


Systematic Review

Hydatid Disease of The Brain Parenchyma: A Systematic Review

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Abstract

Introduction

Isolated brain hydatid disease (BHD) is an extremely rare form of echinococcosis. A prompt and timely diagnosis is a crucial step in disease management. This study is a systematic review of studies on intra-parenchymal BHD.

Methods

Studies that had the following properties were included: 1) The intra-parenchymal brain infection had been confirmed by diagnostic modalities, surgical findings, or histopathology. 2) The patient details were provided in the study. 3) The cystic lesion [s] were located intracranially.

Results

Altogether, 112 studies with a sample size of 178 cases met the inclusion criteria. Males (60.1%) showed a higher prevalence of the disease than females (38.2%). Most of the cases (64%) were affected during the first and second decades of their lives. Left-side multi-lobe involvement was the most common type of involvement (28.1%), followed by right-side multi-lobe involvement (26.4%). Surgery was the primary treatment option (97.2%), with the Dowling technique or the modified Arana-Iniguez method as the preferred approach. The total recurrence and mortality rates were 7.3% and 3.4%, respectively.

Conclusion

The definitive treatment for BHD is surgery, with the aim of removing cysts intact or excising mass lesions completely. A history of cyst rupture during operation may increase the likelihood of recurrence, and an extensive follow-up is required.

1. Introduction

Hydatid disease (HD) is a parasitic infection caused by the larvae of the tapeworm *Echinococcus*. Different genera of this

microorganism can cause disease; however, in humans, two species have major clinical sequelae. *Echinococcus granulosus* results in cystic disease, the most common type, while *Echinococcus multilocularis* causes alveolar echinococcosis

(AE), presenting as a mass or cystic lesion. The latter form of the disease is more invasive and aggressive, accompanied by numerous diagnostic and management challenges [1-3]. The most common organs affected by hydatidosis are the liver and lungs. However, other parts of the body can also be affected, including the bones, pericardium, orbits, ovaries, central nervous system (CNS), and other organs. In the literature, 2–3% of cases show involvement of the CNS. The incidence of isolated brain involvement is reported to be 1–2% of all cases of echinococcosis, representing approximately 2% of all intracranial space-occupying lesions [4-6]. Brain hydatid disease (BHD) is endemic in many regions where livestock raising is prevalent, and human-animal contact is common. The incidence varies geographically, with higher rates reported in rural areas. However, globalization and increased travel have led to sporadic cases being reported in non-endemic regions as well. Humans can become infected through the ingestion of parasite eggs in contaminated food, water, or by direct contact with infected dogs, canines, and sheep [7,8]. Most cases of intracerebral echinococcosis are diagnosed in pediatrics (50-75%) [9]. The clinical presentation of hydatidosis depends on the patient's age, the size, number, and location of the cyst, as well as the host's immune system. Patients with HD can remain asymptomatic for long periods, as the lesions take years to develop. When they grow well, intracranial hypertension secondary to the mass effect on the surrounding tissues is usually the first clinical sign of brain involvement. The disease may not cause focal neurological signs until they become enlarged [10-12]. In the literature, several reviews have been published on cerebral HD; however, there is a scarcity of systematic reviews on the topic. This study is a systematic review of studies on intra-parenchymal BHD published over the last two decades [1-112].

2. Methods

2.1. Study design and reporting standards

The study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

2.2. Search strategy

A systematic review of all published studies on brain parenchymal HD was conducted from 2000 to 2024 using the following databases: Google Scholar, PubMed/MEDLINE, Cochrane Library, Science Direct, and EMBASE. The keywords used in the search included:

[brain OR intraparenchymal OR cerebral OR intracerebral OR cerebrum] AND [hydatid OR hydatidosis OR echinococcoses OR echinococcosis OR echinococcal OR echinococcus].

2.3. Eligibility criteria

Non-English language studies and those unrelated to humans were excluded before or during the initial screening. Studies of BHD were included if: 1) Diagnostic modalities, surgical findings, or histopathology confirmed the intraparenchymal brain infection. 2) Patient details were provided in the study. 3) Studies published in predatory journals (inappropriately peer-

reviewed) and those not meeting inclusion criteria were excluded [113].

2.4. Study selection

Titles and abstracts of identified studies were initially screened, followed by full-text screening to assess eligibility.

2.5. Data extraction

Data extracted from eligible studies included study design, country of study, patient age, gender, residency, symptoms, medical history of HD, cyst characteristics, diagnosis, management, follow-up, and outcomes.

2.6. Data analysis

Data were analyzed qualitatively (descriptive analysis) using the Statistical Package for the Social Sciences (SPSS) version 27.0 software

3. Results

In total, 318 studies were obtained from the resources. Before any screening, 38 of them were directly excluded due to duplication, non-English language, non-articles, and animal studies. Following the initial screening, 92 studies did not meet the inclusion criteria and were excluded. The remaining 188 studies underwent full-text screening, and 122 of them were assessed for eligibility. Ultimately, 112 studies (comprising 178 cases) met the inclusion criteria (Figure 1). The characteristics of the included studies are shown in Table 1. Out of these studies, 101 (90.2%) were case reports, 10 (8.9%) were case series, and one (0.9%) was a retrospective cohort study. Most of the cases were reported in Turkey (24.1%), followed by Iran (16.7%), India (15.2%), and Morocco (9.8%). Males (60.1%) showed a higher prevalence of the disease than females (38.2%). Most of the cases (64%) occurred in the first and second decades of life, with a mean age of 20.44 ± 16.76 years. There were 71 cases (39.9%) in rural areas and eight cases (4.5%) in urban areas. The residency of the remaining 99 cases (55.6%) was not reported. The type of the disease was cystic in 158 cases (88.8%) and alveolar in 20 cases (11.2%). Thirteen (7.3%) cases had a previous history of HD. The most commonly presented symptoms were signs of raised intracranial pressure, including headache (62.9%), vomiting (43.3%), followed by seizure (30.3%) and paresis (28.7%). Multiple organ involvement was present in 48 (27%) cases, involving the lung, liver, kidney, adrenal gland, blood vessels, or bones. The disease was primary with a single cyst or lesion in 118 patients (66.3%), primary with multiple cysts in 27 (15.1%), secondary with a single cyst in 23 (13%), and secondary with multiple cysts in 10 (5.6%). Left-side multi-lobe involvement was the most common type of involvement (28.1%), followed by right-side multi-lobe involvement (926.4%) and parietal lobe involvement (18.5%).

Serology had been done in 55 cases (30.9%), and it was positive in 34 (19.1%). Computed tomography scans (CT) or magnetic resonance imaging (MRI) were used in all cases. Surgery was the main treatment option (97.2%). The Dowling technique, or modified Arana-Iniguez, was the method of choice (95.5%).

Surgery in three cases (1.7%) was done through the Burr-hole technique instead of open craniotomy. Conservative management was performed in five cases (2.8%). The patients underwent follow-up with a mean interval of one year. Recurrence was reported in 13 cases (7.3%). Among those, six cases (46.1 %) had intra-operative complications of traumatic rupture of the cyst, and two cases (15.4 %) had a surgical puncture of the cyst. The remaining five cases (38.5%) did not experience any intraoperative complications. The mortality rate was 3.4% (Table 2).

4. Discussion

The World Health Organization (WHO) has categorized human echinococcosis under the umbrella of tropical neglected diseases (TNDs) that require control, as the disease remains a significant health issue in endemic regions [1].

Domestic dogs serve as the primary definitive hosts for both species of *Echinococcus* and pose the highest risk of transmitting cystic and alveolar echinococcosis to humans. Infection in dogs occurs when they consume livestock offal containing hydatid cysts, after which they release parasite eggs in their feces, contaminating soil, water, and grazing fields. Livestock acquire the infection by ingesting these eggs during grazing, while humans are most often infected through eating or drinking contaminated food or water [114,115].

