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Bacterial and fungal etiologies of meningeal irritation syndrome in an emergency department

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Meningeal irritation syndrome denotes to a range symptoms that require emergency management. Clinically, it is an expression of an irritation of the meninges combining with headache, fever, neck stiffness, altered consciousness and vomiting. The aim of this prospective study was to contribute to the management of medical emergencies. Cerebrospinal fluid (CSF) samples recovered from patients presenting signs of meningeal irritation syndrome were submitted to bacteriological, biochemical and fungal analyses. 2656 patients were received during the study period with 47 (1.8%), which had signs of meningeal irritation syndrome. 17% of cases were bacterial meningitis while 10.6% were fungal meningitis. Microbes isolated were *Streptococcus pneumoniae, Streptococcus agalactiae, Haemophilus influenza* and *Cryptococcus neoformans*. All bacteria were found to be sensitive to amoxicillin + clavulanic acid, gentamycin, chloramphenicol and ceftriaxone, and resistant to penicillin G, ampicillin and cotrimoxazol. All cases of cryptococcal meningitis were HIV (+) subjects. Other causes of meningeal irritation syndrome were HIV-related encephalitis (19.2%) and malaria (19.2%). Bacterial and fungal meningitis accounted for about 1/3 of the cases of meningeal irritation syndrome. The bacteria isolated presented a satisfactory sensitivity profile to the usual antibiotics. Although the prevalence of meningeal irritation syndrome appears to be low, it would be interesting to pay particular attention to it given the high representation of immunocompromised patients.

Key words: Meningeal irritation syndrome, bacterial meningitis, fungal meningitis, Cerebrospinal fluid (CSF) analysis, antibiotic susceptibility.

INTRODUCTION

Meningeal irritation syndrome denotes to arange symptoms (headache, vomiting, neck stiffness, fever and altered consciousness) that require emergency management. Clinically, it is an expression of an irritation of the meninges. One cause can be meningitis, an inflammation of the meninges usually owing to a bacterial infection, viruses, fungi, protozoans, or other causes that cannot be determined (Bruneel and Wolf, 2000; Desmettre et al., 2007).

Bacterial meningitis remains the most dangerous. Early clinical diagnosis and prompt treatment are the hallmark for survival. Empirical antimicrobial treatment is recommended to limit mortality (Loukili et al., 2015). The choice of molecule depends largely on the local epidemiology and the pharmacology of available agents. Infectious meningitis are particularly challenging in developing countries due firstly to poor-socioeconomic conditions that facilitate the spread of the pathogens and poor access to care, and secondly to the HIV epidemic which has changed the pattern of meningitis in African countries in particular (Hakim et al., 2000; Schutte et al., 2000; Traore et al., 2014). In these countries, meningitis remains one of the most serious infections occurring in individuals with HIV infection.

With the view to contribute in the management of medical emergencies, a study on the clinical and biological presentation of patients with meningeal irritation syndrome was conducted at the Yaounde Central Hospital Emergency Unit. The specific objectives were: to determine the prevalence of bacterial or fungal meningitis among patients with meningeal irritation syndrome, to identify the microbes involved and to evaluate the susceptibility to common antibiotics, of isolated bacteria. An attempt to correlate biochemical characteristics of a cerebrospinal fluid sample and the etiology of a meningeal irritation syndrome was also made.

MATERIALS AND METHODS

This study was performed from January to May 2009, in the emergency unit of the Yaounde Central Hospital. It was approved by the National Ethics Committee. Patients aged between 16 to 81 years, presenting with signs of meningeal irritation syndrome were included. Then, a clinical examination was performed by a physician.

Sociodemographic and clinical data were collected using a questionnaire. CSF samples were collected and submitted to cyto-bacteriological, biochemical and fungal analyse.

CSF sample collection and analysis

Two to five milliliters of CSF were collected in a sterile container, according to good clinical practices and were immediately processed. Each CSF sample was subjected to macroscopic examination. It was then centrifuged at 2000 rpm for 15 min. The supernatant was used for biochemical, cytological and immunological tests whereas the pellet was used for microbiological analysis (Joffin and Leyral, 2005).

