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Impetigenised Scabies and Acute Glomerulonephritis in Sri Lanka; a Prospective and Retrospective Study

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Abstract : From a study of patients, hospitalized for acute glomerulonephritis with impetigenised skin lesions, impetigenised scabies was found to be the commonest antecedent infection (79%); this confirms reports from Trinidad and South Africa that impetigenised scabies is a common precedent of acute glomerulonephritis. A prospective study of patients with impetigenised scabies showed that only 8% developed urinary abnormalities. Possible explanations for this difference are discussed. The pattern of the serotypes of the β haemolytic streptococci isolated from these skin lesions was similar to that reported from other countries. *Staphylococcus aureus* alone was recovered from the skin lesions of 40% of patients with acute glomerulonephritis (AGN) but the wide variation of the properties of these isolates did not suggest the existence of special nephritogenic strains. Amongst the isolates of *S. aureus* from the skin lesions of patients with or without AGN, phage Group III was the commonest, with phage Type 54 predominating. The staphylococcal isolates differed in their phage pattern distribution, from those reported from temperate countries. AGN following pyoderma, was found to have a latent period similar to that reported from other countries; the extent of the pyoderma had no relation to the occurrence or severity of the AGN. The ASO titres in the nephritics, following pyoderma were found to be intermediate between those in normal persons and those in acute rheumatic fever. Epidemics of post-streptococcal AGN have not been experienced in this country although sporadic cases are common.

1. Introduction

Acute glomerulonephritis (AGN) as a sequel to a β haemolytic streptococcal infection, has been well documented.[10] In temperate climates, especially in the winter and in spring, the streptococcal infection has most often been an upper respiratory tract infection. In warmer seasons, in these countries and in tropical climates, pyoderma is reported to have been the more common antecedent.[10] This is particularly true of populations living under poor hygienic conditions.

The pathogenesis of the renal lesion of AGN has generally been recognised as being due to immune complexes and the acute nephritic syndrome which typically includes post-streptococcal AGN has also been described in association with other systemic diseases including staphylococcal[23, 28], viral[2] and parasitic infections.[24]

AGN and acute rheumatic fever (ARF) are two major clinical problems in this country and in 1969/1970 the yearly admissions to state hospitals for ARF and AGN were approximately 450 and 760 per 100,000 population, respectively. In 1976, the rates for ARF and AGN were 500 and 720 respectively.

It has been a clinical impression that many of our AGN patients, especially in the paediatric age group, have associated scabies complicated by pyogenic superinfection, which is one of the commonest dermatological conditions seen in this country. In 1969/1970 the admission rate to state hospitals for the treatment of scabies was 4500, while in 1976, the rate was 1990 per 100,000 population. These figures exclude an appreciable number of cases that would have sought outdoor or traditional indigenous treatment.

Since there was no data on the association between AGN and scabies in this country, we studied the inter-relationships between scabies, a supervening β haemolytic streptococcal or staphylococcal infection of the skin, and AGN, both prospectively by following up patients who presented with scabies and retrospectively in patients with AGN, in this district over a one and a half year period-1969/1970- to take into account, seasonal variations in rainfall and temperature. The topics of this study included the Groups and Types of the streptococci, the characteristics of the strains of *Staphylococcus aureus* isolated from the skin lesions and the anti-streptolysin titres (ASOT) in normal persons and in the patients.

2. Experimental

The study populations: All patients were of a low socio-economic status, attending the non-fee levying state hospital in this district. They were consecutive cases divided into the following classes:

Class A had 85 patients (48 male and 37 female) with AGN and impetigenised skin lesions (infected scabies, infected eczema, infected dermatomycosis and impetigo), who were warded in the medical and paediatric wards of this hospital. AGN was diagnosed when any three of the following were present-albuminuria, oedema, hypertension, macroscopic haematuria or microscopic (more than 5 red cells per high power field in the deposit from centrifuged urine) and oliguria.

Class B had 18 patients with AGN without preceding or concomitant pyoderma.

