AN EVALUATION OF COMPUTED BRAIN SCANS IN CHILDREN AT CHRIS HANI BARAGWANATH HOSPITAL

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, in partial fulfillment of the requirements for the degree
of
Master of Science in Medicine (Neurodevelopmental Paediatrics)

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DECLARATION

I, Preeteeben Vallabh, declare that this research report is my own work. It is being submitted in partial fulfillment of the requirements for the degree of Master of Science in Medicine in the branch of Neurodevelopmental Paediatrics, in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

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Preeteeben Vallabh

12 April 2010

DEDICATION

To my family for their unwavering support and encouragement

and

to my late dad for always believing in me.

ABSTRACT

Background: Computed tomography (CT) was introduced 40 years ago and it remains an essential part of medical practice. The indications for CT brain scans vary in different centres depending on the availability of scanners and financial resources. There is no data on the indications and results of CT brain scans in children at Chris Hani Baragwanath (CHB) Hospital.

Aims: The indications for CT brain scans were quantitated and the overall results of the scans were assessed. The rate of radiological abnormalities by referral diagnosis was evaluated.

Methodology: 361 Children undergoing CT brain scans were identified in a four month period from 22/01/2004 to 21/05/2004, and their records were prospectively reviewed.

Results: The ages ranged from 2 days to 14 years. There were 213 males and 148 females with a male: female ratio of 1.4:1. Seizures was the commonest indication for scans (25.8%) in this study. The six common indications (partial and generalized seizures, trauma, central nervous system [CNS] infections, macrocephaly and psychomotor retardation) accounted for 67.6% of the scans. There were 233 (63.5%) abnormal scans. Cerebral atrophy was the commonest finding, present in 58 (16.1%) scans.

Discussion: A high rate of positive scans was detected in this study, with intracranial infections featuring prominently (9.7%). This high yield of positive scans in the study population suggests the need for more scanner facilities at CHB hospital.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

NOMENCLETURE

CHB	Chris Hani Baragwanath
CNS	central nervous system
CP	cerebral palsy
CSF	cerebrospinal fluid
CT	computed tomography/tomographic
EEG	electroencephalogram
HIV	Human Immunodeficiency Virus
MRA	magnetic resonance angiography
MRI	magnetic resonance imaging

1.0 INTRODUCTION

1.1 Literature Review

1.1.1 CT Brain Scans

Computer tomography (CT) was introduced as a diagnostic tool about 40 years ago. It remains an important procedure in most healthcare centres and is an essential component of medical practice.

The use of CT brain scans in the assessment of patients with neurological conditions has been well documented (1,2,3,4,5). Since its introduction virtually all neuroinvestigative techniques, other than electroencephalography (EEG), have been used less frequently (1,2). Several costly and invasive procedures such as radionucleotide scans and pneumoencephalography are no longer required (1,2). The use of cerebral angiography has been markedly reduced (2,4).

Until magnetic resonance imaging (MRI) became widely available, CT of the brain was the most accurate neuroimaging study available (1,2). It provides accurate diagnostic information in many neurological conditions.

In the evaluation of a diagnostic procedure such as computed tomography, several factors need to be considered:

- the degree to which it provides new or additional diagnostic information,
- its accuracy,
- its effect on the use of other diagnostic/therapeutic procedures,
- the changes in cost and or saving, incident to its use and

- whether it has direct therapeutic implications.(1,2)

In resource poor settings, the cost of the procedure and its impact on therapy are particularly important. These factors probably affect the way CT scanners are used in these facilities.

1.1.2 Indications for CT brain scans

There are numerous indications for the use of CT brain scans in children. These will depend on the availability of CT scanners, the cost of CT brain scans and on the availability of other diagnostic procedures such as MRI. The discussion that follows will address some of the indications for CT brain scans in clinical practice and evaluate the evidence available to assess whether these indications are appropriate or not.

Head injury is an important cause of morbidity and mortality in children worldwide (6,7). CT brain scans play an invaluable role in the evaluation of these children. It is the investigation of choice in their initial management. CT brain scans have a high sensitivity in detecting intra- and extra-parenchymal haematomas as well as the resulting mass effect from these bleeds. (7,8)

The role of CT brain scans in the management of children with moderate and severe head injuries is well established (9,10,11,12). However, in children with mild head injury, who account for 65% of all children with head injuries, the role of CT brain scans is controversial (11,13,14,15).

Despite the frequency and importance of mild head injuries, there are no reliable prediction rules or guidelines on how to assess these children. Some authors recommend scanning all children with mild head injuries (9,11,15). The major advantage of this practice is early detection and treatment of brain injury, and earlier discharge from hospital if the CT brain scan is normal (7,9,13). In developing countries, where financial resources are limited, it is not possible to scan all these children (12,14). Under these circumstances, risk factors such as focal neurological deficit, vomiting, severe headaches, loss of consciousness, decreased level of consciousness, seizures, clinical skull fractures and polytrauma are considered for selection of patients for CT brain scans (12,13,14).

Seizures are very common in children (16). CT brain scans are often used in the evaluation of these children (5,17,18). It is estimated that about 1% of all children will have at least one afebrile seizure by the age of 14 years and about 0,4 to 0,8% will have epilepsy by the age of 11 years. 2-5% of children will have febrile seizures. (16)

In children with simple febrile seizures CT brain scans are not recommended as they have been shown to be of no value (17,18,19). However, in children with complex febrile seizures (focal, prolonged or multiple), CT brain scans are often done even though they are unlikely to demonstrate unexpected or therapeutically significant intracranial lesions (18).

Many emergency departments perform CT brain scans on all children presenting with new onset afebrile seizures. However, it is unlikely to be justified in all patients (20,21). Children with a normal neurological examination and no acute symptomatic cause for the seizure probably do not require a CT brain scan. In children with seizures and signs of increased intracranial pressure, persistent altered mental state or new onset focal neurological deficit, an urgent scan is needed. (17,21) Non-urgent CT brain scans are recommended in children presenting with generalized seizures and one or more of the following:

- an abnormal neurological examination (non-acute)
- dysmorphic features associated with intracranial anomalies,
- skin lesions suggestive of neurocutaneous syndromes and
- any focal abnormality on EEG (indicating a focal seizure with secondary generalization. (19,22)

All children with focal seizures should have a CT brain scan done as the yield of therapeutically significant scans is high (20,22,23). MRI has a better yield than CT in patients with seizures and is regarded as the ideal imaging procedure in these patients. However, its use is limited due to the high cost and lack of availability (8,23).

The role of neuroimaging with CT brain scans in the diagnosis of meningitis is limited. A CT brain scan is recommended prior to lumbar puncture in children with suspected meningitis who also have papilloedema, focal neurological deficit or an altered mental state. However in an obtunded child a lumbar puncture is contraindicated despite normal CT scan findings. (17,19,24) CT brain scans are used predominantly in children with meningitis who develop signs of complications such as an inadequate response to therapy or acute neurological deterioration. The development of papilloedema, focal neurological deficit or decreased level of consciousness is regarded as neurological deterioration. Complications such as cerebral infarction, venous sinus thrombosis, intracerebral haemorrhage, dural infection and hydrocephalus are well demonstrated by CT brain scans. (24,25)

CT brain scans are used extensively in children with tuberculous meningitis. The majority of these patients have CT brain scans that demonstrate abnormalities such as hydrocephalus, parenchymal and basal enhancement, cerebral infarction, precontrast basal cistern hyperdensities and tuberculomas. (24,26,27) Scans have also been used to distinguish tuberculous meningitis from pyogenic meningitis (28).

Contrast enhanced CT brain scans are used to diagnose cerebritis and brain abscesses. Serial CT brain scans are used to monitor the response to treatment in these conditions. (2,19) CT brain scans are useful adjuncts in the diagnosis of cytomegalovirus infections and neurocysticercosis (2).

Tumours of the central nervous system (CNS) occur relatively frequently in the early years of life. Primary brain tumours account for approximately 20% of childhood cancers. MRI with enhancement is the preferred study for the evaluation of suspected brain tumors. In the absence of MRI facilities, the high resolution CT brain scan remains an important neuroimaging study. CT brain scans are superior at detecting intracranial calcification. (3,8) Generally, CT brain scans demonstrate the size, shape and location of the tumour as well as the condition of the ventricular system (19). They are particularly useful for follow up studies on patients with brain tumours undergoing surgery and/or radiation therapy (2). MRI, however, is far superior for the delineation of tumours involving the sella, chiasmatic cistern and the brainstem (17,19).

Headache is a frequent physical complaint in children. Headaches can be a symptom of intracranial tumours or acute hydrocephalus. Chronic headaches in children are generally benign, however many children with headaches undergo neuroimaging. (19,29,30) In neurologically normal children, CT brain scans for recurrent headaches are not recommended as there is a low positive yield and have no significant effect on management (29,30). CT brain scans should be considered in children who present with recent onset severe headaches, change in the type of headaches, concomitant neurological dysfunction, or seizures (30).

