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Paediatrics Section

Outcomes and Predictors of Mortality among Young Children with Acute Meningoencephalitis: A Prospective Observational Study

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ABSTRACT

Introduction: Acute Meningoencephalitis (AME) is a life-threatening condition in young children, particularly in low-resource settings, with overlapping features of meningitis and encephalitis. Despite advances in diagnostics and vaccination, evolving pathogens like dengue virus and *Orientia tsutsugamushi* contribute to high morbidity and mortality due to delayed diagnosis and treatment.

Aim: To assess short-term outcomes, and predictors of mortality of AME in children under five years of age.

Materials and Methods: The present prospective observational study was conducted at King George's Medical University, Lucknow,Uttar Pradesh, India, from January 2020 to September 2021. Total 101 children aged between 1 month to 5 years with AME were enrolled in this study after taking a written informed consent from their parents. Detailed clinical history (fever, seizures and its type, altered sensorium, headache, diarrhoea, vomiting, bleeding, swelling, rash) and demographic details were recorded. Outcomes were classified as complete recovery, recovery with neurological sequelae, or mortality. Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 23 for Windows. Logistic regression analysis was performed to identify independent predictors of mortality.

Results: Total 101 children were enrolled with AME, with a mean age of 37.92±18.32 months, with 66 (65.3%) of the cases being male and a male-to-female ratio of 1.9:1. Out of 101 cases 69 (68.3%) were successfully treated and discharged. Among the 69 children who were discharged, 39 (56.5%) cases were fully conscious and recovered completely. However, 30 (43.5%) cases had some degree of altered sensorium at discharge. Of these, three children (4.3%) required nasogastric (RT) feeding, and two children (2.8%) were discharged with both tracheostomy and RT feeds in place. Persistent neurological sequelae were noted in several cases: seizures in five children (7.2%), visual and hearing impairments in five children (2.8%) each, and focal neurological deficits in two children (2.8%). The overall mortality rate was 9.9%, with factors such as immunisation status, Glasgow Coma Scale (GCS) score, renal dysfunction, and the need for mechanical ventilation associated with worse outcomes.

Conclusion: According to the results of the present study key predictors of mortality in children with AME included severe GCS scores, renal dysfunction, and the need for mechanical ventilation. Early diagnosis, immunisation, and prompt treatment are crucial for improving outcomes.

Keywords: Glasgow coma scale, Immunisation status, Meningitis, Neurological symptoms, Prognosis, Seizures

INTRODUCTION

The AME is a severe inflammatory condition involving both meninges and brain parenchyma. Clinically, it is often challenging to distinguish between acute meningitis and encephalitis due to overlapping symptoms; therefore, the term AME is widely used to encompass both entities [1]. This condition remains a major public health concern globally, particularly affecting infants and young children in low-resource settings [2]. Despite advancements in diagnostic methods and antimicrobial therapies, AME continues to present as a medical emergency, with high rates of morbidity, neurological sequelae, and mortality [3,4].

The AME typically manifests as an acute onset of fever accompanied by altered mental status ranging from confusion and disorientation to coma along with seizures, vomiting, headache, and focal neurological deficits. In young children, the presentation may be nonspecific, including irritability, poor feeding, or lethargy. Clinical signs such as a bulging fontanelle in infants and neck stiffness may also be present. Certain infections, such as meningococcal meningitis, can be accompanied by characteristic rashes, which may aid in diagnosis. Increasingly, vector-borne diseases such as dengue, scrub typhus, and Japanese Encephalitis Virus (JEV) are being recognised as important causes of meningoencephalitis, often presenting with distinct cutaneous manifestations [1].

The aetiologies of AME are broad and include a wide range of infectious agents- bacterial, viral, rickettsial, fungal, and parasitic as well as non-infectious causes such as toxins and metabolic disorders. Bacterial meningitis is most frequently caused by *Neisseria meningitidis*, *Streptococcus pneumoniae*, and *Haemophilus influenzae* type B, with the highest incidence in children aged between two months and five years [1,5]. Despite the introduction of vaccines reducing the incidence of certain bacterial pathogens, bacterial meningitis remains almost uniformly fatal if untreated [2]. In contrast, viral meningoencephalitis-caused by agents like JEV, dengue virus, Herpes Simplex Virus (HSV), and enteroviruses may be self-limiting but can also result in severe Central Nervous System (CNS) complications [6].

