66], to frank extensive disease with almost total replacement of the glomerular architecture [67] (Figure 8). Whenever reported, the amyloid protein detected was of the AA type, and involved other organs such as liver and spleen [66]. Most patients present with proteinuria, nephrotic syndrome and variable degrees of renal failure. The lesions do not seem to respond to specific anti-parasitic treatment [67].

The pathogenesis of parasite-associated amyloidosis (Figure 9) displays the full scenario of concomitant immunity. Whereas the immunostimulatory effect of parasitic antigens increases the hepatocyte synthesis of sAA protein under the influence of IL-1 and IL-6 [68,69], the down-regulated monocytes seem unable to clear this protein [70], thereby increasing its circulating blood level. Serum AA protein adheres to extracelluar matrix [71] and subsequently is transformed into the fibrillar form through the action of committed monocytes in the target tissues [72].

Progressive glomerulonephritis

As an exception to most parasitic nephropathies, glomerular disease associated with *S.mansoni*, quartan mal-

aria and *Onchocerca volvulus* tends to progress in a variable proportion of patients. In those cases, renal disease is usually associated with the nephrotic syndrome, hypertension and progressive loss of function. Glomerular lesions exhibit different patterns, mostly characterized by a mesangiocapillary or focal sclerosis pattern. In contrast to the simple glomerulopathy seen in other parasitic glomerulopathies, IgG or IgA tend to override the IgM deposits, parasitic antigens become only rarely detectable, and the deposits extend into subendothelial, subepithelial and intramembranous locations. These features have suggested to students in the field that pathogenetic mechanisms, other than simple deposition of parasitic antigens and immune complexes, must be involved.

Malarial glomerulopathy

This is a disease of children, usually ~ 5 years of age, who develop nephrotic syndrome as a consequence of quartan malarial infection. Renal biopsy (Figure 10) shows mesangial expansion with subendothelial immune complex deposits, mostly of IgG_3, C_3 and occasionally malarial antigens. The renal component of their illness is progressive, and does not respond to anti-malarial treatment, corticosteroids or immuno-suppressive agents.

Several studies have addressed the potential factors that select only a few infected children to develop renal disease. Concomitant infection with other agents has been suggested [73]. HBV, which is highly prevalent in endemic areas, is an eligible candidate [74] supported by experimental data in marmosets [75]. Other studies have produced evidence that autoimmunity may play an important role in the progression of malarial nephropathy [76,77]. Genetic predisposition has also been suggested [73].
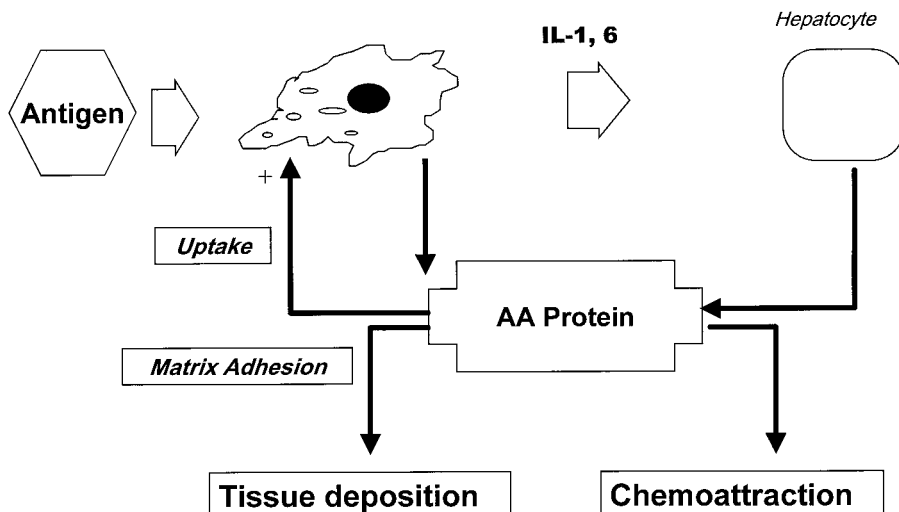