The evaluation of children with hydrocephalus necessitates neuroimaging studies. CT brain scans are very valuable in confirming the diagnosis of hydrocephalus however MRI may be required to determine the cause of the hydrocephalus. (2) CT brain scan with contrast administered into the cerebrospinal fluid (CSF) can be done to determine the site of CSF obstruction (8,17). CT brain scans are necessary in patients with ventricular shunt malfunction to determine if there are signs of shunt blockage or shunt malposition (31).

In children, cerebrovascular disorders constitute a far smaller proportion of neurological disease compared to adults (17). CT brain scans demonstrate non-homogenous lucent areas in children with established intracranial infarction. However, early infarction may be isodense on CTscans and difficult to detect. Mass effect from cerebral oedema may also be seen. (8) Magnetic resonance angiography (MRA) or cerebral angiography is indicated to determine the site of vascular obstruction. The diagnosis of cerebral vein or dural sinus thrombosis is more problematic. MRI is more useful than CT brain scan in these patients. (8,17) In the initial evaluation of children with suspected intracranial haemorrhage, CT brain scan is the diagnostic procedure of choice. A contrast enhanced CT brain scan is able to detect arteriovenous malformations greater than 1.5mm but for those less than 1.5mm a MRA is necessary. (8,19)

The routine use of CT brain scans in evaluating children with mental retardation is not recommended. It should be reserved for children with mental retardation and one or more of the following:

- raised intracranial pressure,
- craniofacial anomalies or
- suspected syndromes associated with structural CNS anomalies.

Management of mental retardation in the presence of the above conditions is not affected by the results of the scans. (32)

Children with human immunodeficiency virus (HIV) do not routinely undergo CT brain scans. The prevalence of CNS disease in HIV infected children ranges from 20 to 60%. (8) The neurological complications in HIV positive children may be caused by the disease itself, opportunistic infections (toxoplasmosis, cytomegalovirus, tuberculous meningitis, cryptococcal meningitis) or neoplasms. The most common abnormalities observed on CT brain scans and MRI scans are cerebral atrophy and white matter disease. White matter changes tend to be located in the periventricular regions and are better demonstrated by MRI. Intracranial calcifications are seen in about a third of HIV infected children. The calcifications are bilateral and symmetrical involving the globus pallidus and putamen. (33 34)

1.2 Background to the study

The use of CT brain scans in medical practice is not without controversy (5,35,36). CT scanners require vast financial resources and its availability is likely to be restricted relative to potential demand. In underprivileged and rural settings, the availability of CT brain scans is further restricted. (2,5)

This study was done at Chris Hani Baragwanath (CHB) Hospital. This is a public, referral hospital affiliated to the University of the Witwatersrand. It has a bed capacity of 2700. The majority of the population served by this hospital is from a lower socioeconomic group who do not have private health insurance.

Two Toshiba multi-slice scanners are used at the hospital for both head and body CT scans. Non-urgent paediatric scans are done once a week on a Thursday. The waiting period for non-urgent scans is 4-6 weeks. Scans needed urgently are done on the same day (within 4-12 hours). Because of the huge case load at the hospital there exists an "as soon as possible" (ASAP) list for hospitalized patients with a waiting period of 2-5 days. The limited scanner facilities at the hospital, necessitates the judicious use of the scanner.

Trauma is responsible for a large proportion of patients seen at CHB Hospital. During the holiday season these numbers escalate even further. The data collection for the study was started after the summer vacations to minimize possible bias created by this phenomenon. At CHB Hospital all children presenting with head trauma are not routinely scanned. Children with a history of loss of consciousness and one or more of the following: decreased level of consciousness, severe headaches, and focal neurological signs, are scanned (37).

There is a high prevalence of HIV infection in the children seen at CHB hospital. These children only undergo CT brain scans if they have other co-morbidities (complications of meningitis, suspected cerebral abscesses or acute encephalopathy)

Internationally there have been a few published studies looking at the indications for CT brain scans in children (3,4,29). Locally the only published study on indications of CT brain scans was done at the Johannesburg Hospital in 1984 and it included both adult and paediatric patients. The study obtained a high yield in terms of positive results. (38)

1.3 Overall aims of the study

- To quantitate the indications for CT scans of the brain in children at CHB Hospital
- To asses the overall results of these scans
- To evaluate the rate of radiological abnormalities by referral diagnosis
- To discuss if available facilities are adequate.

2.0 MATERIALS AND METHODS

2.1 Study Sample

2.1.1 Geographic details

The study was conducted at CHB Hospital in Soweto. Most of the patients come from Soweto and the surrounding areas, however, as CHB is a referral hospital some of the children may have been referred from other areas in Gauteng, North West Province and Mpumalanga for consultation or admission.

2.1.2 Age

Only children aged fourteen years or younger were included in the study.

2.1.3 Sampling Method

The study took place over a four month period from the 22nd January 2004 to 21st May 2004. All children undergoing a CT scan of the brain were eligible for the study. Whenever a child had more than one scan, only the first scan was included for analysis. Children referred from other hospitals for a scan only, were excluded. The children were referred from the hospital wards, the paediatric outpatient clinics and the accident and emergency department.

The scans were evaluated either by a radiology registrar alone or a radiology registrar together with a radiology consultant. The neurological assessment was done by the referring doctor, either a medical officer or a paediatric or surgical registrar or consultant. Only the primary indication was used for analysis. All the relevant information was collected on a data collection sheet (Appendix A).

2.2 Data Analysis

Data was captured on the data collection sheet (Appendix A) and then entered into Microsoft Office Excel 2003 and analyzed using Microsoft Office Excel 2003 and Statistica Version 8.0.

Statistically significant differences in categorical variables were assessed using the Chi-squared test. A p-value less than 0.05 indicated a statistically significant difference.

2.3 Limitations of the study

All the scans were not reported by the same person as there is no dedicated neuroradiology team at the hospital. The accuracy of the report was limited by the experience and expertise of the reporter/s on the day.

The neurological examination was done by the attending doctor and thus the accuracy of the neurological assessment was dependant on that doctor's experience and expertise.

2.4 Ethics

The study was approved by the committee for Research on Human Subjects (Medical) of the University of the Witwatersrand. Reference: R14/49 Vallabh for protocol number M03/09/44 (Appendix B). Written permission to conduct the study was granted by the senior clinical executive of CHB Hospital (Appendix C).

3.0 RESULTS

During the study period 443 CT brain scans were done in children fourteen years or younger. Of these, 82 scans were excluded as 42 were repeat scans and 40 children were referred from other hospitals for CT brain scans only. Thus data collected from 361 patients was included in the study.

3.1 Age and Gender

Of the 361 children scanned, 213 (59.0%) were males and 148 (41.0%) were females. The overall male:female ratio was 1.4:1. This ratio varied with different age categories as demonstrated in figure 3.1. In the 2 - 4 years category there was a 1.8:1 ratio and in the 10 - 12 years category there was no difference in males and females.

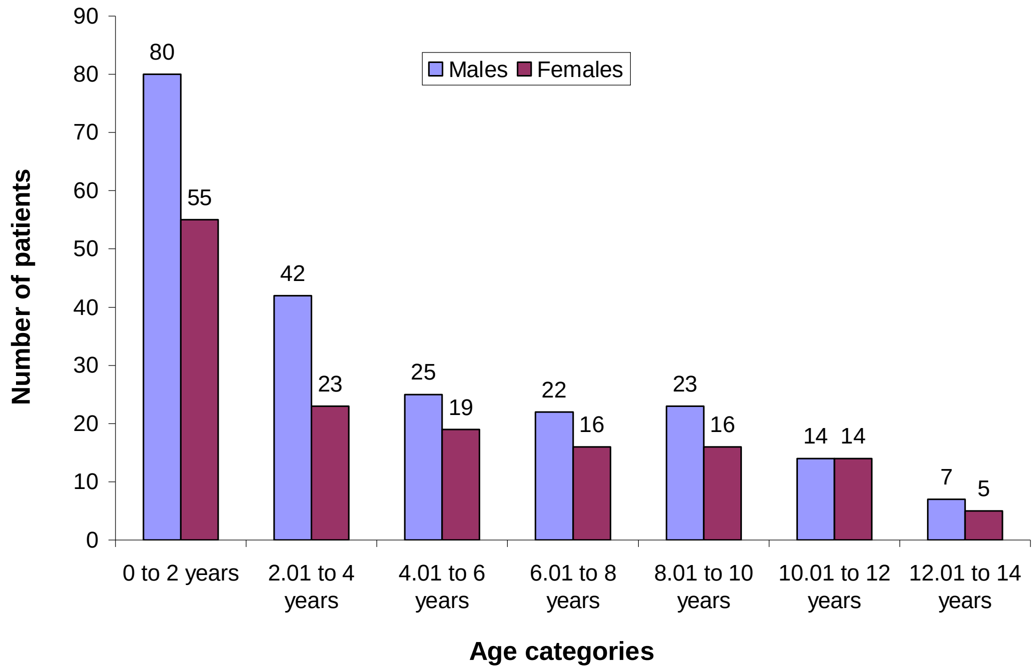

Figure 3.1 Gender breakdown according to age categories.