A previous study by Vasanthapuram R et al., have highlighted a shift in the etiological profile of viral meningoencephalitis in India [7]. In surveillance conducted across six district hospitals, dengue virus was identified in 31% of cases- surpassing the prevalence of JEV, which was detected in 19%. This shift underscores the rising burden of dengue-related CNS manifestations, including dengue encephalopathy and encephalitis, particularly in children under

five years of age [7]. Similarly, scrub typhus has re-emerged as a significant contributor to AME, particularly in rural, post-monsoon outbreaks in regions like eastern Uttar Pradesh [8].

Diagnosing AME requires a combination of clinical suspicion, Cerebrospinal Fluid (CSF) analysis, and pathogen-specific diagnostic testing, which may be limited by cost and accessibility in low-resource settings. Several risk factors influence outcomes, including delayed treatment, age, pathogen type, level of consciousness, and CSF parameters such as leukocyte count. While viral causes may resolve without sequelae, bacterial and rickettsial aetiologies often result in neurological complications such as hearing loss, seizures, hydrocephalus, cognitive impairment, and motor disabilities [9].

As data on outcome of AME and predictors of mortality in young children in Indian set-up is limited. So, the present study was conducted to assess the short-term outcomes of AME in children under five years of age. Additionally, it seeks to identify predictors of mortality in this age group to better inform clinical management and improve outcomes. By understanding the evolving epidemiological trends and associated risk factors, this research aimed to contribute to the development of more effective prevention strategies, early diagnostic tools, and targeted treatment protocols, ultimately reducing both mortality and long-term disability in affected children.

MATERIALS AND METHODS

The present prospective observational study was conducted in the Department of Paediatrics at King George's Medical University, Lucknow, Uttar Pradesh, India, over a period of 21 months from January 2020 to September 2021. The study protocol was approved by the Institutional Ethics Committee (Reference code: 102nd ECM II B-Thesis/P96). Informed written consent was obtained from the parents or legal guardians of all enrolled participants.

Inclusion criteria: Children aged between one month to five years presenting with clinical features suggestive of AME were eligible. AME was defined as the acute onset of fever (1-14 days), followed by any of the followings: (a) Signs of meningeal irritation; (b) Convulsions; or (c) Change in mental status [10].

Exclusion criteria: Children with known chronic neurological disorders (e.g., epilepsy, cerebral palsy) and CNS infections secondary to trauma, neurosurgery, or malignancy, and incomplete clinical data or absence of CSF examination were excluded from study.

Sample size selection: A total of 130 children presenting with suspected AME were screened for enrolment. Of these, two were excluded due to lack of parental consent, and 27 did not meet inclusion criteria. A total of 101 children were enrolled; however, one child died before CSF examination could be performed. Thus, 100 CSF and 101 serum samples were analysed.

Study Procedure

Data collection: Upon admission, detailed clinical history (fever, seizures and its type, altered sensorium, headache, diarrhoea, vomiting, bleeding, swelling,) was recorded, including demographic information (age, sex, residence, socioeconomic status), vaccination status, symptom duration, and presence of rash or focal neurological signs. A comprehensive neurological examination was conducted for each patient.

The following laboratory and diagnostic investigations were performed:

- **Blood tests:** Complete blood count, serum electrolytes, liver and renal function tests;
- **CSF analysis:** Cell count, glucose, protein, Gram stain, and bacterial culture;
- **Serological testing:** CSF and serum samples were tested for IgM antibodies against JEV, dengue virus, *Orientia tsutsugamushi* (scrub typhus), HSV, and others using Enzyme Linked Immunosorbent Assay (ELISA).
- **Neuroimaging:** Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) was performed when clinically indicated;
- **Additional diagnostics:** Blood cultures and Polymerase Chain Reaction (PCR) (if available) were used based on clinical judgment.

Outcome assessment: Short-term outcomes were assessed during hospital stay and documented at the time of discharge. Outcomes were categorised into:

- Recovered completely;
- Recovered with neurological sequelae (e.g., hearing loss, motor deficits, seizures);
- Died during hospital stay.