In this systematic review, studies on two genera of clinical interest, *Echinococcus granulosus* and *Echinococcus multilocularis*, have been reviewed. Several mechanisms have been proposed for the migration of *Echinococcus* larvae to the brain. Larvae hatching from ingested eggs in the intestine enter the portal circulation, spreading to different tissues where they develop hydatid disease. Two barriers can protect against CNS involvement: the first is the liver through portal circulation, and the second is the lung, which may act as a secondary filter. The lack of these effective sieves, problems in the immune system, special architecture of brain tissue, disrupted capillaries in the lungs, and structural heart diseases such as patent ductus arteriosus and patent foramen ovale may all provide a gateway to the brain [10,11]. This disease commonly affects supratentorial regions of the brain, specifically within the distribution of the middle cerebral artery, primarily targeting the parietal and frontal lobes [77,78,107]. Generally, BHD is classified as “primary” or “secondary”. The primary disease is rare; it results from direct infestation of the brain without the involvement of other organs. It most often presents as a solitary, spherical, and unilocular cyst surrounded by a broad capsule, which usually contains protoscoleces and renders a fertile lesion. The secondary type is typically characterized by multiple cerebral cysts that result from the rupture of a cyst in other organs. They lack brood capsules and protoscoleces, rendering them infertile. Therefore, the risk of recurrence after their rupture is negligible. However, on rare occasions, multiple primary cysts can occur within the brain parenchyma due to multiple larval intakes in patients with defective immune systems, metastatic deposits from the rupture

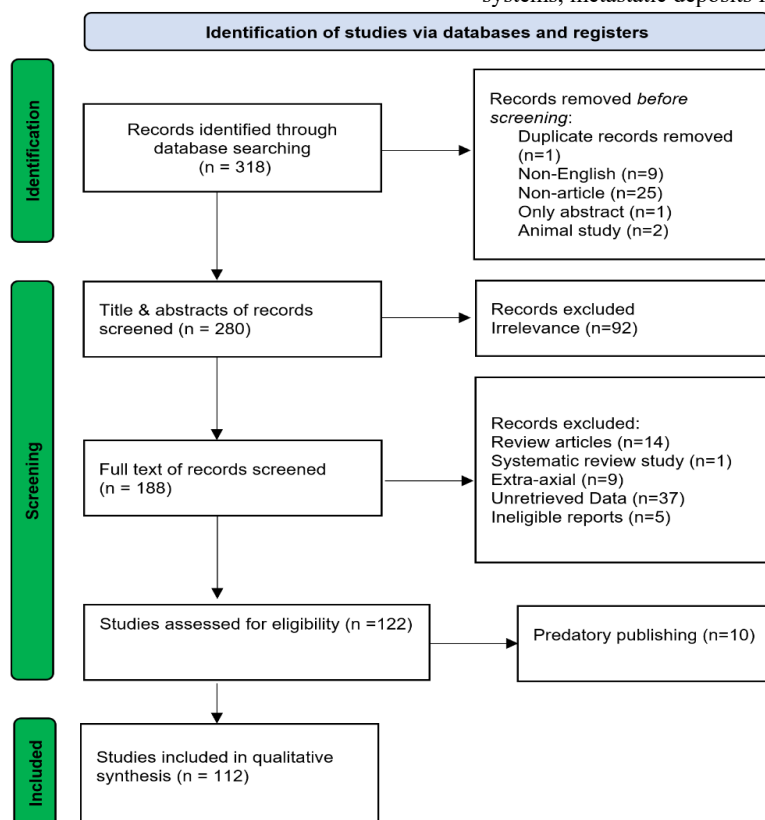


Figure 1. Study selection PRISMA flow chart.

Table 1. Raw data of the included studies.

Author	Country	Study design	No	Age	Sex	Presenting symptoms	Imaging	ISHC	No. of cyst [s] in brain	Location of cyst [s] in brain	Size [cm]	Serology	Type of management	Pre-Op complication	Intra-Op complication	Post-Op complication	Adjuvant therapy	Follow up* outcome
Svrckova et al [1]	United Kingdom	Case report	3	30	M	Headache, seizure	MRI	Yes	>1	Right parietal, right temporal	N/A	Positive	Conservative [Albendazole/praziquantel/steroid/antiepileptic]	N/A	N/A	N/A	None	Improved
				26	M	Collapse, slurred speech, seizure, left side hemiparesis	CT, MRI	Yes	1	Right parietal and basal ganglia	N/A	Positive	Conservative [Albendazole/Praziquantel/steroid/Antiepileptic]	N/A	N/A	N/A	None	Improved
Altibi et al [2]	Brazil	Case report	1	37	M	Dry cough	MRI	Yes	>1	Bilateral hemisphere	N/A	Positive	Conservative [Albendazole]	N/A	N/A	N/A	None	Improved
				13	M	Headache, nausea	CT, MRI	Yes	1	Right parieto-occipital	4.7	Negative	Surgical removal [Dowling]/neuronavigation	None	None	None	N/A	N/A
Casulli et al [3]	Italy	Case report	1	6	M	Right side hemiparesis	CT, MRI	Yes	1	Left fronto-parietal	6.8	Negative	Surgical removal/neuronavigation	None	None	Seizure, headache, worsened right hemiparesis, peri-lesional edema	Albendazole, Antiepileptic, Steroid	Improved
Lakhdar et al [4]	Morocco	Case report	1	30	M	Headache, right side hemiparesis	MRI	Yes	>1	Left fronto-parietal	N/A	Negative	Surgical removal	None	Rupture of cysts	None	Albendazole, Antibiotics, Antiepileptic	Recovered
Fariba Bi. [5]	Iran	Case report	1	18	F	Headache, nausea, vomiting	MRI	Yes	1	Right temporal	N/A	N/A	Surgical removal	None	None	None	Albendazole, anticonvulsant	Recovered
				9	M	Drowsiness, vomiting, blurred vision, headache	CT, MRI	Yes	>1	Right parieto-occipital	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	N/A
Saleh et al [6]	Egypt	Case series	4	10	M	Seizure	CT, MRI	Yes	1	Right frontal	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	N/A
				12	M	Seizure	CT, MRI	Yes	1	Left fronto-parietal	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	N/A
				14	F	Headache	CT, MRI	Yes	1	Right parieto-occipital	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	N/A
Alomari et al [7]	Saudi Arabia	Case report	1	8	F	Bilateral exophthalmos, blurred vision, headache	CT	Yes	1	Left frontal	15.3	Negative	Surgical removal [Dowling]	None	None	Seizure	Albendazole	Recovered
Hafedh et al [8]	Iraq	Case report	1	27	M	Seizure, headache, left side hemiparesis	CT, MRI	Yes	1	Right hemisphere	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Improved

Table 1. Continued...

