

# Head Enlargement in Infants Requiring Neurosurgical Care

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## Abstract

Head enlargement (macrocephaly) is not an uncommon neurosurgical condition in infants presenting to outpatient department and emergency departments of neurosurgery/gynecology/pediatrics. We conducted a prospective and retrospective study of head enlargement in infants requiring neurosurgical care, to establish etiology, imaging findings, clinical profile, and outcome, with emphasis on management. Over a period of 24 months, 65 cases presented with head enlargement.

All had a history of cranial expansion from neonatal period. Of 65 patients, 30 could match the inclusion criteria and were selected for this study. Age group ranged from 151 to 180 days, consisted maximum numbers ( $n = 10$ ; 33.3%) of cases; of 30 23 (76.7%) patients were males. Of 30, 21 (70%) patients were diagnosed to have hydrocephalus, 4 (13.3%) had Dandy–Walker malformation, 2 (6.7%) had subdural effusion, and 3 cases (10%) had other causes as primary diagnoses. All were offered standard treatment as described in literature according to their clinical conditions and stage of diseases which included shunts (ventriculoperitoneal—unilateral, biventricular, and cystoventriculoperitoneal), Ommaya placement, craniotomy, burr holes, and conservative. Four shunts required revision during follow-up period. The postoperative follow-up period ranged from 1 to 24 months. One child with the diagnosis of intracranial tumor died in postoperative period that is 1 month after the surgery due to disease-related morbidities. Thus, there are various causes of head enlargement in neonates where neurosurgical intervention may be required, the most common being the hydrocephalus, Dandy–Walker malformation followed by subdural effusion. The treatment depends on the diagnosis. Benign conditions such as subdural effusion do not require surgical intervention usually.

## Keywords

- macrocephaly
- megalcephaly
- head enlargement

## Introduction

Head enlargement, technically known as megalcephaly or macrocephaly (from the ancient Greek; macro, long + kephalos, head) is not a rare clinical finding encountered by the

gynecologists/ pediatricians/family physicians. The differential diagnosis of macrocephaly poses a great challenge to the clinician. The measurement of head circumference (HC) (also called occipitofrontal circumference, OFC); if it is above the 98th percentile, or greater than 2 standard deviation above the mean

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**Fig. 1** Child with macrocephaly.

for the given age, sex, race, or gestational age; then the child should be labeled as macrocephalic<sup>1</sup> (► **Fig. 1**). The underlying structures which may lead to enlargement of head; include the scalp and/or the cranial bone and/or the contents of the cranium. In the absence of any pathological cause, macrocephaly is synonymous with megalencephaly, that is, an increase in the weight and size of the brain. Benign familial macrocephaly, an autosomal dominant trait, is the most common cause of macrocephaly.<sup>2</sup> Macrocephaly can be sorted into the following: genetic or nongenetic, congenital or acquired, pathological or idiopathic, syndromic or nonsyndromic (isolated), and several other varieties.

The incidence of isolated macrocephaly has been reported to be 0.5%.<sup>3</sup> The incidence increases in populations with mental retardation, autism, or associated malformations. It may be associated with a constellation of other anomalies as part of recognized syndromes.<sup>4</sup> Of many causes of head enlargement, few may need urgent attention of either neurosurgeon and/or pediatric surgeon for an early detection and management, to avoid the harmful effect on growing brain. These causes include hydrocephalus (congenital/acquired), subdural effusions (SDEs), sagittal suture craniosynostosis, Dandy–Walker malformation (DWM), tumors, and arachnoid cysts, etc.

We conducted a retrospective and a prospective study to investigate various aspects of this common neurosurgical condition, that is, etiology, neuroimaging, presenting complaints, clinical findings, treatment and outcome, with emphasis on management.

## Patients and Methods

It was a retrospective and prospective study, performed during the period of 2 years (January 2011–December 2012). All the patients with head enlargement presenting to neurosurgery

department of Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India, as well as to gynecology and obstetrics department of Community Health Center, Chander Nagar, Alambagh, Lucknow, India, were included in this study. All the macrocephalic children with history of head enlargement from neonatal period were considered for this study irrespective of their age of presentation.

**Patients' selection criteria:** Only the patients needing neurosurgical care were included in this study such as:

1. Intracranial expansile conditions, for example; hydrocephalus-congenital/acquired/postinfectious, SDEs, arachnoid cysts, and intracranial tumors etc.
2. Craniosynostosis (scaphocephaly).