Class C had 55 patients (38 males and 17 females) who formed the prospective study group. They presented with infected scabies at the Dermatological unit of this hospital. They were examined weekly for at least 6 weeks for symptoms and signs of AGN. Scabies which was in all cases secondarily infected was diagnosed clinically[32] by a contact history, pruritus, distribution of the lesions

and the response to antiscabetic therapy. Microscopic examination for the parasite was not done at this stage on account of the difficulty of identifying the burrows in the pigmented skin and the isolation of the parasite with secondary infection. The clinical examination, as in the patients of Classes A and B, included a detailed examination of the cardiovascular system, the urinary tract with a laboratory examination of the urine as described below. The clinical examination included a measurement of the blood pressure after a short period of rest especially in outdoor patients. A standard blood pressure chart was used to assess the significance of the measured pressure. A fresh sample of urine was examined for albumin by the acid–heat method and for deposits microscopically. The cell count was expressed as their number per high power field (X 400) in the deposit from 5 ml of urine centrifuged at 150 *g* for 10 min. The throat and at least 10 skin lesions were swabbed with serum coated swabs which were plated immediately. A sample of peripheral venous blood was taken for ASOT determination.

After the examination, the patients were treated appropriately, with 25% benzylbenzoate emulsion, for scabies, with or without oral or parenteral penicillin or tetracycline.

Normal subjects. Sera from 176 normal school children (age range 5–15, geometric mean 6.4; 82% males, 18% females) were used as controls for the ASOT study.

Bacteriological methods. For primary isolation, the throat and skin swabs were plated on 5% sheep blood agar with and without crystal violet and the plates were incubated aerobically and anaerobically. β haemolytic streptococci, after purification were grouped by testing acid extracts by gel diffusion against standard grouping sera ('Wellcome Diagnostic Reagents'). Typing of Group A strains was done by Dr Jiri Rotta (Institute of Epidemiology and Microbiology, Prague, Czechoslovakia).

The strains of *S. aureus* were characterised as follows:– haemolysis on sheep blood agar, pigmentation on milk agar, lipolysis on ('Oxoid') tributryin agar, opacity production on egg yolk agar, DNAse production on ('Difco') DNse test agar, mercuric chloride sensitivity[22] penicillinase production[15], antibiotic resistance using standardised discs ('Rosco' Sensitabs, Denmark) of penicillin, tetracycline and streptomycin with the 'Oxford' staphylococcus as reference strain; independent confirmation of the zone diameters recommended by the manufacturers was made by comparison with the frequency distribution of zone diameters (Arseculeratne, unpublished data) of 300 strains of *S. aureus* isolated in this laboratory and by MIC determinations with penicillin in tube dilution tests. The strains were phage typed with the following phages :–

Group I - 29, 52, 52A, 79, 80

Group II - 3A, 3B, 3C, 55, 71

Group III- 6, 7, 42E, 47, 53, 54, 75, 77, 83A

Group IV - 42D

Miscellaneous - 8I, 187

Strains untypable by these phages were also tested against the following additional phages :- 84, 85, 88.

Antistreptolysin 'O' titres:- these were estimated with commercial kits ('Wellcome Diagnostic Reagents') by the 50% endpoint method determined colorimetrically, as recommended by the manufacturers.

3. Results

Class A. The age distribution of the patients with AGN in Class A was as follows, indicating that AGN in this country is primarily a paediatric problem:-

age (years)	number of cases	approximate %
1–5	16	19
6–10	36	42
11–15	11	13
16–20	11	13
over 20	12	14

Nature of the skin lesion. The nature of the impetigenised skin lesions in the 85 patients with AGN was as follows:-

lesion	number of cases	approximate %
infected scabies	67	79
impetigo	14	16
infected eczema	3	4
wound infection	1	1

Although the lesions in all the scabetic patients appeared to be infected with pyogenic organisms, bacterial isolation was successful in only 63 (74%) of cases 20 patients had been given systemic antibacterial therapy before bacterial culture was attempted. In relation to prior penicillin or tetracycline treatment, the isolation of β haemolytic streptococci from the skin lesions was successful in 5/24 treated and 24/61 untreated patients.

Area of skin affected. Although assessment of the area of the affected skin was imprecise, there appeared to be no correlation between the area of the skin involvement and the occurrence of AGN or its severity.

Latent period. In 79 cases, the modal latent period between the onset of the scabies and the AGN was 4 weeks with a mean of 9·3 weeks.

Table 1 – The incidence of β haemolytic streptococcus and *Staphylococcus aureus* in the impetigenised skin lesions of patients in Class A and Class C.