Umut et al [9]	Turkey	Case report	1	14	M	Double vision, headache nausea, vomiting	MRI	Yes	2	Left occipital lobe, right insula	1 st : 5.6 2 nd :2.6	Negative	Surgical removal [Dowling] first occipital cysts and after 6 m temporal insula	None	None	None	Albendazole	Recovered
Çavusoglu et al [10]	India	Case report	1	8	F	Left side hemiparesis, left side mouth deviation, slurred speech	CT, Contrast MRI	Yes	1	Left fronto-parietal	10.2	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	N/A
Garg et al [11]	India	Case report	1	8	F	Left side hemiparesis, left side mouth deviation, slurred speech	CT, Contrast MRI	Yes	1	Left fronto-parietal	10.2	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	N/A
Raouzi et al [12]	Morocco	Case series	4	14	M	Seizure	CT, MRI	Yes	1	Right parietal area	N/A	Negative	Surgical removal [Dowling]	None	None	None	Albendazole	N/A
				4	M	Headache, vomiting	CT, MRI	Yes	1	Right fronto-parietal	7.05	Positive	Surgical removal [Dowling]	None	None	None	Albendazole	N/A
				3	M	Seizure	CT, MRI	Yes	1	Right parietal lobe	N/A	Positive	Surgical removal [Dowling]	None	None	None	Albendazole	N/A
				22	F	Seizure	CT, MRI	Yes	>1	Left fronto-parietal	N/A	Negative	Surgical removal [Dowling]	None	None	None	Albendazole	N/A
Assefa et al [13]	Ethiopia	Case series	4	8	M	Hemiparesis, nausea and vomiting	Contrast CT	Yes	1	Left fronto-parietal + daughter cyst	N/A	N/A	Surgical Removal	None	Rupture of Cyst	Cystic abscess, pericystic vasogenic edema	N/A	Recurrence
				5	F	Hemiparesis, nausea and vomiting	Contrast CT	Yes	1	Right fronto-parietal	N/A	N/A	Surgical Removal	None	None	None	N/A	N/A
				10	F	Hemiparesis, nausea and vomiting	Contrast MRI	Yes	1	Right parietal	N/A	N/A	Surgical Removal	None	None	None	N/A	N/A
				29	M	Hemiparesis, nausea and vomiting	Contrast MRI	Yes	1	Right parietal	N/A	N/A	Surgical Removal	None	None	None	N/A	N/A
Tanki et al [14]	India	Case series	9	10	M	Seizure	CT, MRI	Yes	1	Right frontal	N/A	N/A	Surgical removal [Dowling]	None	None	N/A	Albendazole	Recovered
				12	F	Headache, nausea, vomiting, hemiparesis	CT, MRI	Yes	>1	Left parietal	N/A	N/A	Surgical removal [Dowling]	None	Rupture of Cyst	N/A	Albendazole	Recurrence
				12	M	Seizure, headache, nausea, vomiting	CT, MRI	Yes	1	Right parietal	N/A	N/A	Surgical removal [Dowling]	None	None	N/A	Albendazole	Recovered
				10	M	Headache, nausea, vomiting	CT, MRI	Yes	1	Left parieto-occipital	N/A	N/A	Surgical removal [Dowling]	None	None	N/A	Albendazole	Recovered
				11	M	Seizure, hemiparesis	CT, MRI	Yes	1	Right parietal	N/A	N/A	Surgical removal [Dowling]	None	None	N/A	Albendazole	Recovered
				16	F	Seizure	CT, MRI	Yes	1	Left frontal	N/A	N/A	Surgical removal [Dowling]	None	None	N/A	Albendazole	Recovered
				14	M	Seizure, hemiparesis	CT, MRI	Yes	>1	Right parietal	N/A	N/A	Surgical removal [Dowling]	None	Rupture of Cyst	N/A	Albendazole	Recurrence
				7	F	Seizure	CT, MRI	Yes	1	Left parietal	N/A	N/A	Surgical removal [Dowling]	None	None	N/A	Albendazole	Recovered
				12	F	Seizure, hemiparesis	CT, MRI	Yes	1	Left parietal	N/A	N/A	Surgical removal [Dowling]	None	None	N/A	Albendazole	Recovered

Table 1. Continued...

Noori et al [15]	Iraq	Case report	1	26	M	Headache, nausea, vomiting	CT	Yes	1	Right temporo-parietal	N/A	N/A	Surgical removal [Dowling]	None	None	None	N/A	N/A
Haradhan et al [16]	Bangladesh	Case report	1	14	M	Headache	Contrast CT, Contrast MRI	Yes	1	Right fronto-parietal	12.48	N/A	Surgical removal	None	None	Right frontoparietal subdural hygroma, hydrocephalus, pseudocyst	Albendazole	N/A
Panda et al [17]	India	Case report	1	4	M	Seizure	CT, MRI	Yes	1	Left fronto-parietal	4.47	N/A	Surgical removal [Dowling]	None	Rupture of Cyst	None	N/A	N/A
Sharifi et al [18]	Iran	Case report	1	44	M	Mood swings, restlessness, and headache	CT	Yes	1	Right frontoparietal lobe	N/A	N/A	Surgical removal	None	None	None	Albendazole	N/A
Aydin et al [19]	Turkey	Case series	2	9	F	Headache, vomiting, bilateral decreased vision, left side tremor, left side hemiparesis	CT, MRI	Yes	1	Right fronto-temporo-parietal	9.81	Negative	Surgical removal [cavity placed balloon/Dowling]	None	None	None	N/A	N/A
				18	M	Headache, vomiting, blurred vision, fever, quadriparesis	CT, MRI	Yes	1	Right fronto-temporo-parietal	8.96	Negative	Surgical removal [cavity placed balloon/Dowling-Orlando]	None	None	None	N/A	Recovered
Çakir et al [20]	Turkey	Case report	1	6	M	Headache	MRI	Yes	1	Left parietal	N/A	N/A	Surgical removal [Dowling]	None	Cardiac arrest/death	N/A	N/A	Death
Ponnambath et al [21]	India	Case report	1	40	M	Headache, seizure	Contrast MRI	No	1	Left occipital lobe	3	N/A	Surgical removal/neuronavigation	None	None	None	Albendazole	Minimal visual field defect
İzgi et al [22]	Turkey	Case report	1	5	M	Headache, nausea, vomiting, deviation of the eyes	MRI	Yes	1	Right parietal lobe	6.92	N/A	Surgical removal [Dowling]	None	None	None	N/A	N/A
El Ouarradi et al [23]	Morocco	Case report	1	11	M	Nausea, vomiting	CT	Yes	1	Right fronto-parieto-temporal lobe	9.75	Positive	Surgical removal [Dowling]	None	Shock/cardiac arrest/death	N/A	N/A	Death
Baboli et al [24]	Iran	Case report	1	19	M	Headache, left hemiparesis	Contrast MRI	Yes	1	Right fronto-parietal lobe	8	Positive	Surgical removal [Dowling]	None	None	None	Albendazole	Improved
Arega et al [25]	Ethiopia	Case report	1	8	F	Headache, vomiting	Contrast MRI	Yes	1	Right temporal	13.27	N/A	Surgical removal	None	None	None	Albendazole	Recovered
Altaş et al [26]	Turkey	Case report	1	26	F	Headache, nausea, vomiting	Contrast CT, MRI	Yes	1	Right parieto-occipital	7.95	Positive	Surgical removal [Dowling]	None	None	None	Albendazole	N/A
Madeo et al [27]	USA	Case report	1	82	F	Emergency case	CT, MRI	Yes	1	Left hemisphere	4.08	Positive	Conservative [Albendazole]	N/A	N/A	N/A	None	Stable cyst
Menschaert et al [28]	Morocco	Case report	1	5	F	Seizures	MRI	Yes	1	Left parietal	N/A	Positive	Surgical removal	None	Puncture of Cyst	None	Albendazole	Learning disabilities
Şule et al [29]	Turkey	Case report	1	83	M	Headache, forgetfulness	Contrast MRI	No	1	Right frontal lobe	4	N/A	Surgical removal	None	None	None	N/A	N/A
Benhayoun et al [30]	Morocco	Case report	1	18	F	Headache, vomiting, seizure	Contrast MRI	No	1	Right parieto-occipital	7.9	N/A	Surgical removal [Arana]	None	None	None	Albendazole, Antiepileptic	Recovered

Table 1. Continued...