Biochemical analysis

Concentrations of proteins, glucose and chlorides in CSF samples were determined using respectively, the Biuret (Falkner and Metter, 1982), Trinder (Trinder, 1969) and Tiezt methods (Tietz et al., 1999).

Glucorachy was considered normal when it was greater than or equal to 0.5 g/l (50% of the patient's blood sugar) and abnormal in the opposite situation. Chlorurorachy was lower, normal and greater for values respectively, less than 110 mmol/l, between 110 and 130 mmol/l and greater than 130 mmol/l. Proteinorachy was lower, normal and higher for values respectively, of less than 0.25 g/l, between 0.25 and 0.45 g/l and greater than 0.45 g/l.

Immunological analysis

Soluble bacterial antigens of *Streptococcus agalactiae*, *Haemophilus influenza* b, *Streptococcus pneumoniae*, *Neisseria meningitidis* and *Escherichia coli* were determined, using latex agglutination tests (LAT) (Reagent Remel Wellcogen Bacterial Antigen Kit). Cerebrospinal fluid (CSF) sample was pre-heated at 100°C in a water bath for 5 min, cooled to room temperature and centrifuged at 2000 rpm for 15 min. The supernatant was then used for LAT.

Disposable reaction cards containing six separate circles with the color codes of different test latex reagents were provided with the kit. A single drop of respective samples was placed on the separate circles of the reaction card and a drop of each of five different test latex reagents was added to the separate circles. These were mixed thoroughly and manually rotated for 3 min. They were then observed for agglutination. Positive and negative controls and control latex tests were put up (Kaldor and Asznowick, 1977).

Cytological exam

Leukocytes were counted using a Nageotte counting chamber after May-Grünwald-Giemsa staining (Piaton et al., 2016).

Bacteriological and mycological analyses

After a microscopic examination of the smears prepared from the sediment, the isolation was carried out onto sheep blood agar, chocolate agar with X and V factors, and Sabouraud agar without Actidione. Bacterial growth was observed after incubation of the agar plates at 37°C during 24 to 48 h. The identification was made on the basis of biochemical and immunological characteristics (presence of catalase and of oxidase, needs in factors V and X for *H. influenzae*, sensibility to optochine for *S. pneumoniae*, oxidase test, serogrouping test for *S. agalactiae*) (Denis and Mounier, 1991; Joffin and Leyral, 2005).

Antimicrobial susceptibility testing with the following antibiotics: penicillin, ampicillin, ceftriaxone, gentamycin, chloramphenicol and cotrimoxazol were performed according to standards for

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Table 1. CSF cell count and biochemical parameters of patients.

Parameter	Patients = 47 (%)
Leukocyte count (cells/mm^3)	
≤ 4	29 (61.7)
5 - 10	6 (12.8)
11 - 99	5 (10.6)
≥ 100	7 (14.9)
Mononuclear cells (%)	
≤ 50	7 (14.9)
> 50	40 (85.1)
Polymorphs cells (%)	
≤ 50	38
> 50	9 (19.2)
Glucose (g/l)	
< 0.5	23 (48.9)
[0.5 - 0.6	24 (51.1)
Chloride (mmol/l)	
< 110	8 (17)
110 - 130	36 (76.6)
> 130	3 (6.4)
Protein (g/l)	
< 0.25	6 (12.8)
0.25 - 0.45	32 (68.1)
> 0.45	9 (19.2)
Normal CSF [(1)]	20/47 (42.6)

[(1)] Normal Cerebrospinal Fluid [leucocytes ≤ 4 cells / mm^3; glucose (0.5 - 0.6 g/l), chloride (110 - 130 mmol/l) and protein (0.25 - 0.45 g/l)] antimicrobial disk susceptibility tests described by Ferraro et al. (2003).

Statistical analysis

The data obtained were subjected to ×2 tests, which was applied for group comparison. A p value <0.05 was considered statistically significant.

RESULTS

Among the 2656 patients that were received at the emergencies, 47 (1.8%) were eligible and the informed consent to participate to the study was obtained for all. 25 (53.2%) subjects were male. Patients aged ≥18 years were found for 45 cases (95.7%).