Various factors like duration of fever prior to admission, gap between fever and CNS symptoms, seizure, signs of meningeal irritation, low GCS, hyperventilation, hypotension, raised Intracranial Tension (ICT), meningeal signs, bleeding manifestation, organomegaly, need for cerebral dehydrants and mechanical ventilation, electrolyte imbalance and deranged kidney functions were assessed [11,12].

STATISTICAL ANALYSIS

Data were entered into a Microsoft Excel sheet and analysed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY). Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as mean±standard deviation or median (IQR), depending on distribution. Chi-square test or Fisher's-exact test was used for categorical variables. Logistic regression analysis was performed to identify independent predictors of mortality. A p-value <0.05 was considered statistically significant.

RESULTS

The study included 101 children with a mean age of 37.92±18.32 months, approximately three-year-old. A male preponderance was observed, with 66 (65.3%) of the cases being male and a male-to-female ratio of 1.9:1. 90 (89.1%) of the children came from lower socioeconomic backgrounds and 91 (90%) of the children were from rural areas [Table/Fig-1].

Variables		N	%
Mean age	**37.92±18.32 months**		
Gender distribution			
Female		35	34.7
Male		66	65.3
Vaccination Status	Unimmunised	3	3.0
	Partially immunised	45	44.6
	Immunised	53	52.5
Socioeconomic status			
Upper class		0	0
Middle class	Upper class	1	1
	Lower class	2	2
Lower class	Middle class	8	7.9
	Lower class	90	89.1
Rural/urban status			
Rural		91	90
Urban		10	10

[Table/Fig-1]: Demographic status of the enrolled cases (n=101).

The most frequently identified aetiologies of AME in this study were dengue and scrub typhus, each accounting for 16 in number (15.8%) A significant proportion, 52 (51.48%), of cases had no identifiable

aetiology (32 in discharged group, 4 in expired group and rest 16 unknown aetiologies in LAMA and abscond group). Other identified aetiologies were Chikungunya (3 cases), Japanese Encephalitis (9 cases), Cerebral Malaria (3 cases), Pneumococcal meningitis (1 case), Acinetobacter meningitis (1 case) [Table/Fig-2].

Aetiology	Discharged (n=69) N	%	Expired (n=10) N	%	p-value
Dengue	12	17.4%	2	20.0%	0.908
Chikungunya	2	2.9%	0	0.0%	1.000
Scrub typhus	14	20.3%	1	10.0%	0.510
Japanese encephalitis	6	8.7%	3	30.0%	0.060
Cerebral malaria	2	2.9%	0	0.0%	1.000
Pneumococcal Meningitis	1	1.4%	0	0.0%	1.000
Unknown	32	46.3%	4	40.0%	0.969
Total	69	100%	10	100%	

[Table/Fig-2]: Aetiological comparison between discharged and expired patients (N=79).

Blood culture report showed growth of *Escherichia coli* in 2 (2%) cases and CONS in 3 cases (3%), and majority cases 96 (95%) showed no growth of organism. On the other hand, 100 (99%) cases had sterile CSF cultures and just one case showed the growth of *Acinetobacter baumanii*; One case showed presence of *Streptococcus pneumoniae* detected by real time PCR. CT/MRI brain was done in 61 patients, and neuroimaging was normal in 24 cases out of 61 while 37 cases showed some abnormality.

The majority 69 cases (68.3%) were successfully treated and discharged. However, 10 children (9.9%) died during hospitalisation. Additionally, 17 patients (16.8%) left the hospital against medical advice and five patients (4.95%) absconded before completion of treatment. Here, demographic, clinical, and laboratory data were compared between discharged and expired patients.

Among the 69 children who were discharged, 39 (56.5%) were fully conscious and recovered completely, representing 38.6% of the total study population. However, 30 (43.5%) had some degree of altered sensorium at discharge. Of these, three children (4.3%) required nasogastric (RT) feeding, and two children (2.8%) were discharged with both tracheostomy and RT feeds in place. Persistent neurological sequelae were noted in several cases: seizures in five children (7.2%), visual and hearing impairments in two children (2.8%) each, and focal neurological deficits in two children (2.8%), including quadriparesis and hemiparesis. Additionally, dystonia was documented in three cases (4.3%) [Table/Fig-3].