Vikaset al [31]	India	Case report	1	20	M	Seizure, right side paresthesia, headache, vomiting	Contrast CT, contrast MRI	Yes	>1	Left fronto-parietal	N/A	N/A	Surgical removal	None	None	None	Albendazole	Recovered
Reddy et al [32]	India	Case report	1	35	F	Headache, vomiting, altered sensorium, loss of consciousness	Contrast CT	Yes	5	Both parietal lobes	N/A	N/A	Surgical removal	None	None	None	N/A	Recovered
				3.5	F	N/A	CT	Yes	1	Left parietal	N/A	N/A	Surgical removal	None	None	None	Antiepileptic	Recovered
				7	F	N/A	CT	Yes	1	Right parietal	N/A	N/A	Surgical removal	None	Rupture of Cyst	Delayed recovery	Antiepileptic	Recurrence
				11	M	N/A	CT	Yes	1	Left fronto-parietal	N/A	N/A	Surgical removal	None	None	None	Antiepileptic	Recovered
Al-Rawi et al [33]	Iraq	Case series	8	13	F	N/A	CT	Yes	1	Right frontal lobe	N/A	N/A	Surgical removal	None	None	None	Antiepileptic	Recovered
				15	M	N/A	CT	Yes	1	Left fronto-parietal	N/A	N/A	Surgical removal	None	None	None	Antiepileptic	Recovered
				15	M	N/A	CT	Yes	1	Right fronto-parietal	N/A	N/A	Surgical removal	None	None	None	Antiepileptic	Recovered
				35	M	N/A	CT	Yes	1	Left fronto-parietal	N/A	N/A	Surgical removal	None	None	None	Antiepileptic	Recovered
Naderzadeh et al [34]	Iran	Case report	1	12	M	Headache, nausea, vomiting, fever, decreased vision	MRI	Yes	1	Left parieto-occipital	4.56	N/A	Surgical removal	None	None	Visual deficit	Albendazole	Myopia, occasional seizure
				3	M	Headache	CT	Yes	1	Left temporo-parietal	5.83	N/A	Surgical removal	None	None	None	Albendazole , Antiepileptic	Recovered
Shafiei et al [35]	Iran	Case series	3	59	F	Headache, fever	CT	Yes	1	Right parieto-occipital	8.48	N/A	Surgical removal	None	None	None	Albendazole , Antiepileptic	Recovered
				53	F	Angiopathy, nausea, vomiting	CT	Yes	1	Left fronto-occipital	N/A	N/A	Surgical removal	None	Rupture of Cyst	None	Albendazole , Antiepileptic	Recurrence
Nechi et al [36]	Tunisia	Case report	1	50	F	Seizure	CT, MRI	Yes	1	Right frontal lobe	4.97	N/A	Surgical removal	None	None	None	Albendazole	Recovered
Ekici et al [37]	Turkey	Case report	1	12	M	Headache, vomiting, diplopia	CT	Yes	>1	Right parieto-occipital	N/A	Negative	Surgical removal [Dowling]/neuronavigation	None	None	None	Albendazole	Recovered
Bagheri et al [38]	Iran	Case report	1	18	M	Nausea, vomiting, right side hemiparesis	CT, MRI	Yes	1	Left temporal	6	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered
Bušić et al [39]	Croatia	Case report	1	37	F	Headache, vomiting, balance difficulties, left side hemiparesis	CT, MRI	Yes	5	Right parietal lobe	N/A	Positive	Surgical removal	None	None	Wound infection and osteomyelitis	Albendazole	Recurrence

Table 1. Continued...

Nashibi et al. [40]	Iran	Case report	1	59	M	Disorientation, right side hemiparesis, headache, dysarthria	CT, MRI	Yes	1	Left parieto-temporal	N/A	N/A	Surgical removal [Dowling]	None	None	None	N/A	Improved	
Ammor et al [41]	Morocco	Case report	1	4	N/A	Weakness, headache, vomiting	Contrast MRI	Yes	1	Right fronto-temporo-parietal	N/A	N/A	Surgical removal	None	None	None	N/A	Headache, subdural hygroma	
Alok et al [42]	Syria	Case report	1	5	F	Right side hemiparesis	CT, MRI	Yes	1	Pons	2.1	Positive	Surgical removal [Dowling-Orlando]	None	None	None	Albendazole	Improved	
Chatzidakis et al [43]	Greece	Case report	1	27	M	Quadriparesis, headache, nausea, vomiting	CT, MRI	Yes	>1	Bilateral frontal, bilateral occipital, cerebellum	N/A	N/A	Surgical removal [3 times]	None	None	Generalized seizure post 1st OP	Albendazole	Recovered	
Panagopoulos et al [44]	Greece	Case report	1	11	M	Headache, vomiting	Contrast CT, contrast MRI	Yes	1	Right fronto-parietal	6.85	Negative	Surgical removal/neuronavigation	None	None	None	Albendazole	Improved	
Karaaslan et al [45]	Turkey	Case report	1	22	M	Nausea, vomiting, headache	CT, MRI	Yes	1	Left parieto-occipital	6.92	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered	
Hajhouji et al [46]	Morocco	Case report	1	17	F	Seizure	Contrast MRI	Yes	1	Left parietal	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered	
Tascu et al [47]	Romania	Case report	1	3	N/A	Post cranio-cerebral trauma	Contrast CT, MRI	Yes	1	Left fronto-parieto-occipital lobe	10	N/A	Surgical removal [Arana]	None	None	None	N/A	Subdural hematoma	
Ghaemi et al [48]	Iran	Case report	1	28	M	Headache, nausea, vomiting	CT, MRI	No	1	Right temporal	6	N/A	Surgical removal	None	None	None	N/A	N/A	
Ganjeifar et al [49]	Iran	Case report	1	13	M	Fever, abdominal pain	CT, MRI	Yes	1	Left parieto-occipital	N/A	Positive	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered	
Nemati et al [50]	Iran	Case report	1	6	M	Ataxia, left side hemiparesis	CT, MRI	Yes	1	Right fronto-parietal	13.29	Negative	Surgical removal [Dowling]	None	None	None	Albendazole	Improved	
Mehrizi et al. [51]	Iran	Case report	1	5	F	Headache, nausea, vomiting	CT	Yes	1	Fronto-parietal	10	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered	
Fakhouri et al [52]	Syria	Case report	1	5	F	Headache, vomiting, difficult walking	CT, MRI	Yes	1	Right Cerebellum	6	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered	
Ghasemi et al [53]	Iran	Case report	1	8	F	Malaise, vomiting, headache	CT, contrast MRI	Yes	1	Left temporo-parieto-occipital	N/A	Negative	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered	
Mallik et al. [54]	India	Case report	2	10	M	Headache, vomiting, right side hemiparesis, aphasia	MRI	Yes	1	Left temporo-parietal	10.32	N/A	Surgical removal [Dowling]	None	Rupture of Cyst	None	Albendazole, Antibiotics, Antiepileptic, Steroids	Improved	
				16	M	Decreased vision, headache, vomiting	CECT	Yes	1	Left fronto-temporo-parietal	N/A	Positive	Surgical removal [Dowling]	None	Rupture of Cyst	None	Albendazole	Seizure, unconsciousness	
Arora et al[55]	India	Case report	1	9	F	Seizure, decreased vision, headache, vomiting	CT	Yes	1	Left parietal lobe	7.23	Positive	Surgical removal [Dowling]	None	None	None	N/A	N/A	
Al-Musawi et al [56]	Iraq	Case report	1	14	F	Seizure	CT	Yes	1	Left parietal	N/A	N/A	Burr-hole surgical removal	Deterioration in the consciousness, right side hemiparesis, apnea	None	None	None	Albendazole, anticonvulsant	Recovered

Table 1. Continued...