Table 3.1: Age distribution of study population

Age parameters	
Range	2 days to 14 years
Mean	4.7 years
Median	3.8 years
Mode	3.0 years

The ages of the study participants ranged from 2 days to 14 years, with a mean age of 4.7 years and a median of 3.8 years (Table 3.1). Children up to the age of 2 years constituted 37.4% of the study population and 18.0% were between 2.01 and 4 years of age. Children over 10 years accounted for only 11.1% of the total. The age distribution is depicted in Figure 3.2.

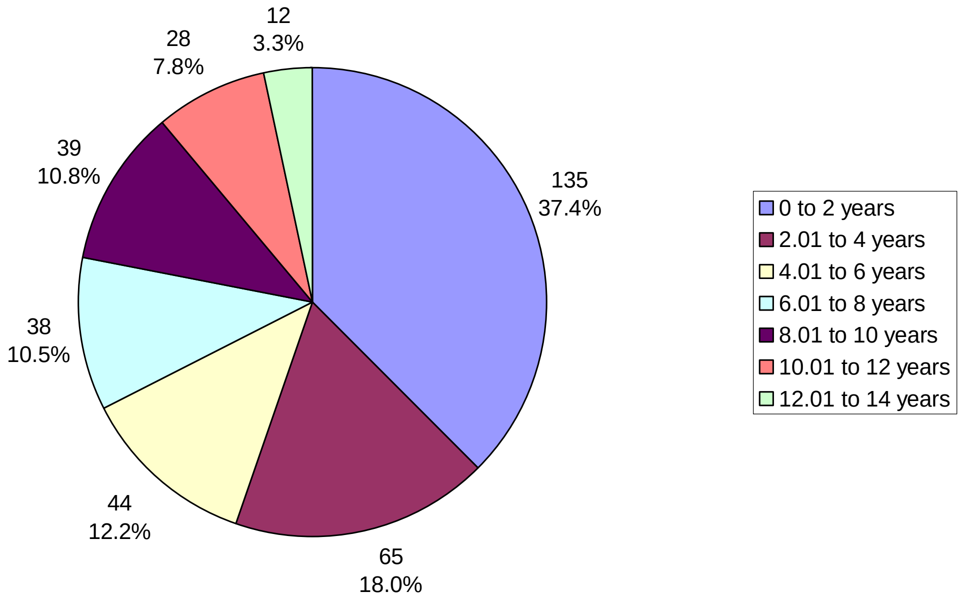

Figure 3.2: Age distribution

3.2 Elective and urgent scans

There were 194 (53.7%) scans done electively and 167 (46.3%) scans done urgently. The occasional scan may have been misclassified if it was not marked appropriately. Two thirds of the urgent scans were for trauma, CNS infections and seizures (114 of 167).

3.3 Neurological assessment

The neurological assessments were divided into four groups for the purpose of analysis. These were: normal, decreased level of consciousness, focal neurological deficit and behavioural problems. The children demonstrating both decreased level of consciousness and focal neurological signs were allocated to the group deemed most appropriate according to the history given. Focal neurological deficit was present in 167 (46.3%) participants, 114 (31.6%) were assessed as neurologically normal, 73 (20.2%) had a decreased level of consciousness and 7 (1.9%) had behavioural problems. Focal neurological deficit and decreased level of consciousness together made up 66.5% of the sample.

3.4 Indications for scans

Table 3.2 summarizes the indications for CT brain scans in this study. Seizures were the commonest reason for requesting a scan (n=93, 25.8%). Of these 55 had partial seizures and 38 had generalized seizures. Head trauma accounted for 45 (12.5%) scans. The severity of the head trauma and the mechanism of the injury were not further examined. Suspected CNS infections or complications thereof accounted for 43 (11.9%) CT brain scans. Most of these children presented with complicated pyogenic meningitis while a few had tuberculous meningitis. Macrocephaly accounted for 36 (10.0%) scans and psychomotor retardation was the indication in 27 (7.5%) scans. These 6 indications accounted for 67.6% of the CT brain scans analyzed.

Table 3.2: Indications for CT brain scans

Indication for CT brain scan	Number of Patients (n=361)	Percentage
Partial seizures	55	15.2%
Trauma	45	12.5%
CNS infection	43	11.9%
Generalized seizures	38	10.5%
Macrocephaly	36	10.0%
Psychomotor retardation	27	7.5%
Space occupying lesion	19	5.3%
Acute hemiplegia	14	3.9%
Blocked shunts	13	3.6%
Headaches	12	3.3%
Encephalopathy	12	3.3%
Periorbital cellulitis	7	1.9%
Behavioural problems	3	0.8%
Congenital malformations	2	0.6%
Other	35	9.7%

Thirty five patients had indications that were not categorized. Of these, 5 patients had follow up scans due to previous surgery, 3 had surgery for tumours and 2 had surgery for trauma. Four children had scans due to birth trauma and 5 were scanned because of cerebral palsy (CP). Three children had scans done to look for intracranial extension of frontal and nasal masses. Acute cerebellar signs accounted for 3 scans. Two children had bony defects of the skull, another had a depression of the parietal bone and a fourth child had craniosynostosis. Two children had suspected optic nerve pathology. The remaining indications were neurofibromatosis, chorea, titubation, myasthenia gravis, Duchenne muscular dystrophy, ascending myelitis, subdural effusion, 3rd nerve palsy and arachnoid cyst.

3.4.1 Indications and gender

The overall male:female ratio was 1.4:1. The gender ratio of participants varied with the indication for scan (Figure 3.3). The male:female ratio in children presenting with trauma was 1.8:1 which is higher than the overall ratio. Indications such as partial seizures, headaches and periorbital cellulitis showed a female predominance. All other indications showed a male:female ratio similar to the overall ratio.

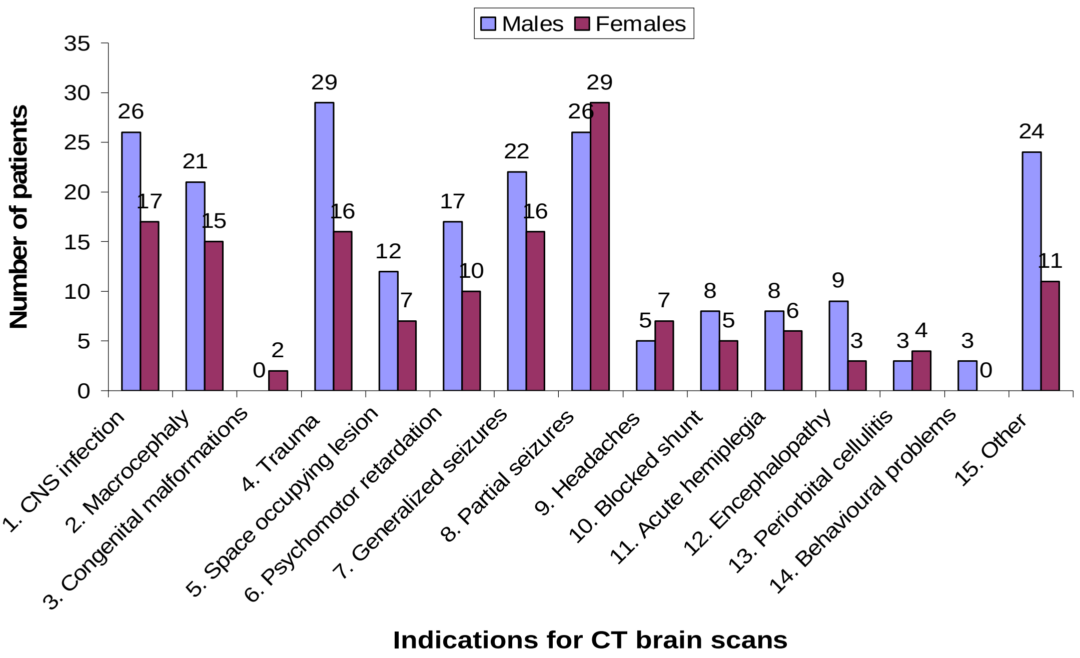

Figure 3.3: Gender breakdown for each indication.

3.4.2 Indications and age

Certain indications were commoner in the younger age groups. Scans for macrocephaly, encephalopathy and CNS infections were more frequently done in children under 2 years of age as shown in Table 3.3.

Table 3.3: Indications in which the majority of children scanned were under 2 years

	Under 2 years / total	Percentage
Macrocephaly	27/36	75.0%
Encephalopathy	8/12	66.7%
CNS infections	20/43	46.5%

Scans for psychomotor retardation and acute hemiplegia were mainly done in children under 4 years. In scans done for trauma, 95.6% (43/45) of the children were above the age of 2 years. All children scanned for behavioural abnormalities were older than 6 years and 75% of children scanned for headaches were above 8 years of age.