**Exclusion criteria:** All the patients with the following were excluded:

1. Benign familial macrocephaly
2. Autism-associated macrocephaly
3. Genetic causes of macrocephaly (majority)
4. Metabolic causes of macrocephaly
5. Inappropriate diagnosis
6. Inadequate record or with inadequate follow-up (< 1 month).

We recorded the following details about the patients: age at presentation, age at the onset of head enlargement, gender, duration of complaints, related obstetric/perinatal history, clinical features, OFC (HC), developmental evaluation, other associated anomalies, neurological status of the patients, and neuroimaging findings. All the infants were investigated to establish the diagnosis and defined standard treatments were given to all in the department of neurosurgery, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India. To record the follow-up details; serial neurological examinations, developmental evaluation, head-circumference measurements, in association with radiological assessment (as and when required), were done in all the children.

## Observations and Results

Over a period of 24 months, 65 patients presented with head enlargement. All of these patients were having history of cranial expansion from neonatal period. Of 65 children, 30 fulfilled the inclusion criterion and were selected for this study. Of the 65 patients, 35 were not selected for the study and the reasons of exclusions were benign familial macrocephaly ( $n = 15$ ), autism-associated macrocephaly ( $n = 7$ ), syndromic macrocephaly ( $n = 5$ ), metabolic cause of macrocephaly ( $n = 3$ ), and subgaleal hematoma ( $n = 5$ ).

**Age and gender:** Of these 30 children, 23 (76.7%) were males and 7 (23.3%) were females. All the patients experienced symptom onset during the first month of life, whereas age of presentation to the hospital varied. Age group ranged from 151 to 180 days and consisted maximum numbers ( $n = 10$ ; 33.3%) of patients (► **Table 1**).

## Diagnosis

Overall, 21(70%) children had hydrocephalus as the primary diagnosis, 4 children (13.3%) had DWM (► **Fig. 2**) 2 children

**Table 1** Age distribution at presentation to the hospital

Age group (in d)	n (%)				
	Hydrocephalus	Dandy-Walker malformation	Subdural collection	Others	Total
0–28	2 (6.7)	1 (3.3)			3 (10)
29–60	2 (6.7)			1 (3.3) craniosynostosis	3 (10)
61–90	2 (6.7)			1 (3.3) intracranial tumor	3 (10)
91–120	6 (20)		1 (3.3)	1 (3.3) arachnoid cyst	8 (26.7)
121–150	2 (6.7)	1 (3.3)			3 (10)
151–180	7 (23.3)	2 (6.7)	1 (3.3)		10 (33.3)
Total	21 (70)	4 (13.3)	2 (6.7)	3 (10)	30 (100)

(6.7%) had SDE (►Fig 3), and 3 children (10%) had other causes as primary diagnoses (►Table 2).

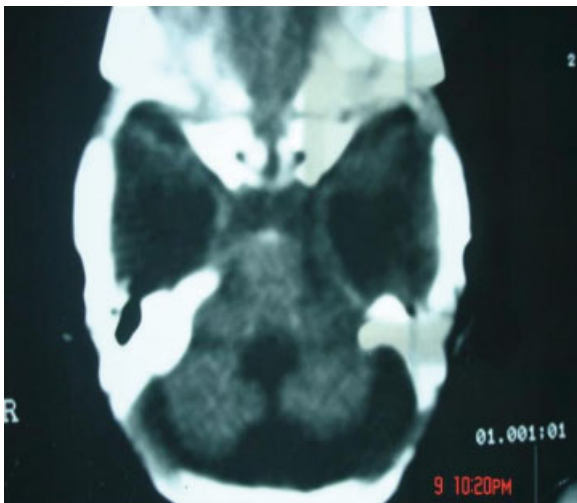
In hydrocephalus group, there were 18 (85.7%) males and 3 (14.3%) females. Whereas, half were males and half were females in DWM as well as subdural fluid collection (SDC) group. There were two males and one female in patients group with other uncommon diagnosis. The hydrocephalus was secondary to congenital aqueductal stenosis in majority (16/21; 76.2%), postinfectious in 4 of 21 (19%) cases, and idiopathic in 1 (4.8%) case.

