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Original Article

Microbiology Section

Acinetobacter Meningitis: A Retrospective Study on its Incidence and Mortality Rates in Postoperative Patients at a Tertiary Care Centre in Northern India

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ABSTRACT

Introduction: *Acinetobacter* is a non fermenting, Gram negative bacillus, a causative pathogen of hospital-acquired infections due to its inherent Multidrug-Resistant (MDR) property. It is held responsible for the majority of nosocomial meningitis in patients undergoing neurosurgical procedures.

Aim: To identify the clinical characteristics, drug-resistance and mortality rate among the patients suffering from meningitis caused by *Acinetobacter baumannii.*

Materials and Methods: This retrospective, single-centre study was carried out in the Bacteriology section of the Department of Microbiology at Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, Uttar Pradesh, India, from February 2019 to February 2022. A total of 150 Cerebrospinal Fluid (CSF) samples from routine bacterial culture-confirmed patients were included in the study. All clinical data were extracted from the Hospital Information System (HIS). All the isolates were identified by Matrix Assisted Laser Desorption/Ionisation-Time of Flight-Mass Spectrometry (MALDI-TOF-MS) assay and antibiotic sensitivity testing was performed according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

Results: The study included 150 (7.55%) cases of culture-proven bacterial meningitis among 1986 CSF samples collected from February 2019 to February 2022. There were 45 (30.0%) cases of *Acinetobacter* meningitis. Thirty-five (77.8%) patients had undergone neurosurgical procedures for the removal of space-occupying lesions from the brain parenchyma. Forty-two (93.3%) isolates were resistant to amikacin and a cumulative resistance of almost 93.3-95.6% was observed among cephalosporins. Fluoroquinolone resistance was observed in 43 (95.6%) patients and carbapenem resistance was observed in 42 (93.33%) isolates. Overall, 12 (26.7%) succumbed to their infections.

Conclusion: *Acinetobacter* meningitis causes delay in the recovery of the patient undergoing intracranial surgery, amounting to a delay in brain parenchyma healing in the case of neurosurgical patients.

Keywords: Bacterial meningitis, Gram negative bacilli, Mass spectrometry, Neurosurgical procedures, Nosocomial meningitis

INTRODUCTION

Hospital-acquired meningitis is the most common morbidity faced by patients undergoing neurosurgical procedures [1]. The causative microorganisms responsible for these nosocomially acquired infections include a wide range of Gram negative and Gram positive microorganisms but this scenario has changed over the past decade to include many polydrug-resistant microorganisms in the list of causative pathogens of nosocomial meningitis. Among all other Gram negative bacilli, *Acinetobacter* species have been held responsible for the majority of nosocomial meningitis in patients undergoing neurosurgical procedures and critical patients admitted to the neurosurgery ward [2].

Acinetobacter species is a non fermenting, Gram negative bacillus which is the known causative pathogen of hospital-acquired infections due to its inherent MDR property [3]. It is an opportunistic pathogen that is capable of causing infection in old and debilitated patients admitted to the hospital for a prolonged period. The common array of infections caused by it includes pneumonia, meningitis, bacteraemia, and rarely wound infections [4,5]. *Acinetobacter* species is known as the most common pathogenic bacteria isolated from patients who have undergone craniotomy or other neurosurgical procedures [2].

The presence of Extraventricular Drain (EVD) and Ventriculo-Peritonial (VP) shunt usually after the intracranial procedure for CSF diversion deems the patient susceptible to bacterial meningitis by MDR microorganisms like *Acinetobacter* species [6].

The study aimed to demonstrate the incidence of *Acinetobacter* meningitis among known cases of bacterial meningitis and also include the propensity of the microorganism to cause infection in neurosurgical patients. An overtime increase in the incidence of *Acinetobacter* meningitis among the patients admitted to the study hospital prompted the authors to conduct this study to analyse the accurate incidence of *Acinetobacter* meningitis among all inpatients, recognise the rate of drug resistance among these isolates and identify the group of patients that were more susceptible to this infection at our centre.

MATERIALS AND METHODS

This retrospective, single-centre study was carried out in the Bacteriology section of the Department of Microbiology at a tertiary care centre, where data of *Acinetobacter* meningitis patients from February 2019 to February 2022 was extracted from the laboratory records and HIS and was analysed from March 2022 to May 2022. The study was performed under the project with Reference number 2020-100-EMP-EXP-16 which was approved by the Institutional Ethics Committee (IEC) of Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, Uttar Pradesh, India.