Ghasem et al [57]	Iran	Case report	1	30	F	Seizure, headache, intellectual impairment, abnormal behavior	CT, MRI	Yes	1	Left frontal	N/A	N/A	Surgical removal [Dowling]	None	None	None	N/A	Recovered
Polat et al. [58]	Turkey	Case report	1	45	M	Personality disorder, nausea, vomiting	CT, MRI	Yes	1	Left fronto-parietal	N/A	Positive	Surgical removal [Dowling]	None	None	None	Albendazole	Recurrence & Death
Hmada et al [59]	Morocco	Case report	2	5	F	Decreased vision, tremor	CT	Yes	1	Right fronto-temporo-parietal	N/A	N/A	Surgical removal [Arana]	None	None	None	Albendazole , Antiepileptic	Improved
				5	F	Right side heaviness	N/A	Yes	1	Right fronto-temporo-parietal	N/A	N/A	Surgical removal [Arana]	None	None	None	anticonvulsant	Recovered
Senapati, et al [60]	India	Case report	2	22	M	Vomiting, disorientation	CT, MRI	Yes	>1	Left parieto-occipital	N/A	N/A	Surgical removal [Dowling]	None	Cyst wall puncture	None	N/A	Recovered
				40	M	Seizure, headache, vomiting, right side hemiparesis	CT	Yes	1	Left fronto-parietal	N/A	N/A	Surgical removal [Dowling]	None	None	None	N/A	Recovered
Imperato et al [61]	Italy	Case report	1	9	M	Headache, diplopia	CT, MRI	Yes	1	Right temporo-parieto-occipital	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered
Ramosaço et al [62]	Albania	Case report	1	22	F	Headache, vomiting, seizure	MRI	Yes	6	Left frontal lobe, left frontal-parietal, left temporo-parietal, right occipital and right frontal	1 st :2.79 2 nd :4.18 3 rd :4.29 4 th :2.89 5 th :4.09 6 th :2.84	Positive	Surgical removal	None	None	None	Albendazole , Antiepileptic	Encephalomalacia
Ravanbakhsh et al [63]	Iran	Case report	1	12	M	Vision disturbance	MRI	Yes	1	Left parietal	8	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	N/A
Pulavarty [64]	India	Case report	1	16	F	Generalized seizure	CT	Yes	1	Left fronto-temporal	4.89	N/A	Surgical removal [Dowling]	None	Rupture of cyst	None	Albendazole	Recovered
Shastri et al. [65]	Iran	Case report	1	7	F	Blurred vision	CT	Yes	1	Left parieto-temporal	5.65	N/A	surgical removal [Dowling]	None	None	None	N/A	N/A
Chen et al [66]	China	Case report	1	28	F	Seizure	MRI	Yes	1	Right frontal	N/A	Positive	Conservative [Albendazole]	N/A	N/A	N/A	None	Size of the cyst reduced
Kaushik et al [67]	India	Case report	1	53	M	Seizure exacerbation	CT	Yes	>1	Right parieto-occipital	N/A	N/A	Surgical removal	None	None	None	Albendazole	N/A
Wani, et al [68]	India	Case report	1	13	M	Generalized seizure, vomiting	Contrast CT	Yes	1	Right occipital	8.48	N/A	Surgical removal	None	None	None	N/A	Recovered
Armanfar et al [69]	Iran	Case report	1	46	F	Headache, blurred vision	CT, MRI	Yes	>1	Right parieto-occipital	N/A	N/A	Surgical removal	None	Rupture of cyst	None	Albendazole	Recovered
Khan et al [70]	Pakistan	Case report	1	8	M	Headache, fever, vomiting	Contrast MRI	Yes	19	Right frontal	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole , Steroid, Antibiotic, Antiepileptic	Recovered
Charles et al [71]	Congo	Case report	1	32	N/A	Seizure, vomiting	Contrast CT	Yes	2	Bilateral hemisphere, right temporo-parietal	1 st :1.02 2 nd :6.87	N/A	Surgical removal [Arana]	None	None	None	Albendazole , Steroid	Improved

Table 1. Continued...

Garg et al. [72]	India	Case report	1	47	M	Headache, vomiting	MRI	Yes	7	Both sides of cerebrum	N/A	Positive	Surgical removal [Dowling]	None	None	None	Albendazole	Disturbed verbal output
Abuhajar et al [73]	Libya	Case report	1	50	M	Headache, left side numbness, left toes paresthesia, vomiting	Contrast CT, MRI	Yes	3	Right temporo-parietal	1 st : 3.5 2 nd : 3.8 3 rd : 4.0	N/A	Surgical removal	N/A	N/A	N/A	N/A	N/A
Umerani et al. [74]	Pakistan	Case report	1	22	F	Headache	CT, MRI	Yes	1	Right temporo-parietal	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered
Touzani et al. [75]	Morocco	Case report	1	5	M	Vomiting, weakness, seizure	CT	Yes	1	Left fronto-parietal	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Improved
				10	M	Left side paresthesia, nausea	CT, contrast MRI	Yes	1	Right temporo-parietal	N/A	N/A	Surgical removal [Dowling]	None	Puncture of Cyst	None	Albendazole, Antiepileptic	Recurrence
Kibzai et al [76]	Pakistan	Case series	3	40	M	Vomiting, altered behavior	CT, MRI	Yes	1	Left parieto-occipital	N/A	N/A	Surgical removal [Dowling]	None	Rupture of cyst	None	Albendazole	Recovered
				72	M	Seizure, personality disorder	CT, MRI	Yes	32	Right frontal	N/A	N/A	Surgical removal	None	None	None	Albendazole	Improved
Duransoy et al [77]	Turkey	Case report	1	13	M	Headache, nausea, vomiting	CT	Yes	1	Right temporo-parietal	10	N/A	Surgical removal [Arana]	None	None	Left hemiparesis, subdural hygroma	Albendazole	Improved
Qureshi et al [78]	Pakistan	Case report	1	11	M	Seizure	MRI	Yes	1	Left posterior-parietal	N/A	N/A	Surgical removal [Dowling]	None	None	None	N/A	N/A
Senol et al. [79]	Turkey	Case report	1	6	F	Headache with photophobia and phonophobia	MRI	Yes	1	Right frontotemporal	10.5	Negative	Surgical removal [Dowling]	None	None	None	Albendazole, Antiepileptic	Recovered
Kandemirli et al [80]	Turkey	Case report	1	6	M	Nausea, vomiting	CT	Yes	1	Right frontal extended to lateral ventricle	7.95	N/A	Surgical removal [Dowling]	None	None	None	Albendazole, Antiepileptic	Recovered
Bahannanet al [81]	Yemen	Case report	1	17	M	Imbalance, ataxia, falls, right side hemiparesis, fever, headache, decreased visual acuity, diplopia.	CT	Yes	1	Right fronto-parietal	5	N/A	Surgical removal	None	None	None	Albendazole	Recovered
Kumar et al[82]	India	Case report	1	25	M	Headache, vomiting, right side weakness, seizure	Contrast CT, MRI	Yes	1	Left parietal	N/A	N/A	Surgical removal	None	None	None	N/A	N/A
Agrawal et al [83]	India	Case report	1	25	M	Difficulty walking, seizure	CT, contrast MRI	Yes	1	Left fronto-parietal	24.63	N/A	Surgical removal	None	None	None	Albendazole	N/A
Mustafa et al [84]	Iraq	Case report	1	2	M	Focal seizure	CT	Yes	1	Left parietal	6	N/A	Surgical removal [Dowling]	None	None	None	none	Recovered
Ijaz et al [85]	Pakistan	Case report	1	8	M	Headache, fever, right-side hemiparesis, difficult walking	CT	Yes	1	Left cerebrum	8.94	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered
Borni et al [86]	Tunisia	Case report	1	5	M	Headache, vomiting	CT, contrast MRI	Yes	2	Left occipital	1 st : 3.39 2 nd : 2.25	Positive	Surgical removal	None	Puncture of Cyst	None	Albendazole	Recovered

Table 1. Continued...