#### Clinical Characteristics

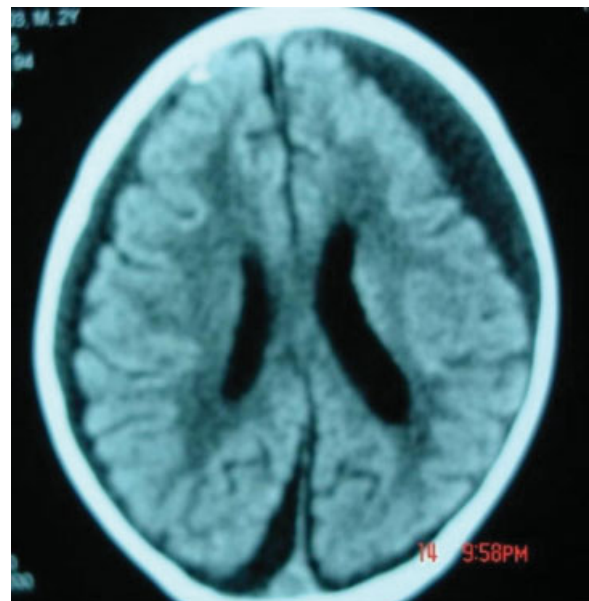
In all the 30 children, a quick clinical survey and thorough clinical evaluation were done at a hospital outpatient department. Increased OFC or HC was the common clinical feature in all the 30 infants. HC of these children varied from 39 to 62 cm with a mean value of 49.8 cm. The common causes other than increased HC, which led to the referral of the children to our centers, were bulging anterior fontanels, vomiting, fever, and irritability in decreasing order of percentage (►Table 3).

All the 30 children had been offered standard treatment as described in literature according to their clinical conditions and stage of diseases. Details of the treatments given are shown in ►Table 4. Ommaya procedure was done in one patient with the diagnosis of hydrocephalus (aqueductal stenosis) in view of patient's poor clinical condition. Later on, a ventriculoperitoneal shunt (VPS) was placed in this patient. One patient with postpyogenic hydrocephalus had septated hydrocephalus (►Fig. 4). This patient required a biventricular shunt after appropriate antibiotic therapy. In the SDE group; both the patients were kept on conservative line of treatment initially, but one of them required drainage of SDE later, due to nonimprovement.

**Follow-Up:** The postoperative follow up period was from 1 to 24 months (mean 1 year). All the kids remained stable at follow-up except one. One patient with the diagnosis of intracranial tumor died in postoperative period, that is, 1 month after the surgery because of the



**Fig. 2** Computed tomography showing Dandy-Walker malformation.



**Fig. 3** Computed tomography showing subdural effusion.

**Table 2** Frequency of main diagnoses ( $n = 30$ )

Diagnosis	$n$ (%)
Hydrocephalus	21 (70)
Dandy–Walker malformations	4 (13.3)
Subdural effusion	2 (6.7)
Craniosynostosis	1 (3.3)
Intracranial tumor	1 (3.3)
Arachnoid cyst	1 (3.3)
Total	30 (100)

disease-related morbidities. Four shunts required revision; two VPS in hydrocephalic patients, one biventricular shunt in hydrocephalic (septated) kid, and one cystoventriculoperitoneal shunt (CVPS) in DWM. In hydrocephalus group, two revisions were in aqueductal stenosis group and these were caused by shunt failure due to blockage. Biventricular shunt placed in postinfectious septated hydrocephalus was revised 2 years after the primary procedure, rest two VPS were revised 1 week and 1 month after the first operation. The reasons for shunt failure in all the three patients were shunt obstruction, most common being proximal obstruction (2/3; 66.7%). In aqueductal stenosis group, one patient had seizures 1.5 years after the ventricular

shunting and another had vomiting 1.5 months after surgery, both of them responded to anticonvulsants and antiemetic, respectively. Another patient, who received biventricular shunting as a primary treatment, had suffered seizures 4 months after the operation which resolved with anticonvulsants only. One patient in postinfectious hydrocephalus group had ptosis and diminution of vision at 2 and 10 months follow-up, respectively.

## Discussion

Macrocephaly refers to an abnormally large head inclusive of the scalp, cranial bone, and intracranial contents. Macrocephaly may be because of the megalencephaly (true enlargement of the brain parenchyma) or due to other conditions such as hydrocephalus, SDEs, or craniosynostosis (scaphocephaly). The HC measurement, herein referred to as the occipital frontal circumference (OFC), extends from the most prominent part of the forehead to the most prominent posterior area of the occiput. The OFC can be affected by thick hair and cranial bone deformations or hypertrophies. Ethnicity and stature must also be considered when evaluating the OFC. A large majority of cases of macrocephaly are because of genetic and metabolic causes which are generally not amenable to surgical treatment.

In a pediatric neurosurgical practice, the three most common etiologies of macrocephaly are as follows: familial (parents have big head), benign SDC of infancy, and hydrocephalus.<sup>2</sup>

**Table 3** Clinical features of cases

Characteristics	$n$ (%)			
	Hydrocephalus	DWM	SDE	Others
Increased HC	21 (70)	4 (13.3)	2 (6.7)	3 (10)
Nausea/vomiting	8 (26.7)	1 (3.3)	1 (3.3)	1 (3.3)
Unsteadiness		1 (3.3)		
Drowsiness	4 (13.3)			1 (3.3)
Whining/irritability	6 (20)			1 (3.3)
Fever	6 (20)			
Convulsions/epilepsy	3 (10)			1 (3.3)
Respiratory problems	2 (6.7)			1 (3.3)
Bulging fontanel	15 (50)			1 (3.3)
Aberrant head shape				1 (3.3)
Eye/vision disturbances	4 (13.3)			
Delayed motor development	3 (10)			1 (3.3)
Loss of consciousness				1 (3.3)
Trauma			1 (3.3)	
Changes in behavior	7 (23.3)			
Difficulties swallowing		1 (3.3)		1 (3.3)
Papilledema	2 (6.7)			1 (3.3)

Abbreviations: DWM, Dandy–Walker malformation; HC, head circumference; SDE, subdural effusion.

**Table 4** Details of treatments offered

S. no.	Treatment	Hydrocephalus ( <i>n</i> = 21)	DWM ( <i>n</i> = 4)	SDC ( <i>n</i> = 2)	Others ( <i>n</i> = 3)
1	Right VPS	17	2		
2	Biventricular shunt	1			
3	3rd ventricle shunt	1			
4	Ommaya procedure	1 (after 1 month converted in to VPS)			
5	CVPS		1		
6	Burr hole			1	
7	Conservative	1	1	2 (one kid had to be operated later)	
8	Other Procedure				3
9	Need for Shunt Revision	3 (2 VPS + 1 Biventricular shunt)	1 (CVPS)		

Abbreviations: CPVS, cystoventriculoperitoneal shunt; DWM, Dandy-Walker malformation; SDE, subdural effusion; VPS, ventriculoperitoneal shunt.

Hydrocephalus is a common clinical condition leading to head enlargement in neonates.<sup>2</sup> Congenital aqueductal stenosis accounts for approximately 10% of all hydrocephalus cases in children.<sup>5</sup> Our study also revealed a high incidence of aqueductal stenosis in selected population of infants (*n* = 16, 76.2%). Infections (tubercular and pyogenic) represent a cause of hydrocephalus, which is potentially preventable with better outreach of public health measures in developing countries. Hydrocephalus secondary to meningitis was seen in four (19%) of our cases and three of four, were tubercular. Most patients with central nervous system tuberculosis do have an identifiable systemic disease. Hydrocephalus usually manifests itself within 4 to 6 weeks of the disease.<sup>6</sup> In our series, all three infants having tubercular hydrocephalus had history of tuberculosis in

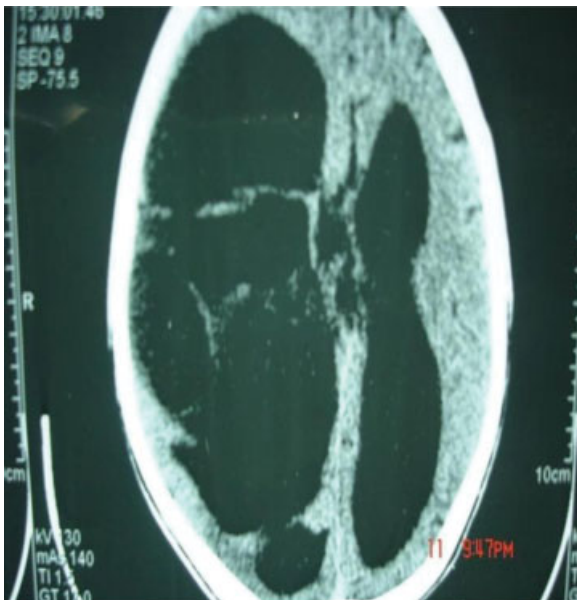
mothers. The treatment requires antitubercular therapy with CSF diversion surgery. Bacterial meningitis may cause hydrocephalus as uncommon sequelae (►Fig. 4). Infective causes of hydrocephalus are more likely to leave behind an adverse neurological outcome in the form of delayed milestones and mental compromises.