Class	β haemolytic streptococcus		*S. aureus*		Both β haemolytic streptococcus and *S. aureus*	neither
	skin	throat	Skin	throat	skin	
A	12	1	34	4[a]	17	22
C	13	2[b]	17	4[b]	18	11

b same strain as from skin lesions
a strains different from those from skin lesions
Figures refer to number of cases

Table 2 – The Phage pattern and Group distribution of *Staphylococcus aureus* from the impetigenised skin lesions of patients in Class A (numbers of strains within parenthesis)

phage Group				
I	II	III	Mixed	untypable
29 (4)	55 (2)	54 (8)	29/54 (1)	24
29/52/52A/79/80 (1)	55/71 (2)	53/54 (2)	71/42E (1)	
29/71 (1)	3A/55/71 (1)	77 (1)		
	71 (1)	6/53/54/83A (1)		
	79/3C/55/71/81 (1)			
Total 6	7	12	2	24

Table 3 – The properties of *Staphylococcus aureus* isolated from the skin lesions of patients in Class A.

Phage Group						colour[a]			P'nase[b]		Lipo[c]		EY[d]		Hg[e]		AB resistance[f]			
I	II	III	IV	Misc	NT*	GY	C	W	+	—	+	—	+	—	S	R	I	2	3	nil
6	9	12	0	0	24	24	25	2	10	41	43	8	43	8	49	2	10	5	0	36

*untypable, a—GY golden yellow, b—penicillinase, c— lipolysis, d— Egg yolk
C cream
W white
e— mercury resistance, f— antibiotic resistance to 1, 2, 3 or nil antibiotics

Identity of the organisms. The incidence of β haemolytic streptococci and *S. aureus* is shown in Table 1. The group and type distribution of the streptococci are shown in Table 5 and 6 respectively. None of the patients had more than one strain.

The properties of the staphylococci are shown in Table 3 and are similar to those of Class C. All the strains were positive for coagulase (slide and tube) and DNase production. As in Class C, the commonest phage Group was III. The phage patterns of 51 strains are shown in Table 2.

The phage group distribution of *S. aureus* in Class A and C was similar to that in a separate series of 110 strains of *S. aureus* which were isolated from skin lesions in this hospital, in which the distribution was as follows :-

Group	number of strains
I	16
II	10
III	23
IV	1
Misc	2
nontypable	58

The commonest phage types in order of frequency were 54 (Group III), 79 (Group II) and 55/71 (Group II). *Class B.* 18 patients with AGN had no history of impetigenised scabies or other skin lesions and no detectable skin lesions on examination. 8 patients (44%) gave a history of sore throat with an average latent period of 3.3 weeks. β- haemolytic streptococci type T 22 and T 44 were isolated from the throat in only two patients (12%) respectively. Throat cultures were negative for *S. aureus*. *Class C.* The incidence of β haemolytic streptococci and *S. aureus* in the skin lesions and in the throat of the 55 patients is shown in Table 1.

Only 50 patients turned up for follow-up examination for the 6 week observation period. The five patients who were not followed up, kept in touch by post and reported cure of their skin lesions and absence of clinical evidence of AGN. Of the 50 patients who were followed up weekly, four (8%) showed microscopic haematuria, with albuminuria but none of these patients developed the clinical picture of overt AGN (Table 4).

The group and type distribution of the strains of β haemolytic streptococci isolated from the skin lesions in patients of Class C are shown in Tables 5 and 6 respectively.

The properties of the strains of *S. aureus* isolated from the skin lesions of these patients are shown in Table 7. Of the 55 patients, 35 had *S. aureus* in their skin lesions, either alone or with β haemolytic streptococci. None had more than one type of *S. aureus*. All these strains were coagulase positive

Table 4 – The characteristics of patients of Class C who developed urinary abnormalities after impetigenised scabies.

age (years)	duration of scabies (weeks)	area affected %	organism in skin	week of albuminuria or haematuria	ASOT
2	2	12	*Staph. aureus*[1]	1	ND*
11	4	5	β haemolytic streptococcus T 9	1	ND*
14	?	3	nil	1	200
18	4th recurrent attack	3	nil	1, 2	710

1 cream coloured, phage untypable, mercury sensitive, EY –, Penicillin resistant
* not determined

Table 5 – The Group distribution of strains of β haemolytic streptococcus isolated from the skin and throat in patients with pyoderma and AGN (Class A), the throat in patients with AGN without pyoderma (Class B) and from patients with impetigenised scabies (Class C)

Lancefield Group	Class A skin	Class A throat	Class B throat	Class C skin	Class C throat
A	23	1	2	26	2
C	1	0	0	1	0
G	2	0	0	4	0
Total	26	1	2	31	2