Fig. 9. Pathogenesis of schistosomal amyloidosis. The monocyte continues to release IL-1 and IL-6 under the influence of schistosomal antigens. These stimulate the hepatocytes to release AA protein, which has a distinct chemoattractant function. The monocyte is the normal scavenger of serum AA protein, a function that is impaired in hepatosplenic schistosomiasis. Serum AA protein accumulates and tends to deposit in tissues.
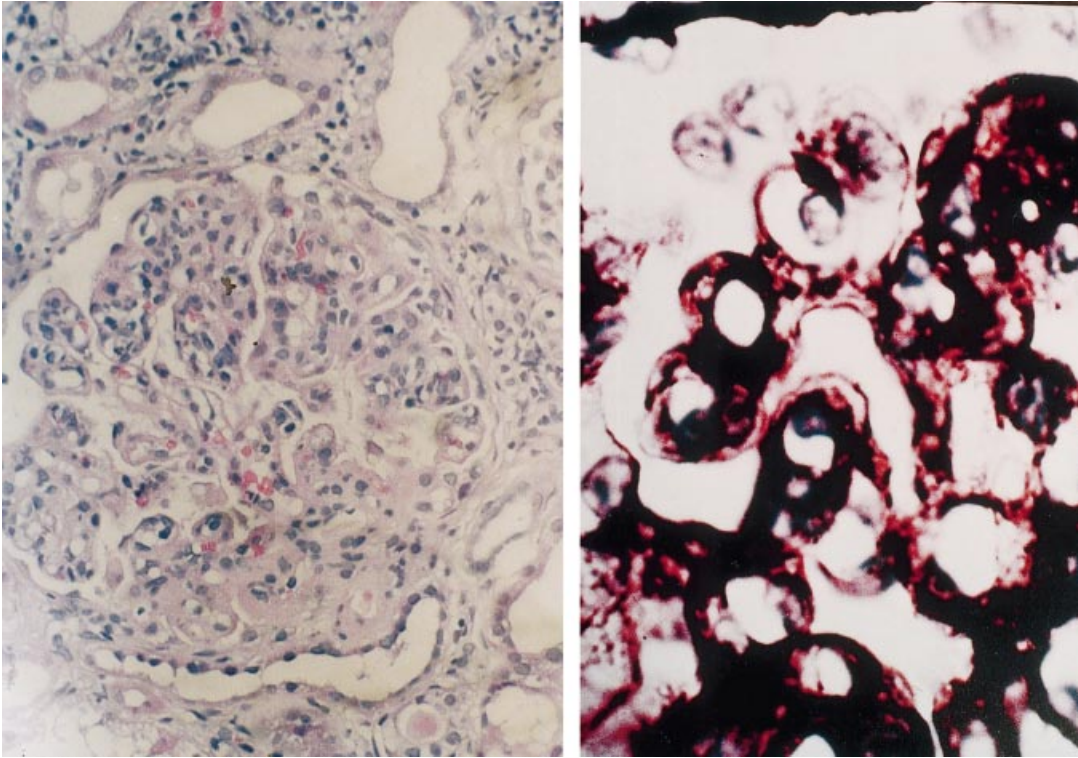
Fig. 10. Quartan malarial nephropathy. Left: mesangial proliferation with capillary wall thickening (H&E stain). Right: silver stain showing the splitting of the basement membrane due to subendothelial deposits.
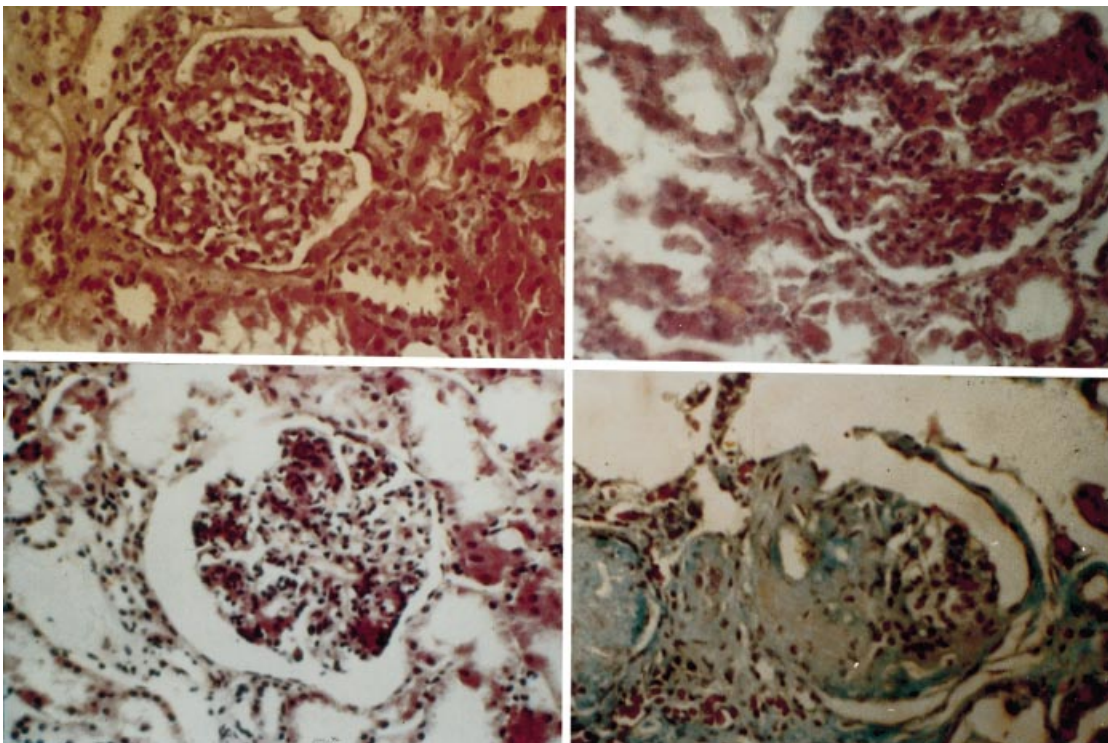