A total of 150 non repeat culture-proven bacterial meningitis samples were included in the study and all clinical data of the patients was extracted from the HIS of the institute.

Inclusion criteria: All CSF samples with culture confirmed bacterial meningitis, from the inpatient department at the centre, without any specific age group and gender were included in the study.

Exclusion criteria: Contaminated samples and samples with delay in transportation for more than two hours were excluded from the study.

Study Procedure

Processing of samples: All CSF samples were collected at a combined receiving station and sent to the bacteriology section of the Department of Microbiology for processing in laboratory according to the standard protocols. The Gram's stain and bacterial culture were performed for each sample. The Blood agar, MacConkey agar, and Robertsons' Cooked Meat broth (RCM) were used for the bacterial culture of the samples. The samples were incubated for 72 hours at 37° C and isolated *Acinetobacter* species colonies were observed on the Blood and MacConkey agar plates. After completion of the incubation period, turbidity was observed in the RCM and identification of the *Acinetobacter* species was facilitated using standard biochemical tests, and MALDI-TOF-MS, (Bruker Daltonics, Germany) assay [7].

Antimicrobial susceptibility testing: The Kirby-Bauer Disc Diffusion method and Epsilometeric test were used for conducting antibiotic susceptibility testing for each of the bacterial isolates, according to the CLSI 2019 guidelines [8]. Antibiotic discs containing amikacin (30 µg), ceftazidime (30 µg), ceftriaxzone (30 µg), cefoperazone-sulbactam (75/10 µg), ciprofloxacin (5 µg), imipenem (10 µg), meropenem (30 µg), and colistin (0.016-256 µg) Epsilometeric test strips were obtained from bioMérieux. Standard inoculums for each bacterial isolate were prepared and set to 0.5 McFarland and a lawn culture was applied on cation-adjusted Muller-Hinton agar plates. The above mentions E-test strips and antibiotic discs were manually placed on the lawn cultured plates and incubated overnight at 37° C. The measurement of zones of inhibition for each antibiotic against each isolate was done and classified as sensitive, intermediate, and resistant according to the tables and guidelines by CLSI 2019 [Table/Fig-1] [8].

Antibiotics	Zone ranges of the antibiotics (mm)		
Susceptibility	Sensitive	Intermediate	Resistant
Amikacin (30 µg)	≥17	15-16	≤14
Ceftazidime (30 µg)	≥18	15-17	≤14
Ceftriaxzone (30 µg)	≥23	20-22	≤19
Ciprofloxacin (5 µg)	≥21	16-20	≤15
Cefoperazone-Sulbactam (75/10 µg)	≥21	16-20	≤15
Imipenem (10 µg)	≥22	19-21	≤18
Meropenem (30 µg)	≥18	15-17	≤14
Colistin (MIC)	≤2	-	≥4

[Table/Fig-1]: Zone ranges and MIC of the antibiotics used against *Acinetobacter* species in performance of antibiotic sensitivity testing according to the tables and guidelines by CLSI 2019 [8].

Microbiological characteristics and drug resistance patterns were analysed for all the *Acinetobacter* species isolated from CSF samples included in the study. The study further demonstrated the risk of isolating MDR-*Acinetobacter* spp, which includes microorganisms resistant to three different classes of antibiotics [9]. The study also assessed the risk factors associated with *Acinetobacter* meningitis in patients with and without shunts.

STATISTICAL ANALYSIS

Quantitative variables were articulated as mean±standard deviation. While analysing of risk factors of acquiring MDR-*Acinetobacter* spp, the comparison between groups for categorical variables was estimated by using χ^2 tests. The results were presented as 95% Confidence Intervals. Statistical analysis was facilitated by the software program International Business Machines (IBM) Statistical Package for the Social Sciences (SPSS) Statistics version 20.0 (IBM Corp., Armonk, NY, USA), with p-value <0.05 considered statistically significant.

RESULTS

The study included 150 (7.55%) cases of culture-proven bacterial meningitis among the 1986 CSF samples collected from February 2019 to February 2022. Forty-five (30.0%) cases of *Acinetobacter* meningitis among the culture-positive bacterial meningitis patients were reported in this study and thus *Acinetobacter* spp. has been deemed the predominant microorganism among the patients suffering predominantly from nosocomial bacterial meningitis. The mean age of the patients was 26.60±18.32 years (range 1-68), and 28 (62.22%) were males. The mean length of hospitalisation was 38.98±22.13 days. The demographic characteristics, presenting complaints, and risk factors of acquiring *Acinetobacter* meningitis are demonstrated in [Table/Fig-2].

Demographic characteristics and risk factors	Frequency (%)
Age (years) mean±SD	26.60±18.32
Gender, male/female	28/17
Source of infection, %	
Nosocomially acquired	41 (91.11)
Community acquired	4 (8.89)
Presenting complaints	
Severe headache	39 (86.7)
High grade fever	26 (57.8)
Altered sensorium	24 (53.3)
Neck stiffness	13 (28.9)
Underlying co-morbidities	
Intracranial surgeries for space occupying lesions	35 (77.8)
Anaemia	35 (77.8)
Encephalopathy	25 (55.6)
Epilepsy	13 (28.9)
Hypertension	11 (24.4)
Diabetes mellitus	9 (20.0)
Stroke	6 (13.3)
Pleural effusion	4 (8.89)
Chronic kidney disease	2 (4.4)
Chronic obstructive pulmonary disease	1 (2.2)
Organ transplant	1 (2.2)
Heart disease	1 (2.2)
Other parameters	
Length of hospital stay, mean±SD	38.98±22.13
CSF total cell count (per cubic mm), mean±SD	1689.67±5861.35
CSF glucose (mg/dL), mean±SD	43.49±30.72
CSF protein (mg/dL), mean±SD	142.166±43.43
Death (%)	12 (26.7)

[Table/Fig-2]: Demographics, presenting complaints and risk factors of the patients meningitis (N=45).

Among these 45 cases of *Acinetobacter* meningitis, 35 (77.8%) had undergone neurosurgical procedures for the removal of space-occupying lesions from the brain parenchyma. Forty (88.89%) patients used shunts where, 27 (60.0%) patients used EVD, and 13 (28.89%) used VP shunts. The mean age of the patients with shunts and without shunts was 27.08±18.02 years and 22.8±22.5 years, respectively. The demographic characteristics and risk factors in patients suffering from *Acinetobacter* meningitis with and without shunt are described in [Table/Fig-3]. The underlying co-morbidities like intracranial space-occupying lesions needing surgery, organ transplant, chronic obstructive pulmonary disease, heart disease, and nosocomial origin of infection is highly significant in patients with shunts in comparison to those without shunts is shown in [Table/Fig-3].

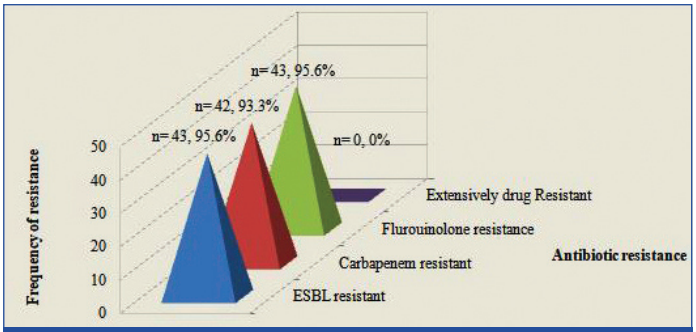
Demographic characteristics and risk factors	With shunt (n=40)	Without shunt (n=5)	p-value
Age (years), mean±SD	27.08±18.02	22.8±22.5	0.628
Gender, male/female	25/15	25/15	0.913
Source of infection, %			
Nosocomially-acquired (n=41, %)	39 (97.5)	2 (40.0)	<0.01*
Community-acquired (n=4, %)	3 (7.5)	1 (20.0)	<0.01*
Underlying co-morbidities			
Intracranial space occupying lesions needing surgery (n=35), %	35 (87.5)	0	<0.001*
Anaemia (n=35), %	32 (80.0)	3 (60.0)	0.310
Encephalopathy (n=25), %	23 (57.5)	2 (40.0)	0.458
Epilepsy (n=13), %	12 (30.0)	1 (20.0)	0.642
Hypertension (n=11), %	9 (22.5)	2 (40.0)	0.391
Diabetes mellitus (n=9), %	8 (20.0)	1 (20.0)	1.00
Stroke (n=6), %	5 (12.5)	1 (20.0)	0.642
Pleural effusion (n=4), %	4 (10.0)	0	0.459
Chronic kidney disease (n=2), %	1 (2.5)	1 (20.0)	0.73
Organ transplant (n=1), %	0	1 (20.0)	0.004*
Chronic obstructive pulmonary disease (n=1), %	0	1 (20.0)	0.004*
Heart disease (n=1), %	0	1 (20.0)	0.004*
Other parameters			
Length of hospital stay, mean±SD	39.98±21.35	31.00±29.26	0.399
CSF total cell count (per cubic mm), mean±SD	1820.13±6211.50	646.00±442.13	0.678
CSF glucose (mg/dL), mean±SD	42.85±30.51	48.60±35.57	0.698
CSF protein (mg/dL), mean±SD	140.58±44.82	154.88±30.51	0.494
Death (n=12), %	10 (25.00)	2 (40)	0.475

[Table/Fig-3]: Descriptive analysis of demographic characteristics and risk factors in patients suffering from *Acinetobacter* meningitis with and without shunt (N=45).
*p-value <0.05 is significant

Among *Acinetobacter* spp isolates obtained from the CSF samples, *Acinetobacter baumannii* was the predominant microrganism isolated from 43 (43/45, 95.6%) samples and *Acinetobacter lowffii* was obtained from 2 (2/45, 4.4%) samples. Overall, a high drug resistance was observed among the *Acinetobacter* spp isolates from CSF samples. The antibiotic resistance among the *Acinetobacter* spp isolates is described in [Table/Fig-4] which demonstrates the percentage resistance of the isolates to a particular isolate. Amikacin was resistant among 42 (93.3%) isolates and among the cephalosporins, a cumulative resistance of almost 93.3-95.6% was observed. Thus, the extended-spectrum beta-lactam antibiotic resistance was thus observed in about 43 patients. Ciprofloxacin was used as a representative of the fluoroquinolone group of antibiotics and was found resistant among 43 patients. Carbapenem resistance was found in 42 isolates as seen in [Table/Fig-5].

Antibiotics	Sensitive (n, %)	Intermediate (n, %)	Resistant (n, %)
Amikacin	3 (6.7)	0	42 (93.3)
Ceftazidime	2 (4.4)	0	43 (95.6)
Ceftriaxzone	3 (6.7)	0	42 (93.3)
Ciprofloxacin	2 (4.4)	0	43 (95.6)
Cefoperazone-Sulbactum	2 (4.4)	0	43 (95.6)
Imipenem	3 (6.7)	0	42 (93.3)
Meropenem	3 (6.7)	0	42 (93.3)
Colistin	45 (100.0)	0	0

[Table/Fig-4]: Antibiotic resistance among the patients with *Acinetobacter* meningitis who were included in the study (N=45).



[Table/Fig-5]: Showing frequency of resistance.

Overall, 35 (77.8%) patients were administered appropriate antibiotics while among the rest of the 10 (22.2%) patients, 5 (11.11%) left against medical advice and 5 (11.11%) died before any treatment could be administered. Overall, 12 (26.7%) succumbed to their infections and could not be saved despite all efforts.

DISCUSSION

A rising trend of nosocomial bacterial meningitis, predominantly in patients after neurosurgical procedures has been observed and the presence of MDR complicates the recovery of infected patients [1]. Among the Gram negative bacilli, *Acinetobacter* species are known to be the most common causative pathogen of nosocomial bacterial meningitis, especially in the case of post neurosurgical procedures and it is also a known cause of MDR infections among those admitted to neurosurgical Intensive Care Units (ICUs) [2,10]. Among the patients included in this study, all the CSF samples were sent to the Bacteriology Section of the Department of Microbiology from the Neurosurgical ward and ICU. The four year incidence of *Acinetobacter* meningitis among the bacterial meningitis patients included in this study was 30.0% (45/150). *Acinetobacter* meningitis was observed in 30% cases of bacterial meningitis and a similar incidence of *Acinetobacter* meningitis was observed in studies by Sipahi OR et al., and Sharma R et al., were the incidence of *Acinetobacter* meningitis was 30.7% and 26.18%, respectively [6,11].

The challenge faced during the treatment of *Acinetobacter* meningitis includes the MDR property of the microorganism that complicates recovery among the patients. The mean age of the patients was 26.60±18.32 years which was in contrast with other studies by Sharma R et al., [6] and Tuon FF et al., [12], where the age of patients with *Acinetobacter* meningitis was in the range of 30-40 years of age, thus the rate of mortality was less in compared to the above-mentioned studies. The majority of patients included in the study had undergone neurosurgical procedures. Patients with hydrocephalus, intracranial bleeding and, CSF leak were managed using a shunt diversion. Thirty-five (87.5%) patients who had undergone intracranial surgeries needed shunt diversion after the procedure making them more susceptible to bacterial meningitis in agreement to a study by Sharma R et al., [6] where all the 25 (100.0%) patients with shunt diversion developed *Acinetobacter* meningitis.

The risk factors associated with *Acinetobacter* meningitis in patients with and without shunts is demonstrated in [Table/Fig-3]. Presence of intracranial space occupying lesions, Chronic Obstructive Pulmonary Disease (COPD), heart disease and organ transplant had significant association with the use of shunts. The above finding of presence of intracranial space occupying lesion leading to neurosurgery corroborate with the finding of a study conducted by Sharma R et al., [6], where *Acinetobacter* meningitis was observed in all patients who underwent neurosurgery followed by shunt placement. Although none of the studies mentioned COPD, heart disease and organ transplant to be significant risk factor associated with *Acinetobacter* meningitis.

Although cefoperazone-sulbactam is universally accepted as antibiotic prophylaxis in many surgical procedures in a study by Niu T et al., [13], the present study suggested a resistance of 95.6% (43/45) to this antimicrobial agent. [Table/Fig-6] shows

Author Name [Reference]	Sample size	Age	Gender distribution (Male: Female)	Place of study and year of publication	Incidence of *Acinetobacter* meningitis	Mortality rate among patients of *Acinetobacter* meningitis
Yang M et al., [18]	35 CSF cultures positive for *Acinetobacter baumannii* meningitis	Mean age 38.5 years	18:17	Shanghai, 2012	NA	N=17, 48.57% overall
Moon C et al., [14]	22 CSF cultures positive for *Acinetobacter baumannii* meningitis	Median age and range 56 (20-8) years	15:7	Republic of Korea, 2013	NA	N=13, 59.09% among post neurosurgical *Acinetobacter* meningitis
Lai WA et al., [19]	18 CSF cultures post neurosurgery cases of mixed infection in adult bacterial meningitis	Median age and range 57.5 (20-77) years	11:7	Taiwan, China, 2013	N=5, 27.78% cases of *Acinetobacter* meningitis	N=1, 20% among cases of post neurosurgical *Acinetobacter* meningitis
Xu T et al., [20]	2831 cases of *Acinetobacter baumannii* infections of which 9.6% cases of CSF cultures post neurosurgery cases of *Acinetobacter baumannii* meningitis	NA	NA	Nanjing, China, 2013	N=273, 9.6% cases of *Acinetobacter* meningitis	NA (not discussed specifically for *Acinetobacter* meningitis)
Chen C et al., [21]	65 cases of CSF infection from patients who underwent craniotomy	NA	41:24	Shanghai, China, 2014	N=2, 3.07% cases of *Acinetobacter* meningitis	NA (not discussed specifically for *Acinetobacter* meningitis)
Kourbeti IS et al., [22]	334 patients who underwent craniotomy with meningitis documented in 16 cases	Median age and range 48.0 (22-58) years	219:115	Greece, United States of America, Cyprus (Multicentre study), 2015	N=7, 44% cases of *Acinetobacter* meningitis among cases of meningitis	NA (not discussed specifically for *Acinetobacter* meningitis)
De Bonis P et al., [23]	18 cases of drug resistant *Acinetobacter baumannii*	Mean age 52.05 years	10:8	Rome, Italy, 2016	NA	N=10, 55.56% among post neurosurgical *Acinetobacter* meningitis
Chen CH et al., [15]	4392 patients who underwent craniotomy and 22 cases of postoperative meningitis were observed	Mean age 45±13.8 years	3455:937	Taiwan, 2016	N=7, 31.8% cases of *Acinetobacter* meningitis post craniotomy among postoperative meningitis cases	N=5, 71.43% among post neurosurgical *Acinetobacter* meningitis
Fotakopoulos G et al., [24]	34 patients presenting with nosocomial meningitis	NA	13:21	Thessaly, Greece, 2016	N=24, 70.58% among post neurosurgical *Acinetobacter* meningitis	N=10, 41.67% among post neurosurgical *Acinetobacter* meningitis
Khan SA et al., [25]	21 patients with post neurosurgical gram negative meningitis/ventriculitis	Mean age 41.7±11 years	16:5	Karachi, Pakistan, 2017	N=14, 66% cases among postoperative cases who developed meningitis due to *Acinetobacter* species	N=1, 7.14% mortality among postoperative patients with *Acinetobacter* meningitis
Ceylan B et al., [26]	77 patients suffering with *Acinetobacter baumannii* meningitis/ventriculitis	Median age and range 48.0 (20-78) years	44:33	Istanbul, Turkey, 2017	NA	N=37, 48.0% among post neurosurgical *Acinetobacter* meningitis
Sipahi OR et al., [11]	689 episodes of nosocomial meningitis	Mean age 26.5 years	NA	Turkey, 2017	N=212, 30.7% cases of *Acinetobacter* meningitis	N=30/54, 55.5% among cases of *Acinetobacter* meningitis
Chursi S et al., [27]	33 patients of post-neurosurgical meningitis and ventriculitis	Median age and range 42.0 (31-47) years	19:14	Thailand, United States of America, Japan (Multicentre study), 2018	N=33, 11% cases of *Acinetobacter* meningitis causing carbapenem-resistant *Acinetobacter baumannii* among 300 post-neurosurgical meningitis and ventriculitis	N=14, 42.4% among post neurosurgical *Acinetobacter* meningitis
Sipahi OR et al., [16]	23 patients with multidrug-resistant *Acinetobacter baumannii* meningitis	Mean age 47.69 years	15:8	Turkey, 2018	NA	N=10, 43.48% among cases of *Acinetobacter* meningitis
Sharma R et al., [6]	72 patients following post neurosurgical *Acinetobacter* meningitis (Total meningitis cases=275)	Mean age 37.4±2.5 years	46:26	New Delhi, India, 2019	N=72, 26.18%	N=29, 40.27% among post neurosurgical *Acinetobacter* meningitis
Liang W et al., [28]	24 patients with postoperative meningitis by Multi-Drug-Resistant/Extensively Drug-Resistant *Acinetobacter baumannii*:	NA	NA	Hangzhou city, China, 2019	NA	N=12, 50% among post neurosurgical *Acinetobacter* meningitis
Pan S et al., [29]	61 cases with positive CSF cultures in patients with *Acinetobacter* meningitis (Total cases of meningitis=428)	Mean age 53.50±15.17 years	30:31	Zhejiang, China, 2018	N=61, 33.88% among post neurosurgical *Acinetobacter* meningitis	N=23, 37.70% among post neurosurgical *Acinetobacter* meningitis
Chen FM et al., [17]	25 patients with extensively drug-resistant *Acinetobacter baumannii*	Mean age 45.60±16.12 years	20:5	Shanghai, China, 2019	NA	N=5, 20% among post neurosurgical *Acinetobacter* meningitis
Hussein K et al., [30]	232 patients' neurosurgical patients with cerebrospinal fluid drains. 34 cases of bacterial meningitis were identified.	Mean age was 50±20 years	167:65	Haifa, Israel, 2019	N=13, 38.2%	Mortality rate not specifically specified for those suffering from *Acinetobacter* meningitis

Chang JB et al., [31]	16 postoperative patients with central nervous system infections caused by extensively drug-resistant/pan-drug-resistant *Acinetobacter baumannii* in approximately 10,000 post neurosurgery cases	Mean age 41.7 years	11:5	Beijing, China, 2020	N=16, 0.17%	N=4, 25% among postoperative patients with central nervous system infections caused by *Acinetobacter* meningitis
Chen Y et al., [32]	40 patients with nosocomial meningitis by multi-drug-resistant Gram negative bacteria in 3533 patients that were screened	Mean age 20.5±20 years	23:17	Beijing, China, 2020	N=21, 5.5%	N=9, 42.85% among patients with *Acinetobacter* meningitis
Qian L et al., [33]	102 patients who underwent neurosurgery and had an EVD/LD in place	Median age 41.0 (29-55) years	59:43	Nanjing, China, 2020	N=5, 4.9%	Mortality rate not specifically specified for those suffering from *Acinetobacter* meningitis
Ye J et al., [34]	5 post-neurosurgical meningitis cases of extensively drug-resistant bacteria in children	Median age 133 (50.5-158.5) months	2:3	Hangzhou, China, 2020	N=3, 60%	No mortality was reported among the extensively drug-resistant *Acinetobacter baumannii* in children after neurosurgical operation
Zhang Z et al., [35]	72 patients with central nervous system infections, mainly neurosurgical patients	Mean age 49.7±18.3 years	54:18	Shanxi, China, 2021	N=6, 7% in patients with central nervous system infections, mainly neurosurgical patients	Mortality rate not specified for those suffering from *Acinetobacter* meningitis
Thatrimontrichai A et al., [36]	38 neonates with multidrug-resistant bacterial meningitis	Median age 35 (29.5-38) weeks	17:21	Songkhla, Thailand, 2021	N=12, 32%	N=7, 58.33% mortality was reported among 12 neonates with *Acinetobacter* meningitis
Panic H et al., [37]	144 patients with Healthcare-Associated Meningitis and Ventriculitis	Median age 53 (35-66) years	91:53	Zagreb, Croatia, 2022	N=24, 16.67%	N=13, 56.0% among healthcare associated *Acinetobacter* meningitis and ventriculitis
Present study	45 patients of *Acinetobacter* meningitis out of 150 patients with culture positive meningitis	Mean age 26.60±18.32 years	28:17	Lucknow, Uttar Pradesh, India, 2022	N=45, 30.0%	N=12, 26.7% among patients with *Acinetobacter* meningitis

[Table/Fig-6]: The review of incidence and mortality of Acinetobacter meningitis from original articles in the last 10 years (N=27) [6,11,14-37].

comparison with other similar published original articles directly or indirectly related to this study cohort [6,11,14-37]. The presence of EVD and VP shunt also increases the risk of acquiring MDR infections. The MDR temperament of *Acinetobacter* isolates was significantly associated with chronic kidney disease, heart disease, and COPD in this study and authors did not come across any such association among the other co-morbidities in recently published studies by Sharma R et al., and Sipahi OR et al., [6,11]. *Acinetobacter* species were 93.3-95.6% resistant to amikacin, ceftazidime, ceftriaxone, ciprofloxacin, cefoperazone-sulbactam, imipenem, meropenem while other studies showed only about 20-80% [6,12]. A study by Moon C et al., suggests that the isolation of carbapenem-resistant isolates was directly proportional to the rate of mortality among the patients [14]. The present study shows that carbapenem resistance was as high as 93.3% (42/45) which did not show a poor prognosis, due to the fact that being a tertiary care centre availability of newer and more effective antibiotic agents facilitated better outcome in comparison to other centres. Thus, the patients showed a higher incidence of resistance in this study, and most patients were treated with colistin infusion which is the drug of last resort and poses a high cost of treatment and morbidity.

The mortality rate in the present study was 26.7% (12/45) which was in agreement with the findings by Chen CH et al., [15], Sipahi OR et al., [16] and Chen FM et al., [17] where the mortality rates were 28.57%, 30% and 20%, respectively. On the other hand, it was much less in comparison to the study conducted by Tuon FF et al., [12] which reported a mortality rate of 72.7% and by Sharma R et al., [6] who reported about 40% mortality. This can be attributed to the early diagnosis and reporting of the antimicrobial resistance at present setting along with the fact that strict hospital infection control measures and prompt treatment with compliance to the antibiotic susceptibility report were followed at this centre.

Limitations(s)

Firstly, the study depicts the incidence of *Acinetobacter* meningitis at a single centre and does not mention about its incidence in the geographical area. Secondly, authors did not specify the groups of patients and found the incidence and mortality among the patients as a whole and not specifically in neonates or post neurosurgical meningitis. Thirdly, this was a retrospective study which is based mainly on previous records and HIS which may not clearly signify the incidence and mortality.

CONCLUSION(S)

Acinetobacter meningitis causes a delay in the recovery of the patient from the operative procedures they had undergone, amounting to a delay in brain parenchyma healing in the case of neurosurgical patients. The associated morbidity and mortality of the disease due to the MDR nature of the microorganism and the nosocomial nature of the infection call for strict compliance to the infection control practices and drug susceptibility report to inhibit the rampant use of last resort antibiotics early in the treatment.

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