3.4.3 Indications and type of scan

Scans were mainly done urgently for CNS infections, trauma, blocked ventricular-peritoneal shunts, encephalopathy and periorbital cellulitis as demonstrated in Figure 3.4. In patients presenting with seizures, less than half were scanned urgently. Those with headaches, macrocephaly and psychomotor retardation were mainly scanned electively.

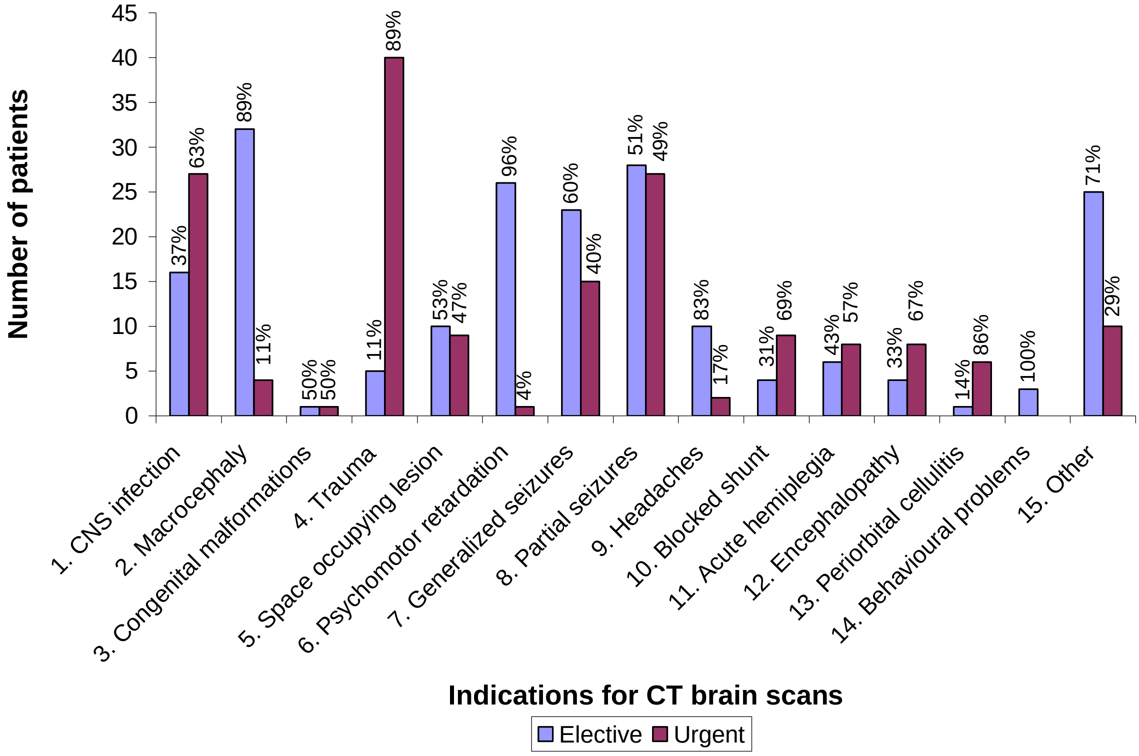

Figure 3.4: Elective and urgent scans according to each indication.

3.5 Results of the scans

Of the 361 scans evaluated 128 (35.5%) were within normal limits and 233 (64.5%) scans showed abnormal findings as summarized in Table 3.4.

Table 3.4: Results of CT brain scans

Results of CT brain scans	Number of participants	Percentage of total scans (n=361)	Percentage of abnormal scans (n=233)
Normal	128	35.5%	-
Cerebral atrophy	58	16.1%	24.9%
Hydrocephalus	42	11.6%	18.0%
Features of CNS infection	35	9.7%	15.0%
Intracranial bleed	18	5.0%	7.7%
Intracranial infarction	18	5.0%	7.7%
Tumour	15	4.2%	6.4%
Congenital malformations	13	3.6%	5.6%
Fractures	8	2.2%	3.4%
Encephalomalacia	8	2.2%	3.4%
Other	18	5.0%	7.9%

The most common finding was cerebral atrophy, which was demonstrated in 58 (16.1%) scans. This accounted for 24.9% of the abnormal scans.

Evidence of hydrocephalus was found in 42 scans (11.6%). Most of these patients presented with macrocephaly, CNS infections or blocked shunts. Thirteen patients were scanned to exclude a blocked shunt, of these, 5 patients had a blocked shunt, 1 had a subarachnoid bleed and the remainder had hydrocephalus with patent shunts.

Evidence of CNS infection was present in 35 (9.7%) patients. Of these, 15 scans showed meningeal enhancement, 6 had tuberculomas, 4 had cysticercosis, 2 showed congenital cytomegalovirus infection, 5 showed cerebral abscesses and 1 showed mastoiditis and destruction of the bony facial canal. In 1 scan focal cerebritis or early abscess was suspected. One patient who was scanned due to a previous head injury had an abscess caused by a gas forming organism. Figure 3.5 demonstrates the breakdown of CT brain scans with evidence of various infective processes.

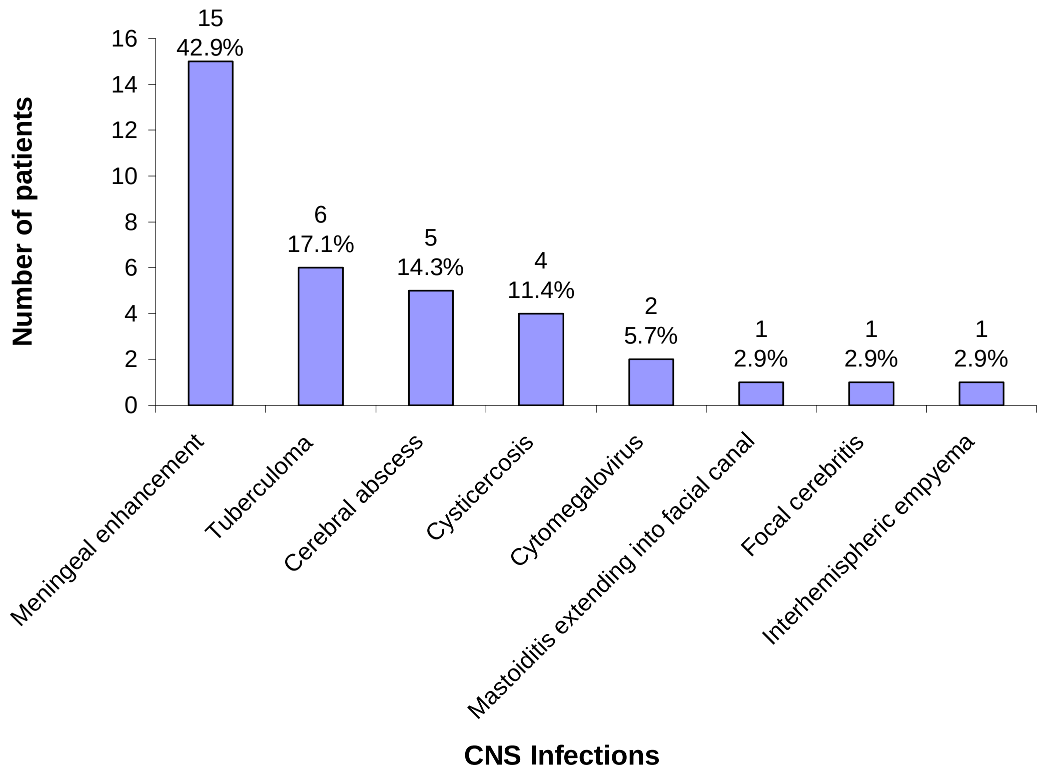

Figure 3.5: Breakdown of CNS infections

Tumours were detected in 15 scans (4.2%). There were 6 infratentorial tumours, 5 retinoblastomas and 4 supratentorial tumours as shown in Figure 3.6. Twelve of these patients had clinical evidence suggestive of space occupying lesions. One presented after a fall and two had follow up scans for recurrence of retinoblastoma.