Kojundzic et al [87]	Croatia	Case report	1	34	F	Headache, vomiting	CT, MRI	Yes	3	Right temporo-parietal	1 st :3.8 2 nd :2.9 3 rd : N/A	Positive	Surgical removal	None	None	Osteomyelitis	Albendazole	Improved
Siyadatpanah et al[88]	USA	Case report	1	39	M	Right side paresthesia, imbalance	MRI	Yes	1	Left fronto-parieto-occipital	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered
Akrim et al [89]	Morocco	Case report	1	22	F	Headache, vomiting, blurred vision	CT	Yes	>1	Left parieto-occipital	N/A	N/A	Surgical removal [Arana]	None	None	Neurological deficit	Albendazole	Improved
				50	M	Headache, left side hemiparesis	CT, MRI	Yes	1	Right parietal	N/A	N/A	Surgical removal	N/A	N/A	N/A	Albendazole	Glasgow outcome: 4
				55	M	Dysarthria, focal seizure	CT, MRI	Yes	1	Left temporo-parietal	N/A	N/A	Surgical removal	N/A	N/A	N/A	Albendazole	Glasgow outcome: 5
				40	M	Headache, nausea, vomiting	CT, MRI	Yes	1	Left parietal	N/A	N/A	Surgical removal	N/A	N/A	N/A	Albendazole	Glasgow outcome: 4
				26	M	Headache, left side hemiparesis	CT, MRI	Yes	1	Left parietal	N/A	N/A	Surgical removal	N/A	N/A	N/A	Albendazole	Glasgow outcome: 5
				35	F	Headache, right side hemiparesis	CT, MRI	Yes	1	Left thalamus	N/A	Positive	Surgical removal	N/A	N/A	N/A	Albendazole	Glasgow outcome: 5
																		Glasgow outcome: 5
Zeynal et al [90]	Turkey	Retrospective cohort	12	25	M	Right side hemiparesis	CT, MRI	Yes	1	Left thalamus	N/A	Positive	Surgical removal	N/A	N/A	N/A	Albendazole	Glasgow outcome: 4
				64	M	Dysphasia	CT, MRI	Yes	1	Right temporal	N/A	Positive	Surgical removal	N/A	N/A	N/A	Albendazole	Death
				27	F	Headache, nausea, vomiting, altered consciousness	CT, MRI	Yes	1	Left parietal	N/A	Positive	Surgical removal	N/A	N/A	N/A	Albendazole	Glasgow outcome: 5
				13	M	Right side hemiparesis	CT, MRI	Yes	1	Left parieto-occipital	N/A	Positive	Surgical removal	N/A	N/A	N/A	Albendazole	Glasgow outcome: 5
				62	M	Left side hemiparesis	CT, MRI	Yes	1	Right fronto-parietal	N/A	Positive	Surgical removal	N/A	N/A	N/A	Albendazole	Death
				49	M	Headache	CT, MRI	Yes	1	Right parieto-occipital	N/A	Positive	Surgical removal	N/A	N/A	N/A	Albendazole	Glasgow outcome: 5
Ozdol et al[91]	Croatia	Case report	1	23	M	Nausea, imbalance, headache, urinary and fecal incontinence	MRI	No	1	Left cerebellum	2.08	Positive	Surgical removal	None	None	None	Albendazole	Recovered
				50	M	Headache, nausea, vomiting	Contrast CT, contrast MRI	Yes	2	Right frontal, left temporal	N/A	N/A	Surgical removal	None	None	None	Albendazole	Recovered
Ma et al [92]	China	Case report	2	42	F	Headache, vomiting	Contrast CT, contrast MRI	Yes	2	Left frontal, left temporal	N/A	N/A	Surgical removal	None	None	None	Albendazole	Recovered
Mokhtari et al [93]	Iran	Case report	1	60	F	Headache, bilateral decreased vision, delusions, cognitive disorders	Contrast CT, MRI	Yes	2	Left fronto-parietal, right parieto-occipital	1 st : 3 2 nd : 2.08	N/A	Surgical removal	None	None	None	Albendazole	Recovered

Table 1. Continued...

Benzagmout et al [94]	Morrocco	Case report	2	21	F	Seizure	Contrast CT, contrast MRI	Yes	1	Right frontal	N/A	N/A	Surgical removal	None	None	None	Antiepileptic	Recovered
				24	F	Headache, vomiting	CT	No	1	Right frontal	4.47	N/A	Surgical removal	None	None	None	Albendazole	Recovered
Ray et al [95]	India	Case report	1	4	M	Headache, nausea, vomiting, altered sensorium, fever	CT	Yes	>1	Left fronto-parietal	N/A	Negative	Surgical removal [Dowling]	N/A	N/A	Meningitis, subdural effusion, hydrocephalus	N/A	Recovered
Yiş et al [96]	Turkey	Case report	1	7	M	Headache, vomiting, myalgia, abdominal pain	MRI	Yes	1	Temporo-parieto-occipital	8	N/A	Surgical removal [Dowling]	None	None	None	Mebendazole	Recovered
				15	M	Headache, intellectual impairment, dysphasia	CT	Yes	4	Left fronto-parietal, left occipital	N/A	N/A	Surgical removal [Dowling]	None	None	None	N/A	Recurrence & Death
				15	M	Headache, faintness, diplopia, vomiting	CT, MRI	Yes	1	Right temporo-parietal	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered
Per et al [97]	Turkey	Case series	5	4	F	Headache, nausea, vomiting, seizure	CT	Yes	1	Right parietal	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Recurrence
				16	M	Vomiting, seizure, headache	MRI	Yes	1	Right parietal	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered
				11	M	Headache, vomiting, strabismus	MRI	Yes	>1	Right occipital, right parietal	N/A	N/A	Surgical removal [Dowling]/neuronavigation	None	None	None	N/A	Improved
Radmenesh et al [98]	Iran	Case report	2	7	F	Headache, vomiting, right side hemiparesis	CT	Yes	4	Left frontal	N/A	Negative	Surgical removal	None	None	Hydrocephalus	Albendazole	Recovered
				12	M	Headache, vomiting	CT	Yes	1	Right fronto-temporal	N/A	Negative	Surgical removal	None	None	None	Albendazole	Recovered
Balak et al [99]	Turkey	Case report	1	16	M	Headache, visual disturbance	CT, MRI	Yes	1	Right parieto-occipital	6	Positive	Surgical removal/microsurgery	None	None	None	Albendazole	Recovered
Najjar et al [100]	Saudi Arabia	Case report	1	11	M	Left side hemiparesis	CT, contrast MRI	Yes	1	Right hemisphere	8	Negative	Burr-hole surgical removal	None	Puncture of Cyst	Abscess at surgical site	Albendazole	Recovered
				7	M	Headache, left side hypoesthesia	CT, MRI	Yes	1	Right parietal	7.65	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Recovered
Tatli et al [101]	Turkey	Case report	3	15	F	Headache, vomiting	CT	Yes	1	Left fronto-parietal	8.48	N/A	Surgical removal [Dowling]	None	Rupture of cyst	None	Albendazole	Recovered
				10	F	Headache, vomiting, left side weakness	CT, MRI	Yes	1	Right fronto-temporo-parieto-occipital	10.32	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	N/A
Yurt et al [102]	Turkey	Case report	1	19	F	Headache, vomiting, seizure	CT, MRI	Yes	>1	Bilateral hemispheres	N/A	Negative	Multiple surgeries	Left side hemiplegia, deterioration	None	Recurrence of symptoms	Albendazole	Recurrence
Aydin et al [103]	Turkey	Case report	1	7	M	Headache, behavioral disturbance, counting and calculation disorders, mental regression	CT	Yes	1	Left temporo-parietal	7.48	Positive	Surgical removal	None	None	Left hemiparesis	Mebendazole	Recovered

Table 1. Continued...