The symptoms commonly observed by us in hydrocephalic children, other than a large head, were vomiting in (36.6%) and fever (20%). Increase in HC was the most common sign (100%) followed by tense anterior fontanels and eye signs. Sunset sign, which probably represents upward gaze palsy because of compression or axial dislocation of the tectal region of the brain stem,<sup>7</sup> was seen in 13.3% cases.

While the increase in head size is only sign of hydrocephalus among most of the children younger than 2 years, older children may present with the classical triad of headache, vomiting, and papilledema. It is generally assumed that the soft compliant skull of infants has a significant ability to accommodate increased intracranial volume without creating extremely elevated intracranial pressure, simply by changing the head's size and shape. Papilledema was noted in only three (10%) cases which could be explained by the fact that all of our patients in the study group were infants (< 1 year) and accurate examination was difficult.

Infants with hydrocephalus are treated with VPS in majority, as the role of endoscopic third ventriculostomy is debatable in children younger than 1 year of age. Ventricular CSF shunting causes a multitude of complications, the most common is mechanical obstruction, as in our study (*n* = 3). This may occur at either or both ends, but usually because of the obstruction of ventricular catheter by entrapped choroid plexus tissue, intraventricular debris, or gliosis around the catheter tip. We observed proximal obstruction in two of three (66.7%) cases (►Fig. 5).

The second most common complication of these procedures is infection. This occurs in 5 to 10% of the cases

**Fig. 4** Postinfective multiseptated hydrocephalus.



and is usually the result of previous infection of CSF or infection introduced during surgery.<sup>8</sup> We did not have any postprocedural infection.

During a mean follow-up period of 1 year, 3 of the 22 (13.6%) cases (patients in whom shunting were done) required shunt revisions because of the shunt-related complications. One of these cases required multiple shunt revisions due to shunt blockage. Of the 22 children, 19 (86.4%) had no complication following shunt insertion and improvement was noted in neurological/functional status of the subjects in form of achievement of mile stones at follow-up. We observed that the postoperative increase in cortical mantle was related to improvement in clinical status and achievement of mile stones in all cases, though to a variable extent. The earlier therapeutic intervention has a significant effect on functional brain development.

Four patients in our series had DWM (► **Fig. 2**). Of four patients, VPSs were placed in two (50%) and cystoventriculoperitoneal shunting done in one (25%) patient. However, one patient of four was managed conservatively because of mild hydrocephalus and small posterior fossa cyst. Marked development of the cerebellar hemispheres was observed after placement of the shunts, but none of the cerebellar vermis. Aplasia of the lower cerebellar vermis is a primary, or essential, pathology of Dandy-Walker syndrome.<sup>9</sup> After shunt, the cyst reduced and the bilateral cerebellar hemispheres grew markedly. We consider that if the aqueduct is patent before surgery, treatment by cystoperitoneal shunt is adequate, even if hydrocephalus is a factor. VPS placement is unnecessary in such situations.

Complications following placement of a cystoperitoneal shunt include cerebrospinal fluid leakage after the shunt, as occurred in one of our case (CVPS). Others include hematoma in the posterior cranial fossa and brainstem symptoms associated with overflow of cerebrospinal fluid.<sup>10-13</sup> We had revised CVPS twice during follow-up,



**Fig. 5** Complication of shunt showing swelling at site of shunt chamber due to blocked shunt.

first instance was because of the CSF leak at proximal end and second time, it was due to blockage of shunt.

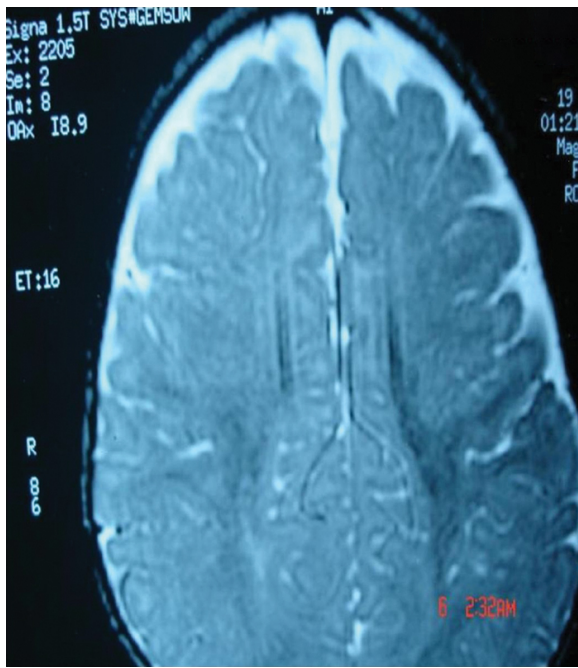
We had two patients with SDE in our series. An SDE is a dynamic pathology and can be because of the trauma or infection. Infections cause SDEs largely by an exudative process, and these may also be associated with a membrane. SDE should be suspected in infants with enlarged heads or rapid head growth.<sup>14</sup> Cases with SDE may present with a variety of nonspecific clinical features (drowsiness, poor feeding, irritability, seizures, pallor, floppiness, etc.) which can cause diagnostic delay. In one study, the diagnosis of SDE was delayed for more than 1 week after admission.<sup>15</sup> Both of our patients with SDE had the diagnosis delayed by an average of 1 month, but they were diagnosed promptly when they presented to us. Thus, SDE should be considered as a possible cause in a drowsy macrocephalic infant. The anterior fontanel is frequently enlarged with the enlargement of the subdural space in the frontoparietal regions. It is associated with normal or minimal alteration in ventricular size. There are no pressure effects on the surrounding brain tissue or cerebral atrophy in majority. There are no signs of raised intracranial pressure, thus, it would be a misnomer to refer this clinical entity as external hydrocephalus.<sup>16</sup> SDE needs to be differentiated from cerebral palsy and posttraumatic subdural collections by labeled criteria given by the senior author (R.K.) in other publications.<sup>17,18</sup> We recommend that a magnetic resonance imaging (MRI) should be done in all cases. The rationale is that the MRI scan will better detect subdural hemorrhages in regions not easily visualized on the CT scan<sup>19,20</sup> (► **Fig. 6**).

The management of SDE is still a matter of discussion. The most common approach for the management of SDE is observation with follow-up along with serial HC measurement, ultrasound, and/or CT/MRI. Most cases gradually resolve spontaneously, often within 8 to 9 months.<sup>21</sup> In our study also; out of two patients, one responded to conservative management very well.

Serial percutaneous subdural taps may be required in some patients, as many as 16 taps have been reported in literature.<sup>22</sup> Burr hole drainage may be needed in a few patients who are not responding to conservative management.<sup>21</sup> One of patients in our series, who was initially kept on conservative line of management, required burr hole drainage at later follow-up.

Subdural peritoneal shunts are generally not used. This type of shunt (unilateral shunt), if required, is usually adequate even for bilateral effusions.<sup>23</sup> An extremely low pressure system should be utilized. The general practice is to remove the shunt after 2 to 3 months of drainage.<sup>21</sup> Subdural-peritoneal shunt was not needed in any of our patients.

The other diagnosis ( $n = 3$ ) observed by us were an arachnoid cyst in sylvian region, intracranial tumor, and scaphocephaly. These are relatively rare causes of macrocephaly as compared with the more common diagnoses of hydrocephalus, DWM, and SDE. These were treated surgically and except for intracranial tumor the other two are stable at follow-up.



**Fig. 6** Axial magnetic resonance image showing subdural effusion.

## Conclusion

The most common causes of macrocephaly which require neurosurgical attention are hydrocephalus, DWM, and SDEs. Improvement in outcome of hydrocephalic children to normalcy or near normalcy appears to be possible with early detection and prompt institution of therapy along with periodic follow-up. Clinicians should consider a benign subdural collection in any infant with progressive head enlargement and normal neurodevelopment. Subdural effusion is a benign condition that usually requires no surgical intervention because it often resolves spontaneously.

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