Table 6 – The Type distribution of Group A strains of β haemolytic streptococci isolated from the skin and throat of patients with pyoderma and AGN (Class A), the throat of patients with AGN without pyoderma (Class B) and from patients with impetigenised scabies (Class C)

Broad range Type classification of T Type	Class A skin	Class A throat	Class B throat	Class C skin	Class C throat
5/11/12/27/44	3	0	0	6	0
3/13/B3264	3	0	0	8	1
8/25/Imp 19	6	0	0	2	0
14/35/49	1	0	1	4	0
15/17/19/23/40/47	0	0	0	1	0
4/24/26/28/29/46	1	0	0	1	0
M55 T25/Imp 19	2	0	0	1a	0
T 22	4	1	1	0	1b
T 9	1	0	0	2	0
untypable	2	0	0	1	0
Total	23	1	2	26	2

a. the only strain typable by the M antigen
b. strain different from that isolated from the skin

by the slide and tube tests and produced DNase. There was a total positive correlation between the EY and lipolysis reactions. The phage patterns in each group were as follows :-

Group I	Group II (number of strains	Group III within parentheses)	Miscellaneous
79 (2)	55/71 (4)	54 (6)	187 (1)
29 (2)		53 (2)	
80 (1)		(83A 1)	
29/79 (1)			
79/80 (1)			
Total 7	4	9	1

A minor outbreak of AGN in a small hamlet.

The hamlet consisted of a closed community of three families which lived in wattle and daub houses, adjacent to one another. The children were siblings or cousins and were in constant and intimate contact. The outbreak occurred during the rainy month of July. Four children were admitted to hospital within two days for AGN and infected scabies. They had all received parenteral penicillin from their rural hospital before admission. The remaining 5 children had no symptoms of AGN but all had impetigenised scabies. These five were treated by us for their skin infection and were followed up weekly for 3 months. None developed the urinary abnormalities or clinical evidence of AGN.

In the children with AGN, the ages ranged from 8 months to 10 years and they had scabies for 1 to $1\frac{1}{2}$ months. No streptococci were isolated from their skin lesions

In the contact children whose ages ranged from 7 months to 7 years, the duration of scabies was from 1 to 2 months with a mean of 1·5 months. The isolates of β haemolytic streptococci from these five contact children had the following serotypes :-

case	site	T antigen	Broad range Type classification
2	throat	5111/12/27/44	5/11/12/27/44
	skin	12	5/11/12/22/44
2	skin	11/12	5/11/12/27/44
	skin	12	5/11/12/27/44
3	skin	5/11/12/27/44	5/11/12/27/44
4	skin	4	4/24/26/28/29/46
5	skin	non - typable	—

The strains of *S. aureus* isolated from the skin lesions in all the children, nephritic and contact, were identical in all the properties tested-golden yellow coloured, phage type 54 (Group III), positive reactions in the following tests - DNase production, tube and slide coagulase production, egg yolk opacity production, lipolysis, sensitivity to mercuric chloride and penicillin

Table 7 – The properties of *Staphylococcus aureus* isolated from the impetigenised scabetic lesions of patients in Class C

Phage Group					colour[a]			P'nase[b]		Lipo[c]		EY[d]		Hg[e]		antibiotic[f] resistance			
I	II	III	Misc.	NT*	GY	C	W	+	—	+	—	+	—	S	R	1	2	3	nil
7	4	9	1	15	15	17	3	11	23	28	7	28	7	32	3	12	4	1	18

*untypable, a – CY golden yellow, b – penicillinase, c – lipolysis, d – Egg yolk
C cream
W white
e – mercury resistance, f – antibiotic resistance to 1, 2, 3 or nil antibiotics

Table 8 – ASOT in normal subjects and in patients with AGN with pyoderma (Class A), patients with AGN without pyoderma (Class B), patients with impetigenised scabies (Class C)

Subjects	number	ASOT range	ASOT mean	mode
normal	176	50 — 1600	354[a] ± 342	170
Class A	59	123 — 1600	233[b] (inappropriate) 760[a] ± 420 668[b] (appropriate)	640
Class B	9	141 — 1600	799	
Class C	14	200 — 1448	644	

[a] arithmetic mean, [b] Geometric mean, Davies' test was used to assess the appropriateness of either mean to the values in the two classes.

Antistreptolysin 'O' titres.