Clinical features of study population

The delay between the onset of symptoms and consultation ranged from 1 to 30 days. The median was 4.5 days. Fever was the most predominant symptom with 85.1% cases, followed by headache (61.7%) and altered consciousness (61.7%). The percentage of neck stiffness (42.6%) and vomiting (27.7%) were relatively low, compared to other symptoms. 15 (31.9%) patients died before the end of the study.

31 patients (65.9%) were HIV positive, 4 (8.5%) were HIV negative, and 12 (25.5%) had an unknown status. Out of the HIV positive patients, 12 (38.7%) were under antiretroviral treatment.

Cytology and biochemistry of CSF

The number of leukocytes from CSF was found to be normal (≤ 4 cells /mm^3) in 29 samples (61.7%), moderate (between 5 and 100 cells/mm3) for 11 samples and high (>100) in 7 samples. Regarding the different kind of leukocytes, mononuclear and Polymorphs cells counts were respectively higher in 40 (85, 1%) and 9 (19, 2%) samples.

The level of glucose, chlorides and proteins was lower in 23 (48.9%), 8 (17%) and 6 (12.8%) samples, respectively. Levels of chlorides and proteins were found to be higher in 3 (6.4%) and 9 (19.2%) samples, respectively. With regard to the criteria that a normal Stem cell factor (SCF) should have, 20 samples (42.6%) out of the 47 analysed were normal, while 27 samples (57.4%) were abnormal (Table 1).

Prevalence of bacterial or fungal meningitis among patients with meningeal irritation syndrome

Bacterial and *Cryptococcus* meningitis accounted respectively for 17 and 10.6% of cases of meningeal irritation syndrome, presented at the Emergency Centre of the Yaounde Central Hospital.

Three other etiologies of meningeal irritation syndrome were recorded: HIV encephalitis (19.2%), malaria (19.2%), and septicemia (2.1%).

Bacteria and fungi involved in bacterial or fungal meningitis among patients with meningeal irritation syndrome

Three bacterial species were isolated and identified in six samples; namely *S. agalactiae* (2 cases), *S. pneumoniae* (2 cases) and *H. influenzae* (2 cases). Bacterial soluble antigens of *S. agalactiae* (3 cases), *S. pneumonia* (3 cases) and *H. influenza* (2 cases) were found from the different samples. *Cryptococcus neoformans* was identified in five samples.

Antibiotic susceptibility of isolated bacteria

All the isolated bacteria were found to be susceptible to

Table 2. Antibiotics sensitivity pattern of bacterial species isolated.

Antibiotics		*S. pneumoniae* (n = 2)		*S. agalactiae* (n = 2)		*H. influenzae* (n = 2) (n = 2)		
		S	R	S	R	S	I	R
Class of β-lactamines	Penicillin G	1	1	1	1	1	0	1
	Ampicillin	1	1	1	1	1	0	1
	Amoxicillin+Clavulanic acid	2	0	2	0	2	0	0
	Ceftriaxone	2	0	2	0	2	0	0
Class of aminosides	Gentamycin	2	0	2	0	1	1	0
Class of phenicoles	Chloramphenicol	2	0	2	0	2	0	0
Class of sulfamides	Cotrimoxazol	1	1	2	0	2	0	0

S, Sensitive; I, intermediary; R, Resistant.

Table 3. Laboratory diagnosed meningitis in patients in relation to their HIV serostatus.

Aetiology of meningitis	HIV positive	HIV negative	Unknown status
Cryptococcal meningitis	5 (100%)	00	00
Bacterial meningitis			
Streptococcus pneumoniae	2 (25%)	1 (12.5%)	00
Streptococcus agalactiae	2 (25%)	00	1 (12.25%)
Haemophilus influenzae	1 (12.5%)	00	1 (12.5%)

amoxicillin + clavulanic acid, gentamycin, chloramphenicol and ceftriaxone; and resistant to penicillin G, Ampicillin and Cotrimoxazol (Table 2).

Meningeal irritation syndrome and HIV

40% of patients with meningeal irritation syndrome were HIV positive. Thus, all patients with encephalitis, fungal meningitis and most of those with bacterial meningitis were HIV infected (Table 3).