Condition at discharge		Number (Percentage)
Fully conscious		39 (56.5)
Altered sensorium		30 (43.5)
	RT feeds	3 (4.3)
	Tracheostomy with RT feeds	2 (2.8)
	Oral feeds	25 (36.2)
Seizures		5 (7.2)
Visual defect		2 (2.8)
Hearing defect		2 (2.8)
Focal deficit		2 (2.8)
Types	Quadriparesis	1 (1.4)
	Hemiparesis	1 (1.4)
Dystonia		3 (4.3)

[Table/Fig-3]: Sensorium and disabilities at the time of discharge (n=69).

The comparative analysis of demographic, clinical, and laboratory features between discharged and expired patients reveals several important factors that influence the outcome of meningoencephalitis. It was seen that duration of fever prior to admission had significant association to mortality of the cases (p-value of 0.014) with mean duration of fever of 4.63±1.78 days in discharged patients in comparison to 6.1±1.1 days in expired patients and also the gap between fever and CNS manifestations was significant (1.94±1.51 days) in the expired group with a p-value of 0.014 as compared to that in discharged cases (3.30±1.57 days), other factors like immunisation status (p-value <0.001), presence of meningeal signs (p-value=0.021), raised ICT (p-value=0.010), low GCS score (p-value=0.015), hyperventilation (p-value=0.0054), hypotension (p-value=0.0054), need of cerebral dehydrants (p-value=0.012) and mechanical ventilation (p-value <0.0001), and laboratory parameters like deranged kidney function (p-value=0.002) and electrolyte imbalance (p-value=0.004) are critical in predicting mortality in meningoencephalitis. Early recognition of these risk factors may improve patient management and outcomes [Table/Fig-4].

Parameter	Discharged (n=69)	Expired (n=10)	p-value
Demographic features			
Age in months (Mean±SD)	39.05±1.36	36.80±0.97	0.174
Gender			
Male	44 (63.8%)	6 (60%)	0.817
Female	25 (36.2%)	4 (40%)	
Immunisation status			
• Non-immunised	0 (0%)	2 (20%)	<0.001
• Partially immunised	32 (46.4%)	1 (10%)	
• Fully immunised	37 (53.6%)	7 (70%)	
Clinical features			
GCS <8	16 (23.1%)	5 (50%)	0.015
GCS >8	53 (76.9%)	5 (50%)	0.07
Duration of fever in days (mean±SD)	4.63±1.78	6.1±1.1	0.014
Gap between fever and CNS symptoms (days) (mean±SD)	3.30±1.57	1.94±1.51	0.010
Seizures	53 (76.8%)	8 (80%)	0.963
Hyperventilation	6 (8.7%)	4 (40%)	0.0054
Hypotension	6 (8.7%)	4 (40%)	0.0054
Swelling	7 (10.1%)	1 (10%)	0.988
Rashes	10 (14.5%)	3 (30%)	0.433
Raised Intracranial Tension (ICT)	15 (8.7%)	6 (60%)	0.010
Meningeal signs	2 (2.9%)	2 (20%)	0.021
Hepatomegaly	41 (59.4%)	4 (40%)	0.293
Splenomegaly	18 (26%)	3 (30%)	0.721
Treatment features			
Requirement of cerebral dehydrants	41 (59.4%)	10 (100%)	0.012
Requirement of mechanical ventilation	14 (20.3%)	10 (100%)	<0.0001
Laboratory parameters			
Dyselectrolytaemia	13 (18.8%)	6 (60%)	0.004
Hypoglycaemia	2 (2.9%)	1 (10%)	0.337
Anaemia	53 (76.8%)	9 (90%)	0.417
Thrombocytopaenia	21 (30.4%)	4 (40%)	0.543
Elevated transaminases	37 (53.6%)	6 (60%)	0.705
Deranged Kidney Function Test (KFT)	16 (23.1%)	7 (70%)	0.002
Deranged INR	23 (33.3%)	7 (70%)	0.026

[Table/Fig-4]: Comparative features of discharged and expired cases at the time of presentation for mortality indicators.