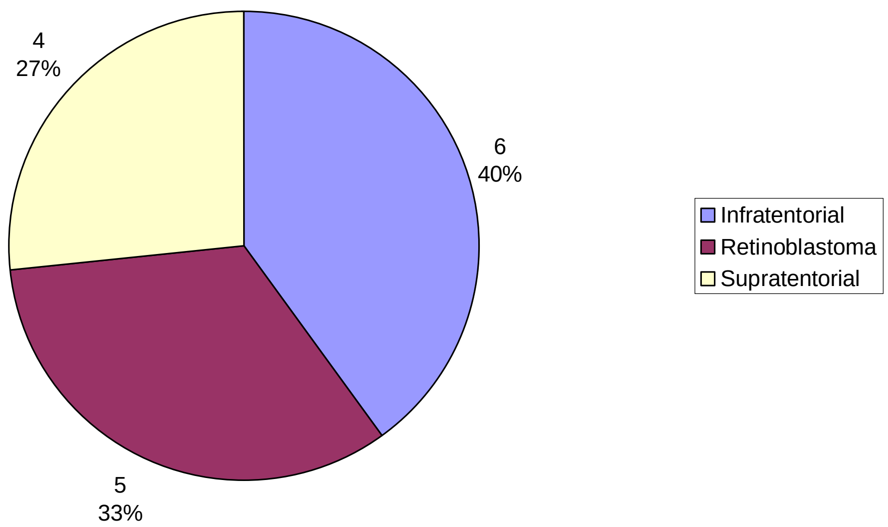

Figure 3.6: Types of tumours

Intracranial bleeds were detected in 18 patients (5.0%). Figure 3.7 depicts the site/s of the intracranial haemorrhage in these patients. Many patients had evidence of more than one type of bleed on CT brain scan. Most patients with intracranial bleeds presented with head injuries. Eight of these patients had evidence of fractures as well.

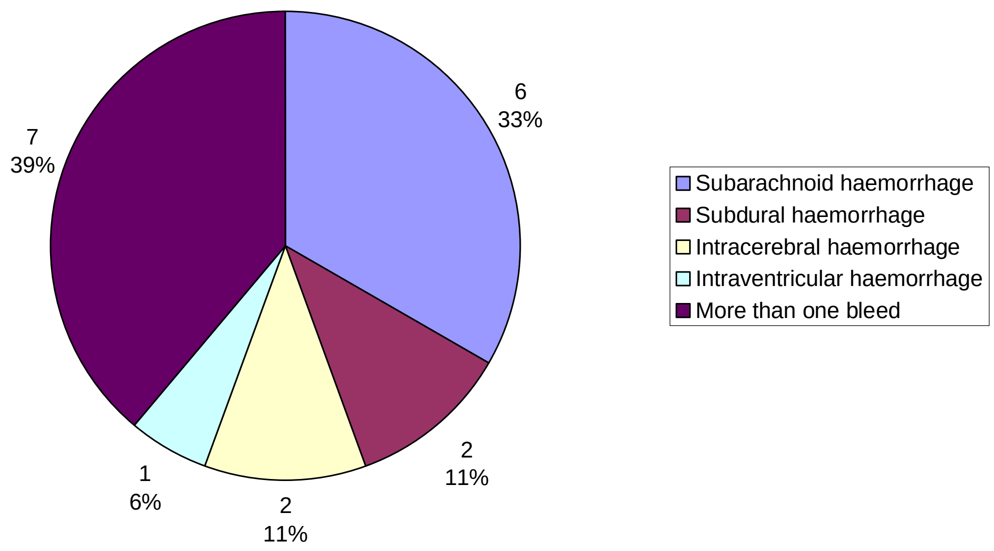

Figure 3.7: Sites of intracranial bleeds

Two 6 month old infants presenting with seizures had evidence of intracranial haemorrhages on CT brain scan. The possibility of non-accidental injury was entertained. A 9 year old haemophiliac presenting with headaches, without a history of trauma, had a subarachnoid bleed.

Radiological evidence of infarction was present in 18 (5.0%) scans. Six patients presented with CNS infections, 5 with seizures (4 focal and 1 generalized) and 4 with an acute hemiplegia.

Congenital malformations were detected in 13 (3.6%) patients, however it was only suspected in one child. The remainder had scans done for macrocephaly, psychomotor retardation and seizures. Partial or complete agenesis of the corpus callosum was suspected in 6 patients. One infant presented with multiple congenital anomalies and the scan showed holoprosencephaly.

3.6 Yield of scans and neurological assessment

Normal and abnormal scans are tabulated by indications in Table 3.5. A particularly high yield of positive scans was detected in certain indications such as blocked shunt, macrocephaly, encephalopathy, CNS infections and acute hemiplegia.

The indications of headaches and behavioural problems had the lowest yield of abnormal scans. There were 3 children with behavioural problems and all had normal scans. Of the 12 children with headaches, 9 had normal scans, 1 had encephalomalacia, 1 had a subarachnoid cyst (probably as a result of an old head injury) and a 9 year old haemophiliac had a subarachnoid bleed.

Table 3.5: Number and percentage of normal and abnormal scans for each indication

Indications for CT brain scans	Normal		Abnormal	
Partial seizures	21	38.2%	34	61.8%
Trauma	17	37.8%	28	62.2%
CNS infection	10	23.3%	33	76.7%
Generalized seizures	20	52.6%	18	47.4%
Macrocephaly	5	13.9%	31	86.1%
Psychomotor retardation	13	48.2%	14	51.9%
Space occupying lesion	7	36.8%	12	63.2%
Acute hemiplegia	4	28.6%	10	71.4%
Blocked shunts	0	0.0%	13	100.0%
Headaches	9	75.0%	3	25.0%
Encephalopathy	2	16.7%	10	83.3%
Periorbital cellulites	4	57.1%	3	42.9%
Behavioural problems	3	100.0%	0	0.0%
Congenital malformations	0	0.0%	2	100.0%
Total (including other)	128	35.5%	233	64.5%

Figure 3.8 below separates the results of the scans showing normal results, cerebral atrophy and other abnormal results. Cerebral atrophy contributes to the high positive yield in psychomotor retardation and seizures. In the patients presenting with trauma and space occupying lesions the high positive yield is more impressive as cerebral atrophy does not contribute to it.

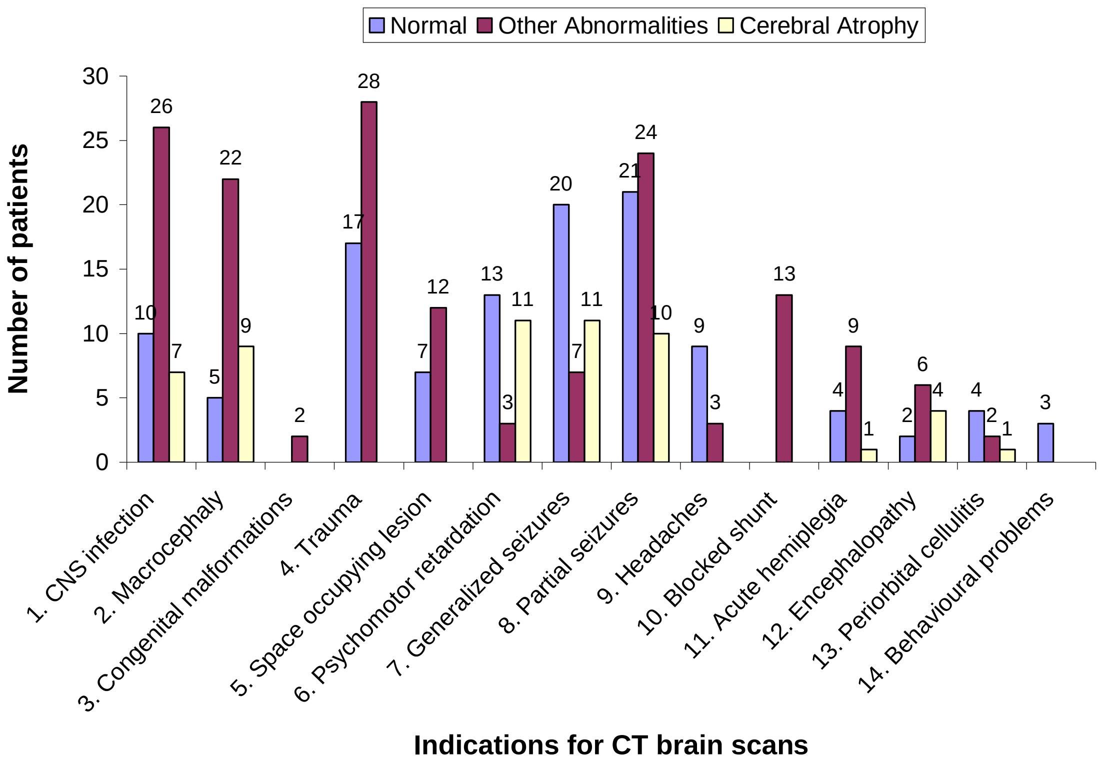

Figure 3.8: Number of scans per indication reported as normal, having cerebral atrophy or other abnormalities.

The yield of abnormal scans was further analyzed together with neurological assessment for the 5 commonest indications in this study.

Figure 3.9 illustrates the increased yield of abnormal scans when the neurological assessment was included as part of the analysis for the indication of partial seizures. However, there was no statistically significant correlation between abnormal neurology and an abnormal scan result (p= 0.1408). A large number of children with an abnormal scan result had a normal neurological assessment.