Cytology and biochemistry of CSF versus etiology of a meningeal irritation syndrome

In the subgroup with normal leukocytes (29 subjects), proteinorachy and chlorurorachy were also normal in all samples. Glucorachy was normal in 24 samples and low in five. The etiologies of the meningeal irritation syndrome identified were one fungal meningitis, unclarified diagnoses, nine malaria (four with hypoglucorachy) and four HIV encephalitis.

In the subgroup with a moderate level of leucocytes (11 samples), hypoglucorachy was observed in all the samples, proteinorachy was normal in three, low in six and high in two samples. Chlorurorachy was normal in one, low in seven and high in three samples. Etiologies identified were five encephalitis (with hypoproteinorachy), four fungal meningitis, one bacterial meningitis and one malaria (with hyperproteinorachy).

In the last subgroup with high levels of leukocytes (seven samples), glucorachy was low in all samples while proteinorachy was high. Chlorurorachy was normal in six and low in one. The meningeal irritation syndrome was caused by bacteria (Table 4).

DISCUSSION

The emergency unit of the YCH receives more than 50% of emergency's cases in Yaounde. With regard to the total number of patients (2656) that were received during the study, 1.8% (47) presented meningeal irritation syndrome. Hence, the situation is not so dramatic, but should not be neglected.

Demographic data analysis of patients revealed that they were mainly males (53.2 %). This finding agrees with those of Fouad et al. (2014); Khater and Elabd (2016) who confirmed that males were more significantly affected with bacterial meningitis than females. Concerning the clinical features of enrolled patients, fever was the most predominant sign (85.1%), followed by headache (61.7%), altered consciousness (61.7%), neck stiffness (42.6%) and vomiting (27.7%). The two first signs are in accordance to those of Newman (2004) for patients with meningitis. However, we did not observed the same proportions regarding the altered consciousness

Table 4. Correlation between the etiology of meningeal irritation syndrome and the biochemical characteristics of CSF.

Leucocytes count diagnoses (cells/mm^3)		Biochemistry								
		Glucorachy (g / l)			Proteinorachy (g / l)			Chlorurorachy (mmol / l)		
		Low (< 0.5)	Normal (≥ 0.5)	High (>0.5)	Low (< 0.25)	Normal (0.25 < n < 0.45)	High (> 0.45)	Low (< 110)	Normal (110 < n < 130)	High (> 130)
Normal (≤ 4) 61.7%	Malaria 31.04%	±	±			+			+	
	Fungal meningitis 3.45%	+				+			+	
	Encephalitis 13.79%		+			+			+	
	Unclarified diagnoses 51.72%		+			+			+	
Moderated (5 < n < 100) 23.4%	Malaria 9.10%	+					+	+		
	Fungal meningitis 36.35%	+			±	±		+		
	Encephalitis 45.45%	+			+			±	±	±
	Bacterial meningitis 9.10%	+					+	+		
High (> 100) 14.9%	Bacterial meningitis 100%	+					+	±	±	

and neck stiffness for which he got 46 and 70%, respectively.

Higher frequency of patients with altered consciousness was observed in our study which could be explained by the long delay between the onset of the symptoms and admission to the hospital as described by Loukili et al. (2015); indeed, the poor socio-economic conditions of the populations resulted to low health care access. The rate of mortality was high (31.9%) because of the very late admission to the emergencies; most of the patients (33.3%) were self-medicated and decided to go to the hospital because of the persistence and worsening of the clinical signs implication; when the causal agent had caused serious damages to their organism.

Analysis of the CSF allowed to distinguish 3 subgroups in which leucocytes counts were normal, moderate or high. The number of leucocytes was normal in patients suffering from malaria. It was normal or moderate for those having HIV encephalitis and fungal meningitis. This was high from those having bacterial meningitis; the last observation was in accordance with those of Khater and Elabd (2016). Patients with hypochlorurachy presented vomiting. Vomiting is a perturbation of cerebrospinal fluid (Pradat and Jan, 2007) and is inconstant at the onset of infection (Desmettre et al., 2007).

High proteinorachy and low glucorachy were observed in patients with meningitis. High proteinorachy can be explained by the increase of the hematomeningeal barrier permeability which results in the passage of many proteins and others plasma molecules (Maugein, 2006). Low glucorachy results from the use of glucose by infectious germs (Pradat and Jan, 2007).