Tuzun et al [104]	Turkey	Case series	13	9	M	Headache, seizure	CT, MRI	Yes	1	Left parieto-occipital	N/A	N/A	Surgical removal [Dowling]	Deterioration	None	Subdural effusion	Albendazole	Improved
				5	M	Right side hemiparesis	CT, MRI	Yes	1	Left parieto-occipital	N/A	N/A	Surgical removal [Dowling]	None	None	Porencephalic cyst	Albendazole	Improved
				16	F	Headache, nausea, vomiting	CT, MRI	Yes	1	Right parieto-occipital	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Improved
				11	F	Headache, nausea, vomiting	CT, MRI	Yes	1	Left temporo-parietal	N/A	N/A	Surgical removal [Dowling]	None	None	Cerebral spinal fluid collection	Albendazole	Improved
				12	M	Left side hemiparesis, seizure	CT, MRI	Yes	1	Right frontal	N/A	N/A	Surgical removal [Dowling]	Deterioration	None	Subdural effusion	Albendazole	Improved
				8	F	Headache, loss of consciousness	CT, MRI	Yes	1	Left fronto-parietal	N/A	N/A	Surgical removal [Dowling]	Deterioration	None	None	Albendazole	Improved
				3	M	Right side hemiparesis	CT, MRI	Yes	1	Left parietal	N/A	N/A	Surgical removal [Dowling]	Deterioration	None	Subdural effusion	Albendazole	Improved
				17	M	Headache, left side hemiparesis	CT, MRI	Yes	1	Right parietal	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Improved
				18	M	Headache, right side hemiparesis	CT, MRI	Yes	1	Left fronto-parietal	N/A	N/A	Surgical removal [Dowling]	None	None	Hemorrhage	Albendazole	Improved
				16	F	Right side hemiparesis	CT, MRI	Yes	>1	Left occipital, left parietal	N/A	N/A	Surgical removal [Dowling]	None	Rupture of cyst	None	Albendazole	Recurrence
				11	M	Headache	CT, MRI	Yes	1	Left parietal	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Improved
				9	F	Headache, nausea, vomiting	CT, MRI	Yes	1	Right occipital	N/A	N/A	Surgical removal [Dowling]	None	None	Hemorrhage	Albendazole	Improved
				5	F	Headache, right side hemiparesis	CT, MRI	Yes	1	Left parietal	N/A	N/A	Surgical removal [Dowling]	None	None	None	Albendazole	Improved
Bakaris et al [105]	Turkey	Case report	1	8	F	Right upper paresis, headache	CT	Yes	1	Left temporo-parieto-occipital	8.14	N/A	Surgical removal	None	None	None	Albendazole	Recovered
Guney et al [106]	Turkey	Case report	1	18	M	Headache, neck pain	CT	Yes	1	Left fronto-parietal	N/A	Positive	Surgical removal	None	None	None	N/A	N/A
Önal et al [107]	Turkey	Case report	1	7	F	Ataxia, apraxia, Headache, tremor	CT, MRI	Yes	1	Right temporo-parietal	6.21	N/A	Surgical removal [Dowling]	None	None	None	N/A	Recovered
Muthusubramanian et al [108]	India	Case report	1	40	F	Headache, right side hemiparesis, double vision, gait abnormality	Contrast CT	Yes	1	Pons	N/A	N/A	Surgical removal	None	None	None	N/A	Improved
Kabatas et al [109]	Turkey	Case report	1	26	F	Headache, nausea, vomiting, seizure	MRI	Yes	1	Left frontal	4.13	Positive	Surgical removal [Dowling]	None	None	None	Albendazole	Improved
Menkü et al [110]	Turkey	Case report	1	35	M	Seizure	CT, MRI	No	1	Right parieto-occipital	4.74	Negative	Surgical removal	None	None	None	N/A	Recovered
Anvari et al [111]	Iran	Case report	1	5	F	Headache, nausea, vomiting	Contrast CT	No	1	Right fronto-parietal	N/A	N/A	Burr-hole surgical removal	None	None	None	Albendazole	Recovered
Karadag et al [112]	Turkey	Case report	1	45	F	Seizure, confusion	CT	Yes	2	Left fronto-parietal, right parietal	5	Negative	Surgical removal	Deterioration	Puncture of the left cyst	None	Albendazole	Recurrence

CT; computed tomography, MRI; magnetic resonance imaging, ISHC; Imaging suggested hydatid cyst, N/A; non-available, OP; operative,

*Improved = Symptomatic improvement but not complete recovery during the follow-up period. Recovered = Complete recovery/free of symptoms.

Table 2. Baseline characteristics of the study and the participants.

Variables	Frequency/Percentage
Country of study	
Turkey	27 (24.1%)
Iran	19 (16.7%)
India	17 (15.2%)
Morocco	11 (9.8%)
Iraq	5 (4.6%)
Pakistan	5 (4.6%)
Croatia	3 (2.7%)
Others	25 (22.3%)
Study design	
Case Report	101 (90.2%)
Case Series	10 (8.9%)
Retrospective cohort	1 (0.9%)
Age, year, mean [SD]	20.44± 16.76
Age group	
≤9	52 (29.2%)
10-19	62 (34.8%)
20-29	24 (13.5%)
30-39	12 (6.7%)
40-49	12 (6.7%)
50-59	10 (5.6%)
60-69	3 (1.7%)
70-79	1 (0.6%)
80-89	2 (1.1%)
Gender	
Male	107 (60.1%)
Female	68 (38.2%)
N/A	3 (1.7%)
Residency	
Rural	71 (39.9%)
Urban	8 (4.5%)
N/A	99 (55.6%)
Previous history of hydatid disease	
Yes	13 (7.3%)
No	161 (90.5%)
N/A	4 (2.2%)
Type of hydatid disease	
Cystic	158 (88.8%)
Alveolar	20 (11.2%)
Presentation	
Symptomatic	168 (94.4%)
Asymptomatic	10 (5.6%)
Presenting complaint	
Headache	112 (62.9%)
Vomiting	77 (43.3%)
Nausea	35 (19.7%)
Seizure	54 (30.3%)
Paresis	51 (28.7%)
Impaired vision	23 (13%)
Impaired conscious level	12 (6.7%)
Speech abnormalities *	10 (5.6%)
Fever	8 (4.5%)
Altered sensorium **	8 (4.5%)
Psychological disturbance	7 (4.0%)
Other symptoms	31 (17.4%)
Duration of presenting symptoms [mean]	19 weeks
Multiple organ involvement	
Yes	48 (27%)
No	128 (71.9%)
N/A	2 (1.1%)

Site of the cyst/lesion [s]	
Left-side multi-lobe involvement	50 (28.1%)
Right-side multi-lobe involvement	47 (26.4%)
Bilateral multi-lobe involvement	11 (6.2%)
Frontal lobe	17 (9.6%)
Parietal lobe	33 (18.5%)
Temporal lobe	5 (2.8%)
Occipital lobe	4 (2.2%)
Left Hemisphere [unspecified location]	2 (1.1%)
Right Hemisphere [unspecified location]	2 (1.1%)
Other [Cerebellum, Thalamus, Pons]	7 (4%)
Disease status per number of cysts/lesions	
Primary-solitary	118 (66.3%)
Primary-multiple	27 (15.1%)
Secondary-solitary	23 (13%)
Secondary-multiple	10 (5.6%)
Neurological+/-other physical examination	
Normal	30 (16.8%)
Positive findings	92 (51.7%)
N/A	56 (31.5%)
CT/MRI Findings	
Suggesting hydatid disease	170 (95.5%)
Not suggesting hydatid disease	8 (4.5%)
Serology	
Positive	34 (19.1%)
Negative	21 (11.8%)
N/A	123 (69.1%)
Type of management	
Conservative	5 (2.8%)
Surgical/Open ***	170 (95.5%)
Burr-hole	3 (1.7%)
Disease outcome	
Death	6 (3.4%)
Survived	139 (78.1%)
N/A	33 (18.5%)
Recurrence	
Recurrence alive	11 (6.2%)
Recurrence dead	2 (1.1%)

* *Speech abnormalities: aphasia, apraxia of speech, dysphonia, slurred speech, and others.*

** *Altered sensorium: paresthesia, numbness, and heaviness.*

*** *Surgical removal by (Dowling technique, modified Arana-Inguinz technique, surgical removal under neuronavigation, and microsurgery).*

of a primary cyst in the brain, or the presence of cardiac anomalies. On the other hand, alveolar disease tends to result in multiple intracerebral lesions and might resemble and behave as a malignant lesion [90-93]. Cerebral HD is considered a childhood disease, most commonly (50–75%) seen in children and young adults. Additionally, patients with cerebral HDs may also have concomitant cysts in other organs, although this occurs in less than 20% of patients with intraparenchymal hydatidosis [5,6,105].

In this systematic review, most of the cases (64%) were affected during their first and second decades of life. Multiple cysts or lesions were present in about 21% of the cases. Among these, 15.1% were primary multiple diseases, while only 5.6% of the cases had secondary multiple hydatidosis. Thus, the findings of this review disagree with the assumption that primary multiple

BHD is rarer than secondary multiple lesions. Additionally, 48 cases (27%) had concomitant disease in other organs.