The comparative study of laboratory parameters between discharged and expired cases highlighted several important findings. A significant difference was observed in serum urea levels, with expired patients having higher levels, suggesting renal dysfunction might be an important factor in mortality (p-value=0.040). On the other hand, serum creatinine levels did not show significant variation. INR levels were significantly higher in expired patients, which indicates that coagulopathy may contribute to a higher risk of mortality in these cases (p-value=0.018). CSF analysis showed no significant differences in parameters between the two groups, though trends in some CSF markers could be important for further investigation [Table/Fig-5].

Laboratory parameters	Discharged (n=69) (Mean±SD)	Expired (n=10) (Mean±SD)	p-value
Haemoglobin (gm/dL)	9.32±2.09	8.62±1.58	0.316
TLC (cells/cumm)	15,300±8,913.3	21,100±13,618.7	0.079
% Polymorphs	65.48±12.97	68.10±12.22	0.549
% Lymphocytes	29.93±13.02	28.50±12.23	0.745
Packed cell volume	27.31±5.74	26.05±4.42	0.508
Platelet count (lac/cu mm)	2.11±1.32	2.11±2.52	0.994
Random blood sugar	84±20.2	70±38.4	0.077
S. Urea (mg/dL)	36.58±24.69	54.24±27.45	0.040
S. Creatinine (mg/dL)	0.70±0.33	0.74±0.25	0.725
S. Na+ (mmol/L)	137.39±6.72	140.6±13.74	0.221
SK+ (mmol/L)	4.11±0.79	4.01±0.71	0.709
S. Bilirubin (mg/dL)	0.61±0.80	1.18±1.77	0.086
SGOT/S.AST (IU/L)	161.15±445.21	149.8±121.7	0.937
SGPT/S.ALT (IU/L)	114.78±283.18	93.00±102.51	0.811
S. Total protein (g/dL)	5.86±0.96	5.75±0.97	0.737
Prothrombin Time (seconds)	17.33±5.28	17.25±7.51	0.968
INR	1.19±0.33	1.50±0.64	0.018
CSF findings*	**n=69**	**n=9**	
Cell count (cumm)	13.42±49.36	22.33±34.81	0.603
CSF polymorphs (%)	13.62±5.19	12.78±4.41	0.646
CSF protein (mg/dL)	111.08±65.03	120.7±68.59	0.681
CSF sugar (mg/dL)	73.74±31.44	87.27±23.67	0.219

[Table/Fig-5]: Comparative study of laboratory parameters in discharged and expired cases.
*Total 100 CSF samples were analysed out of 101 cases (69 in discharged group, 9 in expired group and 22 CSF in LAMA/Abscond group)

DISCUSSION

The present prospective observational study enrolled 101 children aged >1 month to <5 years with suspected AME. The majority of cases (62.4%) were between 36-59 months, with a mean age of 37.92±18.32 months, indicating a higher prevalence in the 3-5 year age group, possibly due to increased mobility and environmental exposure. A male predominance was observed, with 66 males and 35 females (male-to-female ratio 1.9:1), consistent with previous studies such as Kakoti G and Das BR (2020) and Beig FK et al., which reported ratios of 1.5:1 and 1.27:1, respectively [11,13]. While this gender disparity may reflect a combination of biological, behavioural, and sociocultural factors including differences in exposure risk and healthcare-seeking practices no significant association between gender and mortality was identified in this or earlier studies. Additionally, 97% of the children came from lower socioeconomic backgrounds, and 90% were from rural areas, highlighting the increased vulnerability of children in these settings, where access to healthcare and vaccination programs may be limited.

The predominant causes were dengue encephalitis and scrub typhus, each contributing to 15.84% of cases, confirmed by positive serum tests for Anti-dengue IgM antibody, NS1 antigen, and Anti-scrub typhus IgM antibodies. These findings are similar to those reported by Vasanthapuram R et al., where JE and scrub typhus were the leading causes, with dengue being more common in younger age groups [7]. In the present study, dengue and scrub typhus were more commonly identified, consistent with regional variations in the aetiology of AME. Notably, dengue and JE were more prevalent in younger children (1-5 years), with dengue detected in 31% of cases in this age group. In the study by Hirekerur VL et al., (2023) in one month to 18 years of age group, most common diagnosis was observed Rickettsia encephalitis 10 patients (28.6%) followed by dengue encephalitis 6 (17.1%) and Viral encephalitis 6 (17.1%). A total of 28 (80%) cases were cured and 7 (20%) cases refused continuation of treatment midway and were discharged against medical advice. No mortality was found in their study [14].