The fact that detection of antigens was more efficient in diagnosing meningitis even from samples of patients under self antibiotherapy, was not a surprise. As far as immunological and bacteriological tests are concern, immunological test appeared to be more accurate to diagnose active or latent infection since it targets the consequence of the presence of the infectious agent and not the infectious agent itself. *Streptococcus pneumonia* and *S. agalactiae* were the most responsible of bacterial meningitis (75%); our results are in accordance with those of previous studies (Koulla-Shiro et al., 1997; Bruneel and Wolf, 2000; Fonkoua et al., 2001; Popovic et al., 2000; Pradat and Delattre, 2002). Traoré et al. (2014) described *S. pneumonia* as being responsible for meningitis in young adults and the elderly in Cameroon, while *S. agalactiae* was responsible for neonatal meningitis and severe opportunistic infections in immune-compromised patients, mainly those suffering from acquired immune deficiency syndrome (AIDS).

H. influenzae was also isolated; this bacterium generally infects subjects aged from 1 month to 15 years. We did not isolate *Neisseria meningitidis* in this study; that could be explained by the fact that, bacteria are mainly involved in the cases of epidemics of meningitis in sahelian region of Cameroon. *C. neoformans* was the only microbe responsible of fungal meningitis, and in 40% of the cases of meningeal irritation syndrome from patients with AIDS; these results are in accordance with those of previous studies (Gordon et al., 2000; Roos, 2003; Millogo et al., 2004; Békondi et al., 2006), since *Cryptococcal meningitis* has been described as the most common life-threatening opportunistic fungal infection in patients with immune-compromised status.

Conclusion

Bacterial and fungal meningitis accounted for 27 (6%) of cases of meningeal irritation syndrome presented at the Emergency Centre of the Yaounde Central Hospital. *S. pneumonia* and *S. agalactiae* were the main causative agents of bacterial infection, while *C. neoformans,* was the one responsible for fungal infection.

The bacteria isolated presented a satisfactory susceptibility profile to the usual antibiotics although, the prevalence of meningeal irritation syndrome appears to be low in the medical emergencies at Yaoundé Central Hospital. Special consideration should be given to the high representation of immunocompromised patients.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Békondi C, Bernebe C, Passone N, Minssart P, Kamallo C, Mbolidi D, Germani Y (2006). Primary and opportunistic pathogens associated with meningitis in adults in Bangui, Central African Republic, in relation to human immunodeficiency virus serostatus. Int. J. Inf. Dis. 10:387-395.

Bruneel F, Wolff M (2000). Méningites aiguës. In: Encycl Méd Chir (Editions Scientifiques et Médicales Elsevier SAS, Paris, tous droits réservés), Neurologie. 18p.

Denis F, Mounier M (1991). Cytobacteriological analysis of the cerebrospinal fluid. In: Carbonelle B, Denis F, Marmonier A, Pinon G, Vargues R. Medical bacteriology – usual technics. SIMEP edition, Paris. pp. 47-51.

Desmettre T, Rusterholtz T, Capellier G (2007). Acute and infectious meningitis in adults. Initial management in emergency. In: Emergency Medicine, Elsevier, Paris. 23p.

Falkner WR, Metter S (1982). Selected methods of clinical chemistry. AACC Washington D. C., 9, 319.

Ferraro MJ, Wilker MA, Craig WA, Dudley N, Hecht W, Hindler J, Reller BL, Sheldon AT (2003). Performance Standards for Antimicrobial Disk Susceptibility Tests. 8th edition. NCCLS 23:40-50.

Fonkoua MC, Cunin P, Sorlin P, Musi J, Martin PM (2001). Les méningites d'étiologie bactérienne à Yaoundé (Cameroun). Bull. Soc. Pathol. Exot. 94:300-303. http://www.pathexo.fr/documents/articles-bull/T94-4-2312.pdf

Fouad R, Khairy M, Fathalah W, Gad T, El-Kholy B, Yosry A (2014). Role of clinical presentations and routine CSF analysis in the rapid diagnosis of acute bacterial meningitis in cases of negative gram stained smears. J. Trop. Med. Volume 2014 (2014). Article ID 213762. 7p.