Data concerning the ASOT in normal subjects and in patients with AGN (with and without pyoderma) is shown in Table 8. The cumulative frequency distribution of ASOT in normal subjects is shown in Figure 1.

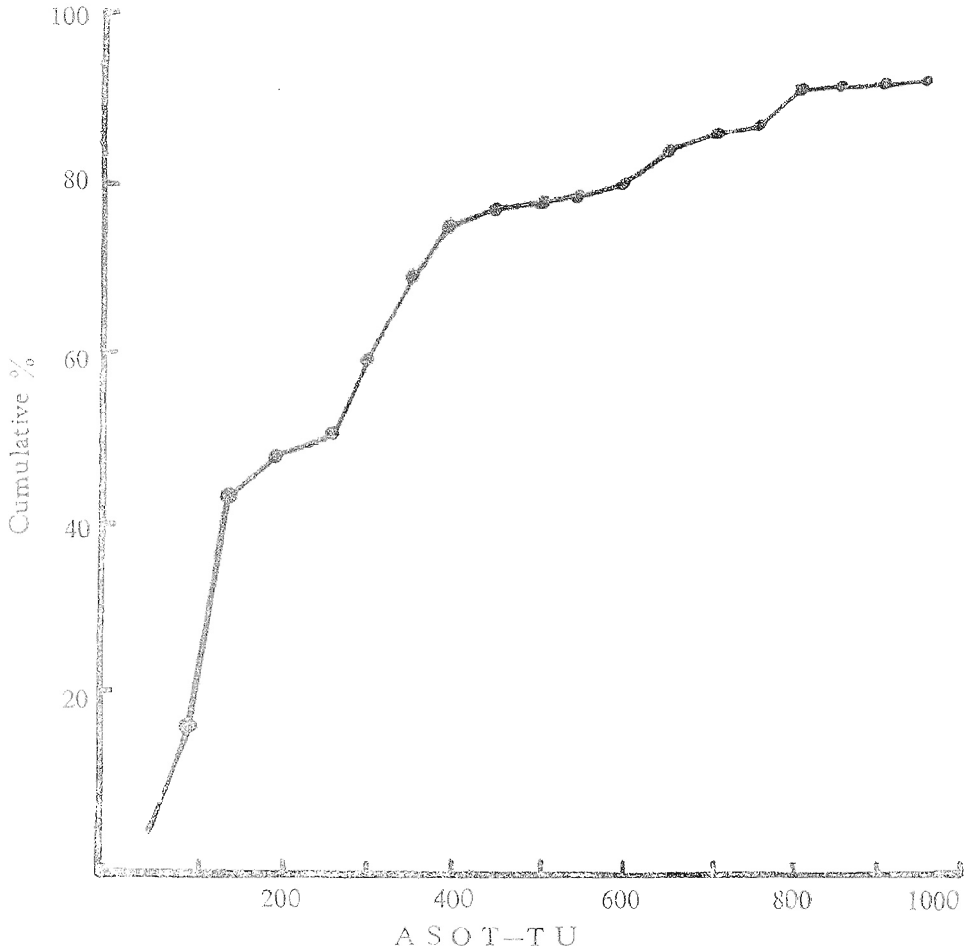

Figure 1. Cumulative percentage distribution of ASO titres (TU) in 176 normal persons

The mean titres in the normal subjects were significantly different from those of Class A ($p < 0.001$), of Class C ($p < 0.05$) and those of 9 patients with ARF ($p < 0.001$); the patients with ARF were hospitalised during this period and their ASOT ranged from 640 to 1600 with a mean of 1112. The mean ARF titre differed significantly ($p < 0.001$) from those of Class A and Class C.

There was no significant difference between the titres of patients Class C and those in either Class A or B. There was also no significant difference between the titres in patients with and without recoverable β haemolytic streptococci from their skin lesions in Class A and in Class C.

4. Discussion

In temperate countries, the streptococcal infection which precedes AGN has commonly been an upper respiratory tract infection.[30] In warmer climates however, the commonest antecedent infection has been streptococcal pyoderma[10]

and recently, pyogenic infection of scabies was documented as a common precedent of AGN in South Africa[14] and in Trinidad.[32] It was stated[5] that over half the children in the Red Lake epidemic of AGN in the Indian Reservation of Minnesota were suspected of having had scabies. Allen[1] described AGN which followed a β haemolytic streptococcal infection on scabetic lesions in a patient in a temperate country in winter. Our finding of the preponderance of impetigenised scabies as the antecedent in AGN in Sri Lanka confirms these observations. In addition, the broad parallelism between the incidence of scabies and AGN in this district (Figure 2) is compatible with this relationship. Hence the early treatment of scabies, which Hersch[14] recommended be classified as a notifiable disease, may be a useful step in reducing the incidence of AGN.