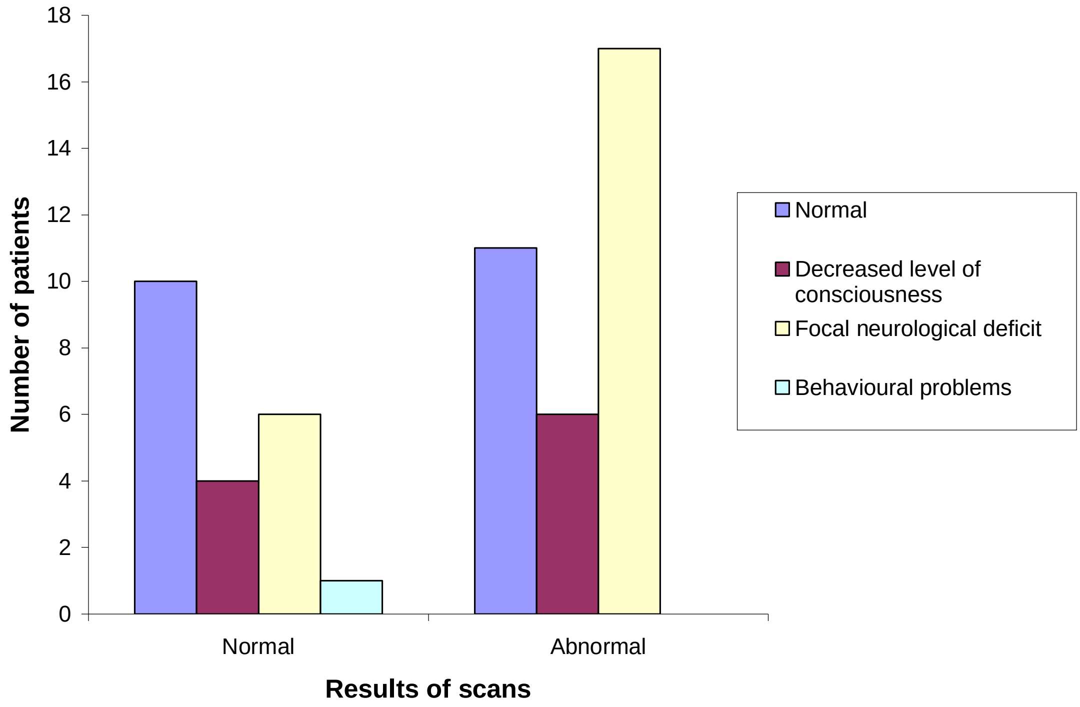

Figure 3.9: Neurological assessment and results of CT brain scans in children with partial seizures.

Most children presenting with generalized seizures and a normal neurological assessment had normal CT brain scan results and most of those with abnormal neurology had abnormal scan results (Figure 3.10). This correlation was statistically significant (p=0.0035).

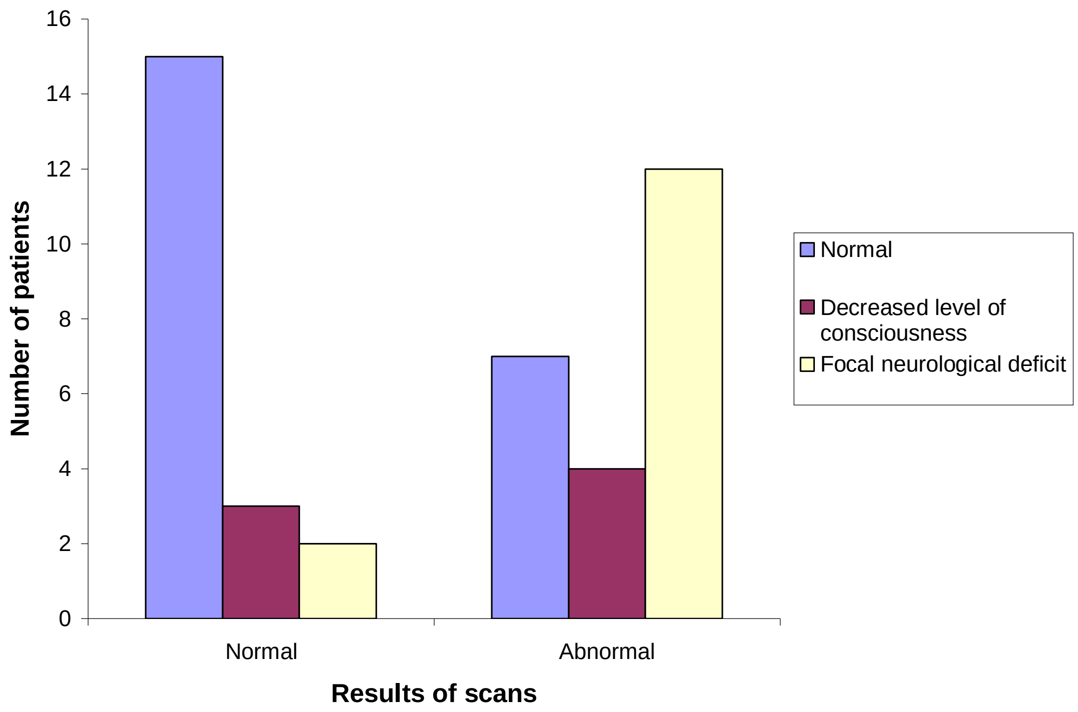

Figure 3.10: Neurological assessment and results of CT brain scans in children with generalized seizures.

Trauma is one of the indications for which abnormal neurology increases the yield of abnormal scan results. This increased yield was statistically significant (p=0.0137). This is depicted in Figure 3.11 below.

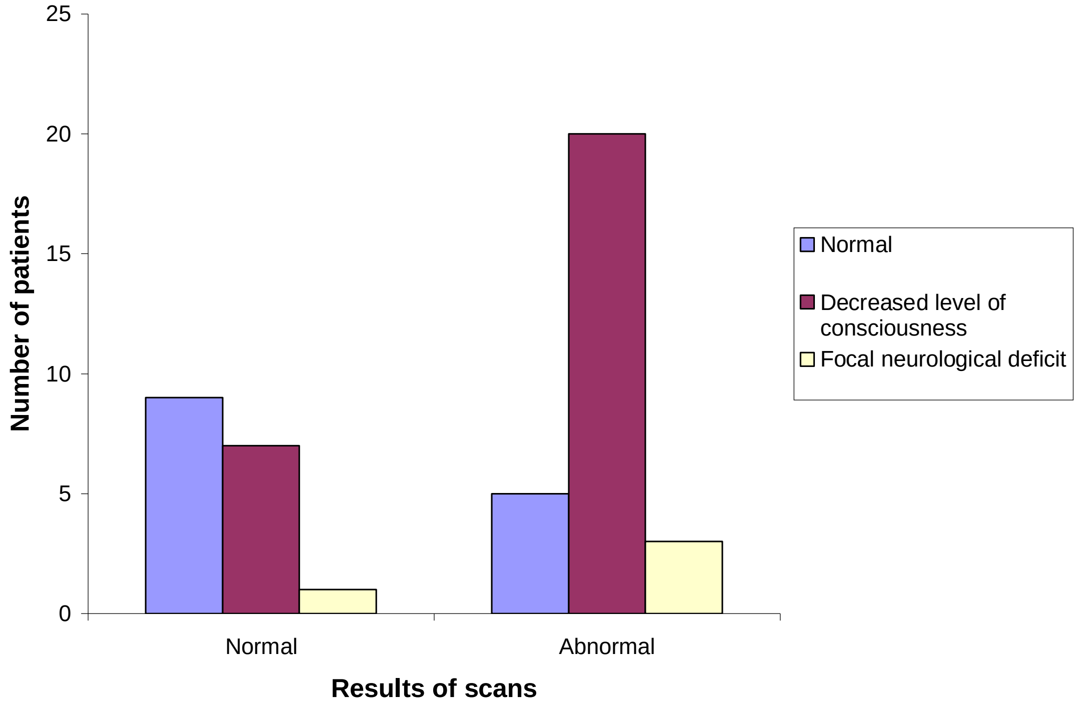

Figure 3.11: Neurological assessment and results of CT brain scans in children presenting with head trauma.

Majority of patients with CNS infections that were scanned had abnormal neurological assessments (Figure 3.12). The yield of abnormal scans in this group was very high (76.7%) however there was no statistically significant correlation with neurological assessment ($p=0.345$).