Gordon SB, Walsh AL, Chaponda M, Gordon MA, Soko D, Mbwvinji M (2000). Bacterial meningitis in Malawian adults: pneumococcal disease is common, severe, and seasonal. Clin. Infect. Dis. 31:53-57.

Hakim JG, Gangaidzo IT, Heyderman RS, Mielke J, Mushangi E, Taziwa A (2000). Impact of HIV infection on meningitis in Harare, Zimbabwe: a prospective study of 406 predominantly adult patients. AIDS 14:1401-1407.

Joffin JN, Leyral G (2005). Microbiology technics – technics dictionary 3th edition, Sceren CRDP Aquitaine, France. pp. 144-217.

Kaldor J, Asznowick R (1977). Latex agglutination in diagnosis of bacterial infection with special reference to patients with meningitis and septicemia. Am. J. Clin. Pathol. 68:284-285.

Khater WS, Elabd SH (2016). Identification of Common Bacterial Pathogens Causing Meningitis in Culture-Negative Cerebrospinal Fluid Samples Using Real-Time Polymerase Chain Reaction. Int. J. Microbiol. Int J Microbiol. 2016:4197187. doi: 10.1155/2016/4197187.

Koulla-Shiro S, Mbuagbaw J, Kuaban C, Kouda Zeh A (1997). Etiology and Outcome of Adult Bacterial Meningitis in Yaounde, Cameroon. Int. J. Infect. Dis. 2:9-11.

Loukili M, Barbach Y, Midaoui A, Souirti Z, Messouak O, Belahsen F (2015). The management of meningitis at the UHC Hassan II emergiencies of Fez. Rev. Neuro. 171(1):142-143.

Maugein J (2006). Regional pneumocoque observation posts: Serotype and antibiotics resistance surveillance of Streptococcus pneumoniae strains isolated in France. Bull. Epidemiol. Hebd. 1:6-8.

Millogo A, Ki-Zerbo GA, Andonaba JB, Lankoande D, Sawadogo A, Yaméogo I and Sawadogo A B (2004). Neuromeningial cryptococcosis during infection by HIV at the Bobo-Dioulasso hospital center (Burkina Faso). Bull. Soc. Pathol. Exot. 97(2):119-121.

Newman HN (2004). Clinical assessment of meningitis in adults. Ann. Emerg. Med. 44:71-73.

Piaton E, Fabre M, Goubin-Versini I, Bretz-Grenier M-F, Courtade-Saïdi M, Vincent S, Belleannée G, Thivolet F, Boutonnat J, Debaque H, Fleury-Feith J, Vielh P, Egelé C, Bellocq J-P, Michiels JF, Cochand-Priollet B (2016). Guidelines for May-Grünwald–Giemsa staining in haematology and non-gynaecological cytopathology: recommendations of the French Society of Clinical Cytology (SFCC) and of the French Association for Quality Assurance in Anatomic and Cytologic Pathology (AFAQAP). Cytopathology 27(5):359-368.

Popovic T, Ajello G, Facklam R (2000). Laboratory technics for the diagnosis of *Neisseria meningitis*, *Streptococcus pneumoniae* and *Haemophilus influenzae*, WHO, 17 – 18.

Pradat F, Delattre J (2002). Chronic meningitis. In. Neurology. Elsevier, Paris. 28p.

Pradat F, Jan M (2007). Meniningeal syndromes. In: Emergiency medecine. Elsevier, Paris. 14p.

Roos (2003). Fungal meningitis. Encycl. Neuro. Sci. 2:405-408.

Schutte CM, Van der Meyden CH, Magazi DS (2000). The impact of HIV on meningitis as seen at a South African Academic Hospital (1994 to 1998). Infection 28:3-7.

Tietz NW, Burtis CA, Ashwood ER, Saunders WB (1999). Text book of clinical chemistry. 3rd edition, Ed C. A. Burtis. pp. 1063-1064, 1104.

Traore FA, Cissoko Y, Tounkara TM, Sako FB, Mouelle AD, Kpami DO, Traore M, Doumbouya M (2014). Etiology of lymphocytic meningitis in people living with HIV followed up at the infectious disease center at Conakry. Med. Sant. Trop. 1:1-4.

Trinder P (1969). Clinical biochemistry. Ann. Clin. Biochem. 6:24-37.