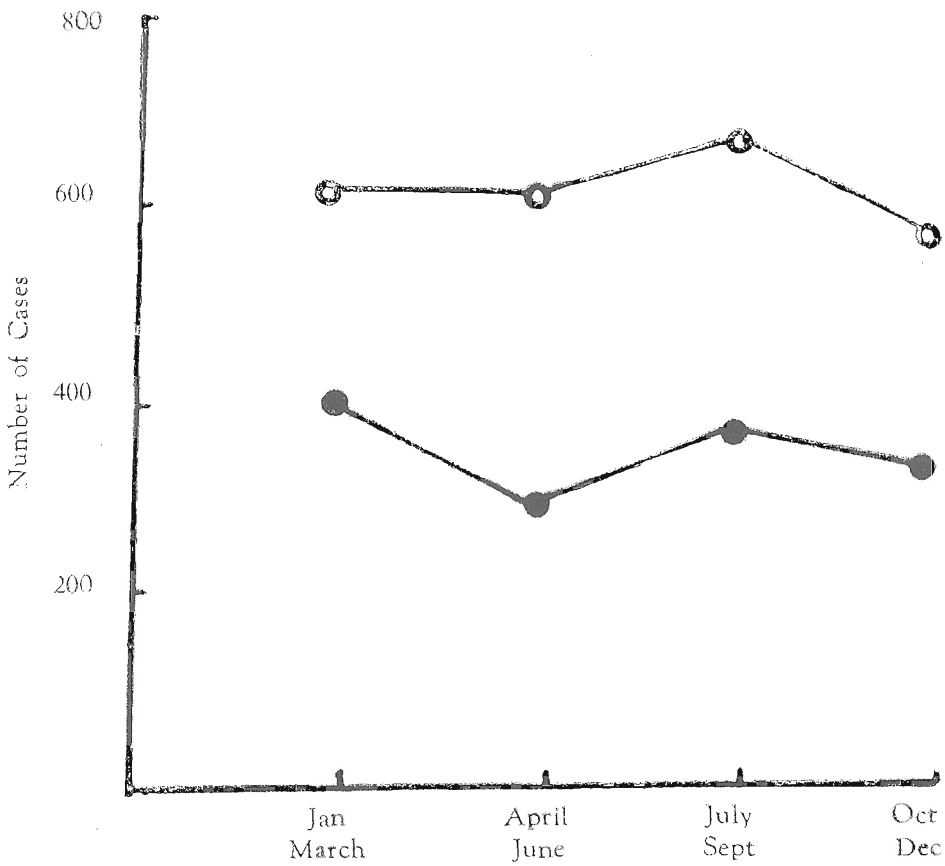

Figure 2. Quarterly admissions for the treatment of Acute Glomerulonephritis (-●-) and of Scabies (-O-) in the General Hospital, Kandy, Sri Lanka: the numbers represent means of quarterly admissions for the years 1969 – 1972.

The incidence rate of streptococcal pyoderma in the nephritics of Class A is in contrast to the lower rate of development of urinary abnormalities suggestive of AGN in patients who had similar skin lesions and a pattern of streptococcal and staphylococcal colonisation, in the prospective series of Class C. Other prospective studies too have recorded relatively low rates for the development of urinary abnormalities.[5, 6, 18, 21] Hersch[14] found evidence of AGN in 8% of 100 outdoor patients who had scabies. Svartman and co-workers[32] found urinary abnormalities, haematuria and proteinuria, in 9% of scabetics on follow up. Several factors could account for this difference between prospective and retrospective studies :-

(i) the treatment of the pyoderma before the patients were seen by us, and the suppression of the streptococcal colonisation and hence the antistreptococcal immune response. This was perhaps the case in those patients who did not develop any urinary abnormalities although nephritogenic strains were isolated from their skin lesions. It has been noted[20] that antibiotic treatment did not prevent the AGN or reduce its severity, although it led to the elimination of the streptococcus and reduced the antibody response.[4]

(ii) The operation of host factors such as genetic or immunological predisposition which may determine whether the renal lesion will supervene on the streptococcal pyoderma. The findings of Lasch and co-workers[20] may also be explained on the basis of host factors which might have increased the susceptibility to AGN.

(iii) The presence of non-nephritogenic strains in the skin lesions of the patients in Class C. The demonstration that the skin lesions may be colonised successively by more than one serological type of streptococcus[5, 26] and the replacement of a nephritogenic strain by a non-nephritogenic one may also be another explanation.

(iv) While it is claimed that approximately 3% of patients with streptococcal infection develop or are likely to develop the primary bout of ARF, glomerulonephritis has a much lower and more erratic incidence.[29] A higher incidence of AGN might be expected in closed communities where not only may the nephritogenic strain be spread with greater ease but also delayed treatment due to remoteness of the village and inaccessibility of medical centres may result in the development of the renal lesion. A greater genetic homogeneity within such populations with closely related individuals may also contribute to a higher incidence of renal abnormalities. These factors were probably operative in the minor outbreak of AGN in our hamlet, as in the Indian Reservations of North America.

Latent period. The average latent period of clinically overt AGN following streptococcal pyoderma is generally reported as being between 1-4 weeks.[10] The modal latent period in our nephritics was 4 weeks. It is significant that microscopic haematuria was observed within the first 2 weeks of pyoderma in

4 patients of Class C. Raffel[29] commented "patients who will subsequently develop nephritis are likely to show some red cells in the urine during the acute stage of the streptococcal infection". It is however difficult to say whether the microscopic haematuria would have progressed to overt AGN in the absence of therapy or follow up. Renal tubular lesions have been described as a reaction to the 'S' streptolysin of the β haemolytic streptococcus[33] including non-nephritogenic strains, and to *S. aureus*.[28] Hence in the absence of renal biopsy in cases not showing clear clinical signs and symptoms of AGN, it is difficult to attribute the haematuria to AGN.

Source of streptococci. It has been concluded from studies in other countries[7, 10, 11] that respiratory colonisation with the same strain of streptococcus as on the skin occurs subsequently to the skin infection. Isolation rates from the pharynx have generally been lower than from the skin.[21, 32] It was our observation too that isolation from the throat, of the same type of streptococcus as found on the skin was less frequent and occurred in only 2 out of 55 prospective patients and in one out of 85 retrospective patients.

Extent of pyoderma. We found no correlation between the extent of the pyoderma and the occurrence or length of the latent period of AGN although Hersch[14] found that the incidence of AGN was roughly related to the extent and severity of the skin lesions. In some of our nephritics, only a few scabetic lesions were found while in others extensive and long standing lesions were followed by clinically overt AGN only after several months. Infection by non-nephritogenic strains in some of these episodes may be one explanation. Other patients may have been inadequately treated for scabies. Kaumheimer quoted by Futcher[12] observed that there was no correlation between the severity of the impetigo and the character of the subsequent nephritis. No relation was found between the duration of the scabies and the presence of albuminuria.[14] Markowitz *et al*[21] also found that the duration and severity of the skin infection did not differ in the nephritics in comparison with patients without urinary abnormalities.

Streptococcal serotypes in pyoderma. The relative isolation rates of the different Groups of β haemolytic streptococcus were similar among the Classes A and C. Broad range types 8/25/Imp 19 and Type 22 in Class A and Types 5/11/12/27/44 and 3/13/B 3264 in Class C were the commonest. Types 8/25/Imp 19, 3/13/B 3264 and 5/27/44 were also described[9,10] as common serotypes isolated from streptococcal impetigo with AGN.

Two out of 22 strains from the skin lesions of nephritics in Class A and one out of 33 strains from patients with pyoderma (Class C) were of M Type 55. Rotta (1970, personal communication) referred to this type as having also been recognised as a new type in other tropical countries. M Type 55/T8/25/Imp 19 has also been isolated from cases of AGN in Trinidad[26, 27] and in Israel.[20]

Most of our pyoderma strains were untypable by the M antigen, an experience previously recorded.[9, 18, 21, 36] The pattern of streptococcal serotypes isolated from our cases as pyoderma conformed to the impetigo serotypes described by other workers [2, 5, 6, 16, 18, 25] especially in our finding that common isolates were of the serotypes 8/25/Imp 19,, 3/13/B 3264 and 5/27/44. The Red Lake serotype M49 was however absent amongst our isolates from cases of AGN.

Staphylococcus aureus. The pattern of staphylococcal isolates from the skin lesions however differed from those reported by other workers.[6, 21, 25] Phage type 71 (Group II) which they found to be the commonest type in impetigo, occurred in only 5/51 of our Class A and 4/21 Class C strains In both Class A and Class C of our series gave phage Group III and I as the predominant groups with phage type 54 (Group III) as the commonest type: phage type 54 was also the commonest type which we recovered in a separate study of 110 strains (unpublished data) from skin infections. Group III strains were also found to be the commonest in pyoderma in American Indian children.[5]

S. aureus was isolated more frequently than β haemolytic streptococci from the skin lesions in both prospective and retrospective patients in our series, an experience also reported by other workers.[6, 21] The latter authors suggested from ASO titres in skin infections, that streptococci may be more frequently associated with pyogenic skin infections than isolation rates would suggest and that staphylococcal infection is perhaps secondary. The finding that *S. aureus* phage type 71, a common impetigo type, inhibits the growth of β haemolytic streptococci[8] may explain the failure to recover the streptococcus from mixed infections.

The pathology of the renal lesions following staphylococcal septicaemia has been described in detail;[28] lesions similar to those of post-streptococcal AGN such as exudation and glomerular proliferation, were seen. Diffuse glomerular lesions indistinguishable from those of post-streptococcal AGN have been described.[23] The characteristics of the staphylococcal strains in Powell's study[28] were not described. In our series, the strains of *S. aureus* isolated from the nephritics of Class A did not fall into any well defined group in terms of biochemical properties, phage types or antibiotic sensitivity patterns. This finding is in contrast to the occurrence of special nephritogenic types of the β haemolytic streptococcus. Our finding, with regard to the isolation and serotypes of the β haemolytic streptococcus which are similar to those reported by other workers, supports the pathogenic role of certain strains in the development of AGN. However the absence of any clear pattern of properties, at least among those tested, of the isolates of *S. aureus* from the nephritics, would suggest the absence of particular 'nephritogenic' strains of this species.

The fact that the strains of *S. aureus* isolated from the minor outbreak were identical not only in phage type but also in all the other properties tested, reflects the ease of spread of a single strain within this community in which the individuals were in close contact.

Epidemic AGN. Widespread epidemics have been reported from the USA[10], in the Red Lake Indian reservation and from Trinidad.[32] "Whether the nephritis follows skin sepsis or infection of the respiratory tract, it tends to appear in epidemics because only some strains of Group A streptococcus are nephritogenic".[3] It is possible that the strain type 5/11/12/27/44 also spread to all the patients in our hamlet, as did the strain of *S. aureus* but the isolation of the streptococcus from the skin lesions of the nephritic children was probably prevented by the penicillin treatment which these patients received before they were examined by us. This type was present in the nephritics of Class A as well and was also isolated by Dillon[10] from skin lesions in patients with AGN. As stated above, the occurrence of outbreaks of AGN in closed communities such as our hamlet and in the Indian reservations of North America may be contributed to by host factors such as genetic homogeneity as well as by close contact of the individuals

Apart from this outbreak, we have not encountered epidemics of AGN in this country. However we do have seasonal increases in the incidence of sporadic cases. The infrequency of epidemics is perhaps also reflected in the multiplicity of serotypes of the streptococci in our cases.

Antistreptolysin titres. Gunatillake and Perera,[13] from a study of normal children under 12 years living in a semi-urban area in Sri Lanka reported that the greatest number of children showed titres between 100 and 166 TU. Our finding of a mode of approximately 150 TU in this age group agrees with their figure. They found that 29·5% of their children under 12 years had titres of over 166 although in our series for the same age group, 56% had titres over 150 TU. A possible explanation for this higher value could be that our study population was of a lower socio-economic status with more overcrowding in their living conditions and a higher incidence or severity of streptococcal infections. Variations of ASOT tend to occur with age, geographic location, the frequency of streptococcal infections, within a given location and with population groups.

The upper level for the normal population in the US (80% of subjects having titres at this level or lower) was 333 for the 5–12 year group and 200 for the young adults.[34] Koshi and Mammen[19] reported an upper level of 333 for normal children between 6–15 years in South India, while Markowitz and co-workers[21] considered a level of 250 for this age group in the USA.

The ASO titres in our nephritics with pyoderma showed lower values than did the patients with ARF, as has been reported from other countries.

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