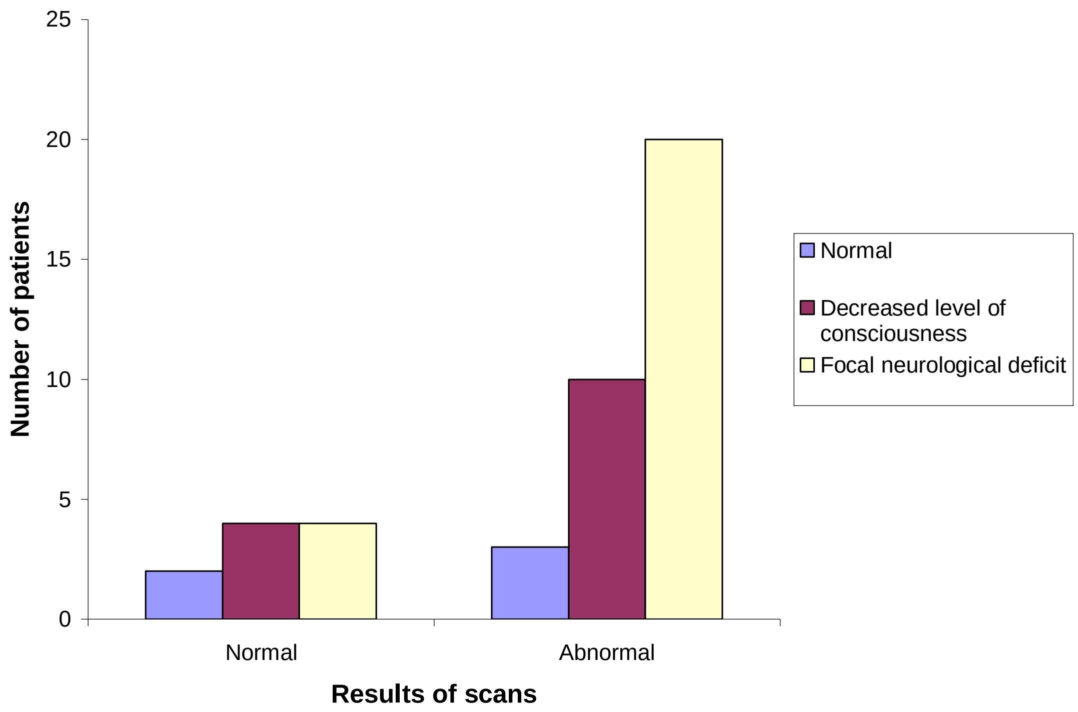

Figure 3.12: Neurological assessment and results of CT brain scans in children presenting with CNS infections.

Macrocephaly had the highest yield of abnormal scans from the 5 common indications. Most of the patients who had abnormal scans also had focal neurological deficit on presentation (figure 3.13). There was a significant correlation between abnormal neurology and an abnormal scan result (p=0.025)

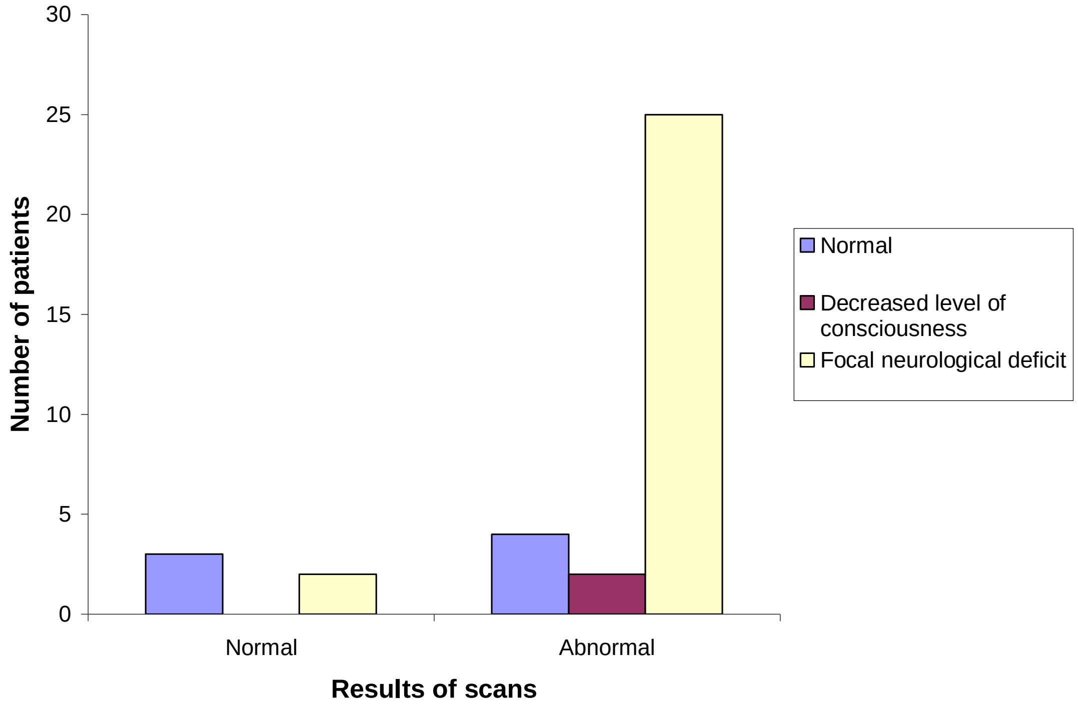

Figure 3.13: Neurological assessment and results of CT brain scans in children presenting with macrocephaly.

4.0 DISCUSSION

4.1 Introduction

The indications for CT brain scans in paediatric patients have been studied for the first time at CHB Hospital. The only other publication from South Africa was in 1986 from a study done at the Johannesburg Hospital in 1984 (38). This study included both adult and paediatric patients.

Four hundred and forty three CT brain scans were done in children 14 years and younger in the four month period. This gives an annual case load of approximately 1300 CT brain scans in this age group. At CHB Hospital, between 15 500 and 16 000 CT scans are done annually. This includes CT scans of the head and body in all age groups. Thus CT scans of the brain in children account for approximately 8.2% of all CT scans done.

4.2 Demographic Data

4.2.1 Age

At CHB Hospital only children up to 14 years of age are seen by the paediatric department. This policy motivated the age cut-off of 14 years in the present study. Most other international studies have included older children up to 18 years of age (3,16,29).

More than one third of the children in the study were less than 2 years and just over half the study population was under the age of 4 years. Most other studies on indications for CT brain scans included both adults and children (35,38) or did not give an age breakdown. Therefore it is difficult to compare the findings of this study to previous studies.

4.2.2 Gender

Under two thirds of the children were male with a male:female ratio of 1.4:1. This is lower than the ratio found in children under the age of ten years at the Johannesburg hospital by Bagg & Anderson (38). Other studies on CT scans for all indications in children did not comment on the gender of study participants (29,35).

The male:female ratio in children presenting with trauma was 1.8:1 which is similar to other studies (9,14,16).

4.3 Elective and urgent scans

Slightly less than half the scans were done urgently. At CHB Hospital urgent scans are done within 4-12 hours. In other studies urgent scans appear to be done within 2 to 3 hours of presentation (12,18).

4.4 Neurological Assessment

All neurological assessments were done prior to obtaining a scan and the scan result would not have influenced the neurological assessment. The assessments were done by the attending doctors. They included paediatricians, neurologists, neurosurgeons, surgical and paediatric registrars and medical officers. The accuracy of the assessment may well be criticized; however this study was only aimed at observing the present practices without altering clinicians' behaviour.

4.5 Indications

The commonest indication was seizures. This is similar to other studies (29,38). Partial and generalized seizures combined, accounted for a quarter of the patients scanned (n=93). At CHB Hospital, scans are done on all children with focal seizures and on children with generalized seizures with focal neurological deficit or decreased level of consciousness. In many centres it is routine practice to scan all children presenting with their first seizure on presentation at the emergency department (18,21). In our setting due to the high case load and limited scanner facilities, this would not be possible. There were no children scanned for simple febrile seizures in this study as it is not the policy of the institution to scan these children. Most authors agree with this practice (18,19,20,22).

Trauma accounts for a large proportion of scans done at CHB Hospital. Not all children with minor head injuries are scanned. Several authors have reported intracranial injuries in a significant proportion of children presenting with minor head trauma (11,14,15). Presently it would not be possible to scan all these children due to pressure on the scanner facility.

In this study, infections accounted for many scans (n=50, 13.6%), Most were for CNS infections (n=43, 11.9%), while periorbital cellulitis necessitated 7 (1.9%) scans. CNS infections were responsible for a lower proportion of patients in other studies (29,38). In our setting patients with CNS infections are only scanned if complications are suspected. The majority of children with CNS infections that were scanned had neurological abnormalities. Of concern is the fact that more than half of the children with CNS infections who presented with a normal neurological assessment had abnormal scan results. Human Immunodeficiency Virus (HIV) imposes a huge burden of disease at CHB Hospital and in South Africa in general. This may be responsible for the higher number of patients with CNS infections in the present study. However, as the HIV status of the patients was not analyzed in the study, this conclusion cannot be reached.

The six common indications namely: partial and generalized seizures, CNS infections, trauma, macrocephaly and psychomotor retardation accounted for two thirds of all indications. Nevo, Reider-Groswasser, Yurgenson, Fatal-Valevski & Harel found headaches and congenital malformations to be common indications for scans, and in their study, CNS infections and macrocephaly did not feature as prominently (29). In Johannesburg 20 years ago Bagg, et al (38) also found CNS infections to feature minimally but this study was done prior to the HIV epidemic in South Africa.

There were only 5 scans (1.4%) done for cerebral palsy. The majority of patients with CP are not scanned at CHB Hospital due to patient load and budget constraints. More than 500 children with CP are seen annually by the neurology department. Ideally all patients with cerebral palsy should be scanned. Cerebral palsy made up 5.9% of the indications in the study by Nevo, et al (29).