Signs of raised intracranial pressure (headache, nausea, vomiting) and focal neurological deficits are the most common presentations of the disease. Seizures, visual disturbances, and cranial nerve involvement are also common presenting complaints reported in the literature [103,104]. In this study, headache was the most common presenting symptom (62.9%), followed by vomiting (43.3%), similar to the other reported studies. Seizure, paresis, nausea, and visual disturbance were reported in 30.3%, 28.7%, 19.7%, and 13% of the cases, respectively. The mean duration of symptoms at the time of presentation was 19 weeks.

Timely diagnosis of BHDs is crucial because failure to make a prompt diagnosis could result in fatal consequences. Moreover, handling the cystic or mass lesion during surgical intervention is essential for reducing intraoperative complications and preventing disease recurrence. It has been declared that serological testing for the diagnosis of HD is of limited accuracy. Therefore, it is not sufficient on its own to confirm the diagnosis of HD [104]. Imaging modalities are the mainstay of diagnosis in patients with suggestive history and clinical findings, even when serological tests are negative. The disease generally poses common characteristics and pathognomonic features on scanners. Typically, CT and MRI are the primary imaging techniques, which can often be sufficient to achieve a diagnosis. For BHD, the main appearance on CT is a round, intra-parenchymal, usually large cystic lesion with a well-defined border. The cyst fluid is typically isodense or slightly hyperdense compared to cerebrospinal fluid. Calcifications or septations may or may not be present. Calcifications are primarily peri-cystic, giving a 'ground-glass' appearance, suggesting infection or damage before the larva's death. The MRI scans show a thin-walled spherical cyst containing fluid with cerebrospinal fluid characteristics on all sequences. Rim wall contrast enhancement and peripheral edema are much less common in hydatid cysts, and when present, may suggest other radiological differential diagnoses. The presence of multiple small daughter endocysts, characteristic of cystic echinococcosis, is the key distinguishing feature from other cystic lesions in the brain [1-4]. There are few reports on the CT and MRI appearance of cerebral AE. The lesions may appear as solid, semisolid, or lobulated cystic or mass lesions with definite margins. Calcifications are usually scattered throughout the lesion, unlike in CE, where they are mainly confined to the pericystic region. Predominant features include surrounding edema and various types of contrast enhancement, such as peripheral ring-like, heterogeneous, nodular, and cauliflower-like patterns, indicating an inflammatory reaction around the lesion. Diffusion-weighted MRI is useful in distinguishing lesions from edema. Therefore, the diagnosis should be based on evidence of a primary focus in another location, an appropriate clinical history, the prevalence of the infection in the host's geographic location, and laboratory findings, as a standard practice for diagnosing and differentiating cerebral AE [90-94]. Following laboratory tests and imaging, a histopathological examination confirms the final diagnosis [80,97]. Regarding the findings of this systematic review, a serology test was performed in 30.9% of the studies, and it was positive in 19.1% of the cases.

Although this study could not statistically confirm the exact role of serology in detecting BHD, the data suggest that serology alone cannot be relied upon for diagnosing cerebral HD. Additionally, imaging modalities, including both CT and MRI, were indicated for the diagnosis of the disease in 95.5% of cases. The management of BHD typically involves a combination of surgical and adjunctive medical therapies. The treatment plan may vary depending on the size, number, location, and depth of invasion of the lesions into the brain parenchyma. Consequently, the prognosis of the disease can vary based on these factors. The most effective method is surgery. Although different surgical techniques have been investigated, there is consensus that intact cyst removal and total resection of the mass lesion without rupturing it or spilling its contents should be the core of the surgery. This approach is crucial in preventing perioperative complications, recurrence, and progression of the disease. The Dowling-Orlando technique, later modified by Arana-Iniguez and San Julian, is the most widely used surgical method for removing CNS hydatid cysts. This technique involves the formation of a hydrostatic assistant and continuous irrigation with hypertonic saline to dissect the cyst wall from the brain parenchyma, thereby achieving the intact removal of the cyst [26,42,53]. The location of the cyst, its size, adhesion to surrounding structures, multiplicity, and the presence of deep-seated lesions, especially in cases of alveolar E. multilocularis, can make the removal of the cyst intact challenging. The Dowling-Orlando technique may not be feasible in all cases of brain HD. In such situations, alternative methods aimed at minimizing the spillage of the cyst contents can be considered. The PAIR technique, which involves puncture and needle aspiration of the cyst, followed by the injection of a scolicidal solution for 20-30 minutes and cyst re-aspiration, has been reported as a reasonable approach [74,75,111].

Furthermore, the technique of burr-hole opening over the site of the cyst and the introduction of a cannula through the brain to drain the cyst, followed by removal of the cyst wall, has also been reported. However, this method of aspiration is discouraged unless total removal by other techniques is impossible. In patients with brain AE, radical excision should be performed for all accessible lesions. These procedures can be combined with the use of microsurgical and neuronavigation modalities to reduce perioperative complications [56,104]. Intraoperative cyst rupture is a common and serious event. Spillage of the cyst content into the brain tissue may lead to a fatal anaphylactic reaction, which is a chief cause of mortality during surgery. Furthermore, it increases the risk of high recurrence rates of the disease, particularly if the cyst is primary, as it is a fertile lesion [33,35]. The main reported early post-operative complications often arise due to the space left after the excision of large lesions. These may include subdural hematomas, hyperpyrexia, cerebral edema, cortical collapse, or even cardiorespiratory failure. Late post-operative complications such as porencephalic cyst, hydrocephalus, pneumocephalus, hemorrhage, seizures, and focal neurological deficits can occur in the days following surgery. These complications may require conservative management or further intervention [11,20,33]. Although the principal treatment of HD is surgery, pre-and post-operative adjunctive anthelmintic therapy, mainly with albendazole, may be considered. Albendazole can sterilize the cysts, decrease the tension in the

cyst wall (thus reducing the risk of spillage during surgery and subsequently the risk of anaphylaxis and recurrence), and is also used for inoperable lesions. The optimal duration of treatment is still unclear but recommended regimens involve albendazole taken orally at 10–15 mg/kg/day for 3–6 months, followed by a 'rest period' of 15 days after each month. Supportive medications can also be used to manage the presenting symptoms associated with the disease [12,93]. Among the several reviewed studies, a history of traumatic cyst rupture or iatrogenic cyst puncture during surgical procedures played a role in causing the recurrence of the disease [14,76,97]. In the present study, the primary treatment was surgical intervention in most cases (97.2%). The surgical approaches were commonly Dowling-Orlando or modified Arana-Iniguez (95.5%), while three cases (1.7%) underwent burr-hole surgery. In addition, five cases (2.8%) had been managed with conservative treatment only. The recurrence was reported in 13 cases (7.3%). Among them, six cases had intraoperative rupture of the cyst, and two had iatrogenic puncture of the cyst. No alveolar cases showed a recurrence. For this reason, this study recommends surgical intervention over conservative treatment. Follow-up for up to two years is recommended, especially in cases of giant hydatid disease or perioperative complications. In this systematic review, the mean follow-up period was 12 months. It has been reported that the majority of BHD cases can recover and survive with proper management [11,20]. Accordingly, the mortality rate in this study was only 3.4%. The major limitation of this study is the predominantly descriptive nature of the included studies, which may not yield reliable outcomes and can introduce bias. Further research employing rigorous study designs, such as trials comparing different surgical techniques for managing BHD, is recommended, particularly for the alveolar form.

5. Conclusion

Imaging modalities, such as CT and MRI, are the primary diagnostic tools for intra-parenchymal BHD, while serological tests alone are not reliable. Surgical intervention remains the definitive treatment for BHD. However, clinical diagnosis and treatment of AE continue to pose significant challenges. Therefore, in endemic regions, early diagnosis and treatment are crucial for improving prognosis. A history of cyst rupture during surgery may increase the risk of recurrence, necessitating extensive follow-up.

Declarations

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