Fig. 11. Glomeruli belonging to four classes of schistosomal glomerulopathy: top left, simple mesangial proliferation; top right, exudative glomerulonephritis; bottom left, mesangiocapillary glomerulonephritis (H&E stain); bottom right, focal and segmental glomerulosclerosis. (Masson trichrome stain).

Filarial glomerulopathy

Clinically insignificant, asymptomatic proteinuria is often seen in many filarial infections worldwide. Yet clinically overt nephrotic syndrome may be encountered with *O.volvulus* infection, a type of filariasis hyperendemic in the Cameroon [78]. Mesangiocapillary and chronic sclerosing glomerulonephritis are the lesions most often reported. Subendothelial and mesangial immune complexes containing IgM, IgG, C_3 and *Onchocerca* antigens were detected by immunofluorescence, and mesangial electron-dense deposits [79] by electron microscopy. Similar lesions have also been described occasionally in bancroftiasis [80,81] and loasis [82].

Autoimmunity has been blamed as an essential pathogenetic mechanism in the development of overt and progressive disease. Nephrotic syndrome is usually seen in patients who also suffer from polyarthritis and chorioretinitis, the latter underlying the common term 'river blindness' used to describe the disease in endemic areas. Anti-DNA, anti-idiotypic and anti-phospholipid antibodies [83], and autoantibodies against human homologue antigens 35, 51, 64, 83 and110 kDa and calreticulin [84] have been detected in the sera of such patients.