4.6 Results

A little over one third of the scans were reported as normal. The rate of normal scans varies depending on the selection of patients undergoing scans. Nevo, et al (29) reported 55% normal scans, while Bagg, et al (38) reported normal results in 50% of the cases. In this study only 35.5% (n=128) of scans done were reported as normal. This is a much higher yield for abnormal scans than any other study (6,29,37).

Cerebral atrophy was the commonest abnormal result in 58 scans (16.1%). In the study by Nevo, et al (29) 30.6% of scans showed evidence of cerebral atrophy. This is much higher than the present study. The difference in the 2 studies may be due to the higher proportion of patients with cerebral palsy, headaches and learning disabilities that were scanned in their study. The majority of these scans showed cerebral atrophy. In the present study 12 scans were done for headaches and 5 for cerebral palsy. These 2 indications made up 4.7% of the scans analyzed. No scans were done for learning disabilities. In the present study, HIV infection may have contributed to the proportion of scans that showed cerebral atrophy, but as the HIV status of the patients was not analyzed this assumption cannot be made.

Tumors were suspected in 19 patients, of these 12 demonstrated tumours on the scans (63.2%). This proportion is similar to the yield found by Nevo, et al (58%) (29), however Bagg, et al had a higher yield for suspected tumours in their study (72.7%) (38). Tumours were detected in 4.2% of scans in this study while in the study by Bagg, et al (38) tumours were found in a similar percentage of scans (4.9%).

Intracranial bleeds were detected in 5.0% of scans. This is less than that found in other studies (~9%) (6,38). Most of the intracranial bleeds were found in scans done for trauma. In this study 26.6% of patients presenting with trauma had intracranial bleeds. This is similar to Dietrich, Bowman, Ginn-Pease, Kosnik & King's findings (9). Of the children presenting with trauma 62.2% had abnormal scans. This is a much higher yield than other studies (12,13,15,39). The high yield in this study may be due to the stringent criteria for scanning children with minor head injuries at our hospital.

Hydrocephalus was found in 11.6% of the scans. This is similar to the findings of Bagg, et al (38). Three percent of normal children have non-pathological macrocephaly. In this study 86.1% of children with macrocephaly had abnormal scans and 80.6% had an abnormal neurological assessment. This is much higher than the rate of abnormal scans found by Bagg, et al (38) for patients with suspected hydrocephalus (65%). It is possible that at CHB Hospital we are not scanning all children with macrocephaly.

In certain clinical entities such as trauma, space occupying lesions, CNS infections and macrocephaly, the CT brain scan findings may have direct therapeutic implications. In the present study the rate of abnormal scans in this subgroup was 72.7% (104/143). When cerebral atrophy was excluded from the total abnormal scans there was still a yield of 61.5%.

In other clinical entities such as headaches, behavioural problems and mental retardation, the CT brain scan findings may have little therapeutic significance (5,29,32). In this study 3 children with headaches had abnormal scans. Of these only 1 had a significant abnormality (a subarachnoid bleed). This was managed conservatively.

4.7 Conclusion

The significance of a negative scan is often underestimated. To the attending physician and the patient a negative scan may be very important (5). However, the high cost of computed tomography and the inherent radiation risk especially in the developing child should not be underestimated (40,41). In indications such as cerebral palsy, psychomotor retardation and congenital malformations; the result of the scan may have little impact on therapy. Imaging studies in this subgroup of children is debatable, especially when sedation is required and the scan carries the added risks of general anesthesia.

A very high abnormal yield as found in this study could indicate that presently an inadequate number of children requiring scans, actually get scanned. This is particularly important in indications for which abnormal scan results have significant therapeutic implications.

5.0 CONCLUSION

This descriptive study analyzed the indications and results of CT brain scans in children at CHB Hospital. There was a very high yield of abnormal results in the scans analyzed. This could be due to the stringent scanning criteria at the hospital. As a result pathology may be missed, especially in neurologically normal children.

5.1 Limitations of the study

This study was done over a period of 4 months only. A more comprehensive picture could be obtained if this study was done over a longer period.

The age cut off in this study is 14 years whereas other studies have included children up to the age of 18 years.

Only four categories of neurological assessments were included even though some patients may have had a combination of findings. An additional category of patients with more than one neurological findings may have had an effect on the positive predictive value of abnormal scans.

Evidence of CNS infection was found in a high proportion of scans. The high prevalence of HIV in the children seen at the hospital may have contributed to this. This conclusion cannot be drawn as the HIV status of the patients scanned was not analyzed.

Head injuries were not further subdivided into mild, moderate or severe. The results of this study are therefore difficult to compare to other studies. Comments on the adequacy of our scanning policy for patients with mild head injury cannot be made.

Seizures were not subdivided into first time seizures or chronic epilepsy. This may have influenced the number of scans that showed cerebral atrophy.

The lack of access to MRI made it impossible to confirm that there were no definitive intracranial abnormalities in children with normal CT scans.

5.2 Recommendations

The two scanners at the hospital provide an inadequate service. The waiting period for scans is probably too long. MRI facility has recently been introduced in the hospital, and another CT scanner has been proposed for the new upgraded accident and emergency department. A follow up study would be interesting, to see if there are any differences in the findings with the availability of MRI and a new dedicated accident and emergency CT scanner.

The high rate of abnormal scans in children with macrocephaly is worrying. Children with macrocephaly seem to be missed. They appear to be scanned only when neurological problems develop. This practice needs to be addressed and more children with macrocephaly need to be scanned.

Further research is needed for specific indications such as epilepsy, head injuries and CNS infections. This will enable us to deduce if our stringent scanning policy in these children is adequate. Future study is needed which includes the HIV status of the children as the findings of cerebral atrophy was substantial.

A dedicated paediatric neuroradiology team could be beneficial.

APPENDIX A

Data Collection Sheet

Study No:

Sex:

Age:

Hospital of origin:

Ward of origin (if from Chris Hani Baragwanath Hospital):

Elective scan: Yes □ No □

Emergency scan: Yes □ No □

Doctor requesting the scan:

Indications for the scan (only primary indications):

1. Brain infection
2. Large head / hydrocephalus
3. Congenital malformation
4. Trauma
5. Suspected tumor / space occupying lesion
6. Psychomotor retardation
7. Seizures – generalized
8. Seizures – focal
9. Headaches
10. Blocked shunt
11. Other

First scan: Repeat scan:

Neurological assessment:

1. Decreased level of consciousness
2. Focal neurological deficit
3. Normal
4. Behavioral changes

Results of the scan:

1. Normal
2. Cerebral atrophy
3. Hydrocephalus
4. Congenital anomalies
5. Tumor / Neoplastic disease
6. Intracranial bleeds - Subdural
   - Subarachnoid

- Intracerebral
- Intraventricular

7. Infarction
8. Oedema
9. Infection
   - Meningeal enhancement
   - Tuberculoma
   - Cysticercosis
   - Cerebral abscess
10. Other

APPENDIX B

Ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

COMMITTEE FOR RESEARCH ON HUMAN SUBJECTS (MEDICAL)
Ref: R14/49 Vallabh

CLEARANCE CERTIFICATE **PROTOCOL NUMBER** M03-09-44

PROJECT An Evaluation of Brain Scans in Children at CH Baragwanth Hospital

INVESTIGATORS Dr P Vallabh

DEPARTMENT School of Clinical Medicine, CH Baragwanath Hospital

DATE CONSIDERED 03-09-26

DECISION OF THE COMMITTEE Approved unconditionally

Unless otherwise specified the ethical clearance is valid for 5 years but may be renewed upon application
This ethical clearance will expire on 1 January 2008.

DATE 03-10-16 CHAIRMAN...................................(Professor P E Cleaton-Jones)

* Guidelines for written "informed consent" attached where applicable.

c c Supervisor: J Rodda
Dept of School of Clinical Medicine, CH Baragwanath Hospital

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DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and ONE COPY returned to the Secretary at Room 10001, 10th Floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. I agree to a completion of a yearly progress form. I/we agree to inform the Committee once the study is completed.

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX C

Consent from senior clinical executive at Chris Hani Baragwanath Hospital

GAUTENG PROVINCIAL GOVERNMENT

Gauteng Department of Health

CHRIS HANI BARAGWANATH HOSPITAL

PERMISSION FOR RESEARCH

DATE: 01-09-2003

NAME OF RESEARCH WORKER: Dr. P. Vallabh

TITLE OF RESEARCH PROJECT: Evaluation of CT scan Brain in a Paed. Population

OBJECTIVES OF STUDY (Briefly or include a protocol): requirements for MSc NeuroDevelop Paeds

METHODOLOGY (Briefly or include a protocol): Hospital record reviews

CONFIDENTIALITY OF PATIENTS MAINTAINED: Yes

COSTS TO THE HOSPITAL: none.

APPROