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Review of group B Streptococci and their infections

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Summary

This review article discusses the stages in the development of research on group B streptococcus (GBS), otherwise called *Streptococcus agalactiae*. Emphasis was placed on the bacteriology, clinical spectrum of disease, immunity to GBS infections and antibiotic susceptibility of the causative organism.

The organism, first recognized by Billroth in 1873, is classified into order *Eubacteriales*, family *Lactobacillceae*, class *Schizomycetes* and genus *Streptococcus* on the basis of its biochemical and physiological characteristics. It is subdivided into types Ia, Ib, Ic, II, III, X and R on the basis of carbohydrate and protein antigens present on its cell wall.

Bovine strains of GBS are found in the bovine teat while human strains are present in the female vagina, the oro-pharynx, ano-rectum and the external auditory canal of newborns. It could be transmitted vertically from mother to child *in-utero* and during parturition. Cross infection by the nursery staff could also occur during the immediate post partum period.

Two types of diseases are caused in the newborn: (i) the early disease occurring within a week of birth; and (ii) the late disease presenting during the late neonatal period. The former usually presents in the form of septicaemia while the latter presents as meningitis. Adult infections include puerperal sepsis, pyelonephritis and a wide range of other infections. Usually they are associated with other underlying clinical conditions such as malignancy, diabetes mellitus and sickle cell disease.

The organism is sensitive to penicillin which is the drug choice in treating established infections by GBS. Control measures are based on treatment of cases, eradication of vaginal colonization and chemoprophylaxis of infants at risk. An effective vaccine may become available in the near future.

Résumé

Cet article traite des étapes de la recherche sur le groupe B des streptocoques (GBS) autrement appelés streptocoques de l'agalactie. On a insisté sur le spectre bacteriologique et clinique des maladies, sur l'immunité contre les infections du GBS et sur la susceptibilité des antibiotiques a l'organisme causatif.

L'organisme, déconvert par Billroth en 1873, est classifié de la manière suivante sur la base de ses caractéristiques biochimiques et physiologiques: ordre *Eubacteriales*, famille *Lactobacillceae*, classe *Schizomycetes*, et genie *Streptocoque*. Sur la base des antigènes d'hydrate de carbone et de proteine presentes dans sa paroi cellulaire, il est subdivise en Ia, Ib, Ic, II, III, X et R.

Le GBS dans les vaches se trouve dans la tette tandis que le GBS chez l'homme se trouve dans le vagin pour la femme, dans le propharynx, l'ano-rectum et le canal anditif externe des nouveaux-nés. Il peut être transmis tout droit de la mère au bébé *in-utero* et al cours de la parturition. L'infection attrapée dans des crèches peut se produire pendant la période post-partum.

Il y a deux genres de maladies chez un nouveau-né: (i); la maladie qui se produit tôt, environ une semaine après la naissance; et (ii) la maladie qui se produit plus tard pendant la période néo-natale. L'une se présente d'ordinaire sous forme de septicémie alors que l'autre se presente sous forme de méningite. Les infections chez les adultes incluent la septicémie puerpérale, Pyélo-néphrite et toute une série d'autres infections. Elles sont habituellement

associées a d' autres elements profonds comme la malignite, le diabete, le mellite et la maladie de cellule faucille.

L'organisme est sensible à la pénicilline qui est la drogue par excellence contre toutes les infections connues du GBS. Les mesures de contrôle sont basées sur le traitement des cas, traitement du vagin infecté et traitement, a l'aide de chimo-prophylaxie, des enfants en danger. On espère qu'un vaccin efficace sera disponible daus l'avenir proche.

Introduction

The normal habitat of *Streptococcus agalactiae* (group B Streptococcus, GBS) is the bovine teat, especially those with chronic mastitis (Ayres & Mudge, 1922). It was initially thought to be non-pathogenic for man. However within the past decade, reports from Europe and North America showed that GBS is becoming a major cause of serious infections especially during the neonatal period and occasionally among adults as well (Butter & DeMoor, 1967; Bayer *et al.*, 1976). The aim of the present communication is to review the literature on the bacteriology, epidemiology and clinical disease spectrum of GBS.

History

Billroth (1873) demonstrated chain-forming organisms, then called *Bacteria lactis*, from purulent exudates of erysipelas. The term *Streptococcus* was later applied by Billroth and Ehrlich (1877). Fehleisen (1883) also confirmed that the organisms caused erysipelas while Resenbach (1884) applied the term *Streptococcus pyogenes* to the cocci he isolated for suppurative lesions in man. The first reference to an organism which we now know as *Streptococcus agalactiae* was by Nocard and Mollereau (1887). They experimentally produced bovine mastitis by inoculating a streptococcus from the mile of another cow with the same condition.

Marmorek (1895) noted the ability of some streptococci to lyse red blood cells, while Schottmuller (1903) used this property to classify the organism. Those showing no haemolysis were called *Streptococcus mucosus*, those showing complete lysis were called *Streptococcus mitior*. The haemolytic properties of Streptococci were also described by Brown (1920, 1937) and Noble and Vosti (1971) as follows: α for greening, β for complete haemolysis, γ for no haemolysis and α′ for incomplete haemolysis. α′ haemolysis is the so-called 'double-zone β haemolysis' and is characterized by a central halo of partial haemolysis surrounded by an outer area of complete (β) haemolysis. Only GBS manifests α′-haemolysis. The latter organism also shows β-haemolysis as a rule, although non-haemolytic strains could be encountered in the same serotype of GBS (Ayers & Mudge, 1922; Stableforth, 1932).

Systematic classification and nomenclature

The streptococci being true bacteria are included within the class *Schizomycetes* along with the filamentous bacteria, spirochaetes and mycoplasmas. The genus *Streptococcus* is also placed in the family *Lactobacillaceae* (along with *Lactobacillus* because of biochemical similarities) and order *Eubacteriales* (Buchanan & Gibbons, 1974). All strains of *Streptococcus agalactiae* are classified as Lancefield's serological group B (GBS).

GBS was variously named *Str. nocardi*, *Str. mastitis sporadiceae*, *Str. agalactiae contagiosae*, *Str. opportunus*, *Str. agalactiae* and *Str. mastitidis* (Sherman, 1937; Brown, 1947). *Str. agalactiae* remains the widely accepted name.

Morphology and cultural characteristics

Str. agalactiae shares many common charcteristics with the other streptococci: they are non-motile, non-sporulating, Gram-positive cocci (0.6–1.2 mm diameter), which occur in chains that are frequently very long. Streptococci grow poorly in nutrient media; on media enriched with blood, serum or glucose growth is more rapid.

Pigment production

Pigment production by GBS was first observed by Orla-Jensen (1919) on a starch-containing medium. Lancefield (1934) found that pigment production was dependent on cultivation conditions, while Fallon (1974) and Merrit and

Jacobs (1976) described orange or brown pigment production on Columbia agar under anaerobic conditions. Islam (1977) described a modified starch/serum agar on which GBS produced deep orange/red pigmented colonies. Parker (pers. comm.) found that incorporating antibiotics (Neomycin 30 mg/ml, Nalidixic acid 15 mg/ml and Metronidazole 50 mg/ml) made the Islam agar plates more selective for GBS. Onile (1983) found that the Parker's modified Islam plates were better than Columbia agar plates for demonstration of pigment production, and that growth was quicker on the former than the latter plates.

Antigenic structure and classification

Neufeld (1909) proposed antigenic typing of the streptococci as a basis for classification. There was however no progress along this line until Lancefield (1933) used hot dilute hydrochloric acid to extract the streptococcal cell wall polysaccharide and used the precipitation technique to classify them. She found that the distribution of group antigens corresponded to the animal host and the type of disease from which the streptococci were isolated. Group A caused human infections; group B, cattle infections; group C, infections in other mammals; group D was isolated from cheese and group E was isolated from certified milk. In 1935 Lancefield and Hare added two more groups (F and G) to the grouping battery. Hare in the same year also identified groups H and K from organisms isolated from the human throat.

Sherman (1973) recognized four main divisions of streptococci which formed a most widely accepted classification:

(a) the Pyogenic group, consisting of groups A, B, C, F, G and H;

(b) the Viridans group, groups R, S, T and the pneumococcus;

(c) the Lactic group, group N;

(d) the Enterococcus group, groupd D.

He further split group C haemolytic streptococcus into three sections:

(i) *Str. equis*, causing 'strangles' in horses;

(ii) *Str. zooepidermicus*, also isolated from horses;

(iii) *Str. equisimilis*, isolated from man.

Colman and Williams (1965) reported on the cell wall composition of different streptococcal groups as follows:

(a) Group A was made up mainly of rhamnose;

(b) groups B and C were made up mainly of galactose and glucose;

(c) group D was made up of galactose, galactosamine, with glucose and ribitol.

Antigenic components

By the acid extraction method GBS were classified into types Ia, Ib, II and III by Lancefield (1934), the type Ia, and Ib being related by sharing a common 'minor polysaccharide' antigen compound, 'Ibc' (Table 1).

Pattison, Mathews and Maxted (1955) added protein antigens R and X to the Lancefield Scheme. Some strains without a type antigen (I, II or III), and many others possess one of these two proteins. Protein antigen R is indistinguishable from R28 antigen of *Str. pyogenes* and is resistant to trypsin but sensitive to pepsin Protein antigen X is sensitive to both trypsin and pepsin.

An intermediate type Ii (intermedius) was introduced by Wilkinson and Eagon (1971). This is based on the presence of another protein, protein C, and is identical with that labelled 'Ibc' by Lancefield (1934).

Recently the presence of strains without any polysaccharide-type antigen and which are distinct from types R and X have been described by Jelincova (1978) and Parker (pers. comm.). These have 'Ibc' protein only and may be called 'Ic protein only'.

Composition of antigenic determinants

Group B antigen. This is composed of L-rhamnose, N-acetyl glucosamine and galactose, L-rhamnose being the significant determinant (Curtis & Krause, 1964).

Type I antigen. This consists of galactose and N-acetyl glucosamine and glucosamine. The immunological determinants are N-acetyl glucosesamine and glucosamine for types Ia and Ib respectively.

Type II antigen. This consists of D-galactose (34%), D-glucose (27.2%) and N-acetyl glucosamine (14%). The specific determinant is

Table 1. Antigenic composition of group B Streptococcus

Antigenic determinants	Types*							
	Ia	Ib	Ic	Ic protein only	II	III	R	X
Carbohydrate antigen	Ia	Ib	Ia	—	II	III	—	—
Protein antigen	—	Ibc	Ibc	Ibc	—	—	R	X

*3% of strains are not typable (Wilkinson, 1978).

D-galactose (Lancefield & Freimer, 1966; Freimer, 1967).

Type III antigen. This was found (Baker & Kasper, 1976) to be made up of sialic acid (24%), galactose (25%), heptose (21%), glucose (13%), glucosamine (10%) and mannose (7%). The sialic acid component allows the type III organism to have a special affinity for the meninges.

Physiological and biochemical characteristics

Like the other streptococci GBS are facultative anaerobes. They ferment sugars with the production of lactic acid as the main end product. The main characteristics are shown in Table 2. GBS can be distinguished from the other streptococci by its ability to hydrolyse sodium hippurate, its inability to hydrolyse aesculin and a final pH or broth culture of 4.2–4.3 (Sherman & Albus, 1918; Buchanan and Gibbons, 1974; Facklam *et al.*, 1974; Hwang & Ederer 1975).

CAMP reaction. GBS produces an extracellular substance (Camp-Factor) which, acting with staphylococcal beta haemolysin completely lyses sheep red blood cells, converting the partial haemolysis to complete haemolysis. The phenomenon, described by Christie, Atkins and Munch-Peteron (1944) is highly specific for human strains of GBS but of limited value for bovine strains (Darling, 1975).

DNAse. The GBS DNAse is immunologically distinct from the Group A streptococcal nuclease and is produced by 42% of all strains (Ferrier *et al.*, 1975; Flandrosis & Fleurette, 1975).

Table 2. Characteristics of group B Streptococcus

Shape	cocci
Spores	–
Motility	–
Gram reaction	+
Growth in air	+
Growth anaerobically	+
Haemolysis	α/β/α′/
Catalase	–
Oxidase	–
Growth in 4% NaCl broth	
in pH 9.4	–
at 10°C	–
at 45°C	–
in 10% bile agar	–
in 40% bile agar	
in 1/400 tellurite	+
in 0.1% methylene blue	+ (–)
Pigment production on Columbia agar	+ (–)
Resistance to 60°C for 30 min.	– (–)
Aesculin hydrolysis	+
Gelatin liquefaction	–
Hippurate hydrolysis	–
+ Starch hydrolysis	–
cAMP test	+
Acid from glucose	–
maltose	+
sucrose	+
lactose	+
salicin	+
trehalose	variable
xylose	+ (–)
arabinose	+
raffinose	–
inulin	–
mannitol	–
sorbitol	–
glycerol	–
	–
	+ (aerobic)

Hyaluronidase. Among the streptococci GBS are the highest producers of hyaluronidase (McClean, 1941; Sherwood, 1949). The enzyme is however only produced by the rough, mostly avirulent strains of GBS, showing it is not related to pathogenicity (Sherwood, 1949; Gochnaeur & Wilson, 1951).

Resistance. GBS is highly bile-tolerant: all will grow on 10% bile salts agar, while many strains will grow on 40% bile salts agar. They do not grow in the presence of methylene blue and mercuric chloride but will grow in the presence of optochin (5 mg). They do not grow at 10°C nor at 45°C; they are killed by boiling at 60°C for 30 min.

Laboratory Diagnosis

A selective broth medium was described by Baker, Clarke and Barrett (1973) to enhance the isolation of GBS from sites where there is mixed flora, like the vagina. This medium consisted of Todd Hewitt broth, sheep blood and incorporated Nalidixic acid (15 mg/ml) and gentamicin (8 mg/ml).

A combination of any two of the following tests were found to detect 99.8% of GBS strains by Jokipi and Jokipi (1976): CAMP reaction, aesculin hydrolysis, hippurate hydrolysis and pigment production. Each of the tests has a minimum detection rate of 95%. The definitive identification of GBS rests on immunological reactivity with specific antisera. The available tests are the Lancefield precipitation test and the coagglutination technique using antibodies bound to the cell surface of dead staphylococci (Finch & Phillips, 1977; Rosner, 1977).

Immunity to group B streptococcal infections

The possible protective mechanisms against GBS infections are as follows:

(a) transplacental transfer of IgG antibodies offering protection against neonatal infections (Baker & Kasper, 1976; Jamal, 1981);

(b) antigen-antibody (i.e. antibodies induced by infection) interaction leading to opsonization, phagocytosis and digestion in macrophages (Klesius *et al.*, 1973);

(c) antigen-antibody interaction with complement fixation leading to the formation of C'3b, and possibly also C'5a which are important for apsonization and immune adherence (Mattew *et al.*, 1974; Horn *et al.*, 1974; Lachmann 1975).

Epidemiology

The bovine teat is the main habitat of GBS. In man the vagina is belived to be the main colonized site. Table 3 shows the vaginal colonization rates from different authors. Other colonized sites in man are the naso-pharynx, the ano-rectum, the male urethra and the external auditory meatus (Simmons & Keogh, 1940; Pass *et al.*, 1979; Onile, 1980).

Type distribution of human strains of group B streptococcus

It is generally believed that there are serotypes of GBS from materials of human and bovine origin. There are however differences between the two strains as shown in Table 4. Most authors in Europe and North America found that approximately one-third of human isolates are type Ia, Ib or Ic, one-third are type II and one-third are type III (Table 5) (Baker & Barrett, 1973; Fransiosi, Knostman & Zimmerman, 1973; Steere *et al.*, 1975; Aber *et al.*, 1976). However in Nigeria one-fifth were type Ia, Ib, or Ic; one-twentieth were type II; a little less than three-fifths were type III and another one-fifth were either X or R (Onile, 1980). A high incidence of R (43.9%) and X (12.1%) strains, commonly associated with the bovidae, was also reported from human sources in Nigeria by latter author. There has however been no evidence of zoonotic transmission of GBS (Patterson & Hafeez, 1976; Onile, 1983).

Modes of acquisition of group B streptococcus

(a) Perinatal colonization. GBS may be acquired by the newborn through the following means: ascending infection from the vagina; foetal monitoring scalp electrodes; foetal hypoxia leading to gasping and aspiration or swallowing of contaminated amniotic fluid; and contamination of external auditory meatus and umbilicus (Overturf & Balfour, 1975; Anthony

Table 3. Summary of literature reviews of vaginal colonization rates of group B Streptococcus*

Population	Year	Country	Author	No. examined	% positive
Pregnant women	1935	U.S.A.	Lancefield	837	3
	1961	U.S.A.	Hood	208	5.8
	1967	Holland	Butter	205	8
	1971	Sweden	Bergquist	118	14
	1972	U.K.	Reid	369	4.9
	1973	U.S.A.	Franciosi	977	4.6
	1974	New Zealand	Becroft	134	9
	1975	U.S.A.	Badri	789	10.2
	1975	U.S.A.	Ferrieri	802	5.6
	1976	U.K.	Finch	110	6.4
	1977	France	Rousset	583	9.8
	1980	Nigeria	Onile	150	19.3
Women in Labour	1975	U.S.A.	Ferrieri	759	8.3
	1977	U.K.	Mhalu	125	14.2
	1978	Senegal	David	100	6
	1980	Nigeria	Onile	238	17.6
Non-pregnant women	1973	U.S.A.	Franciosi	354	11.6
	1977	U.S.A.	Baker	459	17.9
	1976	U.K.	Finch	123	17.1
Women attending veneology clinics	1974	Sweden	Christensen	364	22.3
	1975	U.K.	Wallin	300	20.6
	1976	U.S.A.	Baker	76	36.8
	1976	U.K.	Finch	250	36
	1977	France	Rousset	4252	16.8
	1980	Nigeria	Onile	200	19

*Modified from David, 1978.
'First' author's name listed only.

Table 4. Differences between human and bovine strains of group B Streptococcus

Human strains	Bovine strains
Virulent for mice and usually lactose negative	Less virulent for mice and usually lactose positive*
Most strains typable by Lancefield's precipitation test	up to 15% of strains may be untypable*
R and X strains less frequently found (2–6%)	R and X strains more frequently found (30–40%)

*From Simmons & Keogh (1940).
†From Pattison *et al.* (1955).

& Okada, 1977; Onile *et al.*, 1980; Dawodu, Damole & Onile, 1983).

(b) Postnatal colonization. Nosocomial transmission and persistence of organisms acquired during the perinatal period have been suggested to be the means of post-natal acquisition of GBS (Roberts, 1976, Ferrieri *et al.*, 1977; Paredes *et al.*, 1977).

(c) Acquisition in adults. The female genital tract is the most highly colonized site by GBS. The organism gets to this site by sexual transmission and contamination from the ano-rectal flora which in the first place originated from the naso-pharyngeal flora (Franciosi *et al.*, 1973; Christensen *et al.*, 1974; Badri *et al.*, 1977; Onile, 1980).

Table 5. Type distribution of human strains of group B Streptococcus

Author	Isolates (% Total)										
	Ia	Ib	Ic	Ic protein only	II	III	Other	X	R	NT	No. tested
1. Finch *et al.*, 1976	11.4	22.2	—	—	21.7	40	—	—	—	14.8	115
2. Bavenger & Maeland, 1977	7.8	15.6	6.7	—	41.1	22.2	—	—	—	6.7	90
3. Paredes *et al.*, 1977	—	9.3	16.3	—	46.5	27.9	—	—	—	—	43
(a) Mother											
(b) Infants†		6.1	18.2	—	33.3	39.4	—	—	—	3.0	33
4. Parker, 1978	7	10	26	—	22	25	1	—	—	9	117
5. Pass *et al.*, 1979	12	16	7	—	3.1	33	—	—	—	11	290
6. Onile 1980	—	5.3	7.6	6.8	4.5‡	56.1§	—	11.4	3.8	4.6	132

NT, non-typable.

Mothers on admission. †Newborns; 2.1% acquired type Ia organism on discharge (usually 3 days).

‡X and R antigens were each associated with 16.6% of type II strains.

§R antigen was associated with 71.6% of type III strains.

Clinical spectrum of GBS infections

Animal pathogen

The earliest reports of GBS infections were in the bovidae (Nocard & Mollerau, 1887) among whom it causes mastitis. Prevalence rates of bovine mastitis varies from place to place. In India, herd prevalence rates of 10.23% and 7.55% were reported for urban and rural areas respectively (Kalra & Dhonda, 1964). A prevalence rate of 20–40% were reported by Anon (1974) for Australia, while in Nigeria it varied between 17 and 38% (Ojo & Falade, 1974; Onile, 1983). The organism damages the cells of the mammary gland alveoli and their surrounding structures, leading to progressive involusion of the alveoli. Consequently there is a decrease in milk production, an alteration in the concentration of the various minerals, a depression of the butter fat and solids-not-fat (SNF) percentages, and high bacteria and somatic cell content, which may lead to coagulation or curdling of milk (King, 1969; Ojo & Falade, 1974).

Human pathogen

Cases of uterine infection by GBS were reported by Lancefield and Hare (1935) and later confirmed by Rantz (1942). However it was not until the past decade that attention was focused on GBS as an important cause of human infection.

Neonatal disease

This has been classified into 'early' and 'late syndromes' on the basis of the time of onset of neonatal disease (Franciosi *et al.*, 1973; Anthony & Okada, 1977).

Early syndrome

This usually presents within the first 2–3 days of life or at the latest within the first week of birth in the form of septicaemia (Franciosi *et al.*, 1973; Onile *et al.*, 1980). The condition resembles the Idiopathic Respiratory Distress Syndrome (IRDS) clinically and although it may occur in full-term infants without any associated obstetric complications it is usually associated with prematurity, premature rupture of the membranes, maternal fever and other signs of post-partum infection (Paredes, Wang & Yow, 1976; Anthony and Okada, 1977). The incidence in Europe and North America is 3–4/1000 live births while in Nigeria it is about 0.4/1000 live births (Anthony & Okada, 1977; Onile 1983). The degree of severity varies and mortality is usually between 50 and 60%

(Anthony & Okada, 1977; Knox, 1979) although no fatality has been reported in Nigeria (Onile, 1983). Baker and Kasper (1976) associated susceptibility to neonatal GBS infection with maternal antibody deficiency to the homologous strains.

The early syndrome may be caused by any of the common five serotypes (Ia, Ib, Ic, II and III) of GBS, although it has been more frequently associated with type Ia strains (Eichoff *et al.*, 1964; Franciosi *et al.*, 1973). In Nigeria type Ia is very rare indeed and infections are caused by other serotypes (Onile, 1980; Dawodu *et al.*, 1983).

Late syndrome

During the late neonatal period GBS infection usually appears in the form of meningitis (Anthony & Okada, 1977). The baby may present with drowsiness, fever, irritability, tachypnoea or seizures (Jamal, 1981). Two cases of late GBS infection have been reported from Nigeria: one fatal case of meningitis from Lagos (Odugbemi *et al.*, 1979) and another case of meningitis with epidural effusion from Ibadan (Onile, 1983). The latter patient recovered without neurological sequelae.

The late syndrome has a better prognosis than the early disease with a case fatality rate of about 23% (Barton, Feigin & Lin, 1973).

The type III organism is usually responsible for meningitis whether in the 'early' or 'late' disease. This is because type III organisms have invasive properties for the meninges, a property conferred on it by its sialic acid content.

Other neonatal infections

Other manifestations of neonatal disease by GBS are conjunctivitis, otitis media, peritonitis, osteomyelitis and haemorrhage; perhaps due to disseminated intravascular coagulation DIC (Ellis, Johnson & Austin 1976; Ragnhildstreit & Ose, 1976; Anthony & Okada, 1977; Henderson, Roberts & Dorsey, 1977). Apart from GBS other organisms have been documented as causing DIC. A case of DIC giving rise to symmetrical gangrene of the extremities was reported by Odugbemi Lesi & Fegisitan (1976) in Lagos, Nigeria. This was associated with *Neisseria meningitidis* type C meningitis. McGehee, Ragaport and Hjort (1967) also reported a case of DIC in fulminant meningococcaemia. DIC could also be due to viral causes (McKay & Margaretten, 1967).

Adult infections

It is infrequently that adult GBS infections are reported. The common conditions it causes are endometritis, pyelonephritis, meningitis, tracheo-bronchitis, arthritis, peritonitis and impetigo (Eickhoff *et al.*, 1964; Butter and De Moor, 1967; Duma *et al.*, 1969; Bayer *et al.*, 1976; Onile, 1983). The common predisposing factors as reported by these authors are prolonged labour, prolonged rupture of the membranes, urological disorders including prostatic hypertrophy, renal failure, bladder trauma and chronic indwelling Foley catheterization. Liver disease, malignancy, sickle-cell disease and diabetes mellitus are other factors. Polymicrobial endocarditis may also be caused by GBS in conjunction with *Eikenella corrodens*, a normal flora of the oral cavity, especially in drug addicts, patients with artificial heart valves and following dental extractions (Brooks *et al.*, 1974; Khairat, 1967; Saravolatz *et al.*, 1980; Shinher *et al.*, 1980).

Prognosis of adult GBS infection is worse with endocarditis and meningitis and the presence of debilitating underlying disease. Recent reports by Bayer *et al.*, (1976) recorded a mortality of 8% among their patients in the United States of America. No mortality has been recorded from Nigeria (Onile, 1983). The serotypes frequently associated with adult infections probably depend on the prevailing strains among the local population (Bayer *et al.*, 1976).

Pathological changes

The gross changes may include clinical signs of localized infection on the skin and mucous membranes; septic spots, impetigo and conjuctivitis (Jamal, 1981, Onile, 1983). The cerebrospinal fluid (CSF) findings in cases with meningitis are those typical of pyogenic meningitis. Gram stained smears may show numerous Gram positive cocci in pairs or

chains. The cell count is raised, mainly polymorphonuclear leucocytes and may range from 100 cells/ml of CSF to 2000 cells/ml and above.

Microscopic sections of lungs obtained at autopsy may show interstitial haemorrhage and dilatation of interlobular lymphatics in the early onset type of neonatal infection. Hyaline membrane formation, both focal and typical may also be observed (Ablow *et al.*, 1976). Gram positive cocci are also commonly present within the membrane and in the lung tissue.

Radiological findings in the early syndrome are similar to those of the IRDS: ranging from a diffuse and granular pattern to that of generalized opacification and the typical picture of pneumonia (Katzarstein, Davis & Braude, 1976; Vollman *et al.*, 1976). Cardiomegaly is a common feature of infants with septicaemia from GBS (Leonidas *et al.*, 1977). The total white blood count is usually low during the first 24 h of GBS sepsis. Abnormalities are also detected in the band neutrophil ratio in the peripheral blood (Jamal, 1981).

Antibiotics susceptibility and treatment

GBS is highly sensitive to penicillin, cefotaxime, chloramphenicol and erythromicin (Bayer *et al.*, 1976; Jokipi & Jokipi, 1976). Eickhoff and Klein (1964) reported MICs of penicillin G and ampicillin for GBS to be 0.02 mg/ml and 0.04 mg/ml respectively; while Onile (1983) reported that penicillin had an MIC of 0.1 i.u./ml for Nigerian strains of GBS. These indicate that the organism is highly sensitive to penicillin which is the drug of choice for treating established infections by GBS.

A combination of penicllin and gentamicin is to be strongly recommended in Nigeria for the empiric treatment of neonatal sepsis because the enterobactericeae are common causes of sepsis during the neonatal period and are resistant to penicillin (Alausa & Montefiore, 1978). The recommended dose of penicillin for children is 250 000 units/kg/day.

Control of GBS infections

The control of neonatal GBS sepsis should be based on the following principles.

(i) Eradication of vaginal colonization in patients with amnionitis. Antenatal patients could be screened routinely for GBS carriage at 28 and 34 weeks. Colonized mothers found during labour to have ruptured their membranes for more than 24 h or with evidence of amnionitis as indicated by the presence of offensive liquor, or maternal fever could be treated with 500 mg penicillin (Yow *et al.*, 1979) to suppress vaginal and rectal colonization. The danger of penicillin allergy should not be overlooked and the cost of screening antenatal patients may make it difficult in developing countries where GBS is not yet a major health problem.

(ii) Limiting nosocomial acquisition of GBS by treating the umbilical cord of newborns with triple dye.

(iii) Chemoprophylaxis of infants at risk: All children who get early respiratory distress should have a blood culture done and immediately given benzyl penicillin (30 mg/kg twice daily) and gentamicin (3 mg/kg/day) until the results of the cultures are available. If GBS is isolated then the patient is continued on penicillin alone for two weeks.

Immunization (prophylaxis)

Type III polysaccharide vaccines are being developed by Baker, Edwards and Kasper (1978). Antibodies of the IgG class are induced by these vaccines, and may be of use in the near future in preventing GBS sepsis if administered to mothers. This vaccine when available should be useful when given to adolescents before they are married as it is done with Rubella vaccine.

Administration of specific high litre immune globulin to all infants delivered to carriers immediately after birth could prevent late onset disease and perhaps reduce the incidence of early onset as well (Eichenwald, 1978). It is expensive to screen all pregnant mothers for GBS carriage and to produce immune globulins. Also there is great danger in giving penicillin to mothers as a routine, while an effective vaccine is yet to be in the market. In view of this, the most practicable way of controlling neonatal GBS sepsis in developing

countries as of now would be by chemoprophylaxis of infants at risk.

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