Schistosomal glomerulopathy

Although mild glomerular lesions have been described in *S.mansoni* [43], *S.hematobium* [85] and *S.japonicum* [44] infections, only the former has been associated with progressive glomerular disease ending with ESRD [22,23]. Overt renal disease is usually encountered in adult males, 30–40 years old, who almost invariably have evidence of hepatosplenic schistosomiasis. Hypertension is seen in 50% of patients [85]. The renal histological changes have been categorized under five classes (Figure 11) [86]. Class 1 lesions are seen more often in early, asymptomatic lesions and may be reversed with anti-helminthic treatment. Class 2 lesions are characteristic of patients who have concomitant *Schistosoma* and *Salmonella* infections, a fairly common association described in Egypt [87] and Brazil [88], and associated with acute yet reversible nephrotic syndrome among Egyptians [89]. Classes 3 and 4 are those reported most often in patients with progressive disease. Several studies have documented the ineffectiveness of treatment at this stage of disease evolution [90,91]. Class 5 is renal amyloidosis, already alluded to, earlier on in this review.

There is a lot of experimental and clinical evidence that progression into classes 3 and 4 schistosomal glomerulopathy requires a fibrotic liver [92–95]. In one of our earlier studies, it was shown that proteinuria and mesangial expansion correlate with the impairment of hepatic macrophage function, as measured by isotopically labelled sulfur colloid [96]. It was assumed initially that such functional hepatic impairment would allow adult worm schistosomal gut antigens to escape in higher concentrations from the portal blood into the systemic circulation. Indeed, it has been shown that such antigens constitute the majority of parasitic antigen deposits in the affected glomeruli in experimental animals [97] as well as humans [98].

However, we also noticed that the more advanced lesions display IgA much more frequently than IgM in the mesangial deposits [96]. In patients with hepatosplenic schistosomiasis, the level of IgA-containing circulating immune complexes was significantly higher when there was evidence of significant renal disease [99]; it was then assumed that impaired hepatic clearance of IgA may be a superimposed pathogenetic mechanism.

More recently, we noticed that the serological immunoglobulin profile was characterized by the predominance of IgA- at the expense of IgM-anti-gliadin antibodies in patients with schistosomal glomerulopathy, in contrast to those with hepatosplenic schistosomiasis sparing the kidneys [100]. The proportion of IgA-coated peripheral B-lymphocytes was significantly higher in the former cohort of patients [101] (Figure 12). These data indicate that switching from IgM to IgA predominance may be a critical feature in the immunopathogenesis of schistosomal glomerulopathy. Such switching, which occurs at a pre-transcriptional level in the C gene [102], is known to be mediated largely by IL-6 and IL-10 [103]. As described earlier, these cytokines play a major role in the late modulation of schistosomal granulomata.

It would appear then, that for schistosomal glomerulopathy to progress into overt renal disease, the glomerulus should receive dual injury. Initial 'priming' may occur as a result of immune complex deposits, similar to what happens in most other parasitic glomerulopathies. At this point, the patient may remain asymptomatic or develop mild, often asymptomatic, proteinuria. When 'switching' takes place, IgA deposits infiltrate the lesions in their own right, irrespective of the initial aetiology (Figure 13). This scenario is, in essence, very similar to the currently prevailing concepts in primary IgA nephropathy.

Autoimmunity also seems to play a pathogenetic role in schistosomal glomerulopathy, as suggested by many serological abnormalities including false-positive Wassermann reaction [85], rheumatoid factor [89], anti-DNA antibodies [104], seropositivity for anti-idiotypic and anticardiolipin antibodies [83], and others. It is interesting that IgA 'switching' can also be demonstrated in the autoantibody profile in patients with schistosomal glomerulopathy [100].

Conclusion

The foregoing has shown that glomerular immune complex deposition in a variety of parasitic diseases leads to mild and self-limited disease, reflecting the critical balance of concomitant immunity. Some other pathogenetic mechanisms have to be superimposed in the few parasitic glomerulopathies that tend to progress. These may include infection with certain viruses (e.g. in malarial nephropathy) or bacteria (e.g. in
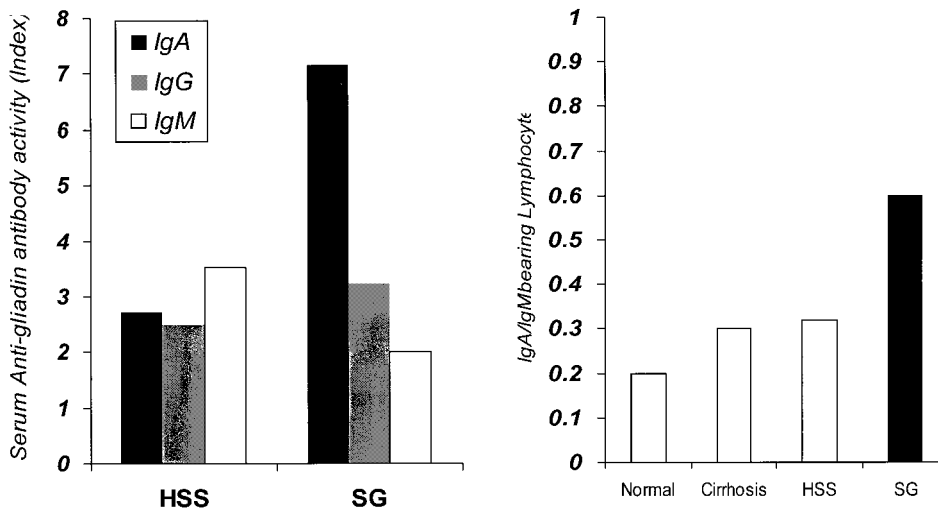
Fig. 12. IgA switching in patients with schistosomal glomerulopathy. Left: anti-gliadin antibodies. Right: IgA/IgM-bearing peripheral blood mononuclear cells.
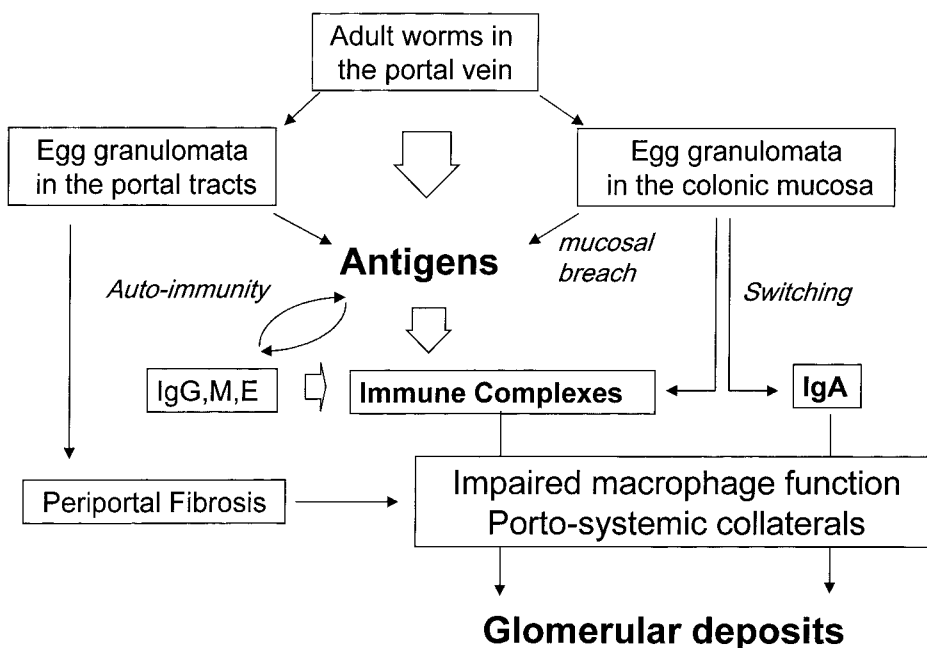

Fig. 13. Probable pathogenetic mechanisms involved in the pathogenesis of schistosomal glomerulopathy.

schistosomal nephropathy). Autoimmunity seems to play an important role in filarial, schistosomal and possibly malarial nephropathy. Disturbed IgA kinetics seems to be crucial in schistosomal nephropathy.

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