In terms of clinical outcomes, 68.3% of cases were discharged, with 56.5% fully conscious at discharge, while 43.5% had altered consciousness in which 7.1% cases were discharged on nasogastric feeds. Visual defect in the form of diminished vision, hearing defect and focal deficit were seen in 2.8% cases each in which one case each of hemiparesis and quadriparesis was seen with abnormal movements like dystonia in 4.3% cases. Seizures at discharge were still prevalent in 7.2% cases.

Notably, 9.9% of patients died, and 16.8% Left Against Medical Advice (LAMA). These outcomes are comparable to those of Kakoti G and Das BR (2020), where 72.3% were discharged, but the mortality rate was slightly higher (27%) [11]. The mortality rate in our study was similar to that reported by Rathore SK et al., (2014), which was 7%, though in their study, all patients were discharged [15].

In the study of Vasanthapuram R et al., 2019, where JE (16%), scrub typhus (16%) and dengue (5.2%) cases formed 88% of all known aetiologies had the outcome of 57.9% patients of JE getting discharged in fully recovered state and 1.1 % being discharged with some neurological deficit and 21.8% were referred/LAMA and 19.1% died [7], whereas 73.2% of dengue cases got discharged with full recovery and just 0.4% had some neurological deficit at discharge, 16.1% going for LAMA and 10.4% patients dying. In a study by Paswan DW et al., 2017 [16], it was seen that 45.5% AES patients had neurological sequelae at the time of discharge, while 28.4% had died in hospital.

The present study identified significant clinical factors associated with mortality, including a prolonged illness duration prior to admission (>6 days), a shorter gap between fever onset and CNS involvement (<2 days), and low GCS scores at presentation. In contrast to previous studies, we found that GCS <8 at admission had a strong association with mortality (p=0.015). Raised ICT, hypotension, and the need for vasopressor support were also significant predictors of mortality. These findings align with studies by Kakoti G and Das BR (2020), and Tripathy SK et al., (2019) who also identified these factors as key predictors of poor outcomes [11,12]. Dyselectrolytaemia, including hyponatraemia and hypernatraemia, was strongly correlated with mortality, with 60% of expired cases having electrolyte disturbances. Additionally, deranged renal function tests (KFT) and coagulopathy were also significant predictors of mortality, echoing findings from Tripathy SK et al., (2019) [12].

In a study by Majhi SC et al., (2024), five variables that is refractory seizure, GCS <8, features of raised ICT, shock, requirement of ventilatory support were found to be significant predictor of mortality [17]. Bhadouriya R et al., found that three factors had a statistically significant association with mortality. Patients who had shock and needed inotropic support, low GCS, and required mechanical ventilation showed greater mortality [18], which is similar to the present study. Meshram RM et al., (2025) showed that, GCS score <8, low mean blood pressure, children having respiratory distress, presence of cyanosis, need of mechanical ventilatory support, low sugar, and high protein in CSF, low serum albumin and low mean

age group were significantly associated with mortality, many of their findings are matching with the current study [19].

In study of Ary KA et al., (2023) in more than 18 years of age group, the variables which predicted the mortality with a significant statistical difference were: 1) Female gender; 2) Persistent fever on presentation; 3) Abnormal MRI at admission; 4) GCS score ≤7; 5) Indeterminate/undiagnosed cases, most of them were not correlating with the present study [20].

Limitation(s)

The study does not represent the entire community so it cannot reflect true picture of prevailing clinic-demographic status and outcome of AME. Long-term follow-up of discharged cases was not done that would have been useful in deciding further necessary work-up and rehabilitation measures for the patients that is a crucial part of patient care.

CONCLUSION(S)

The present study highlights the significant burden of AME in children, particularly in the 3-5 year age group, with a male predominance and high prevalence in lower socioeconomic and rural populations. dengue encephalitis and scrub typhus were the most common aetiologies. Mortality was associated with factors like prolonged illness, low GCS, and raised ICT. Early identification of risk factors and better healthcare access are crucial for improving outcomes. Further research is needed to enhance understanding and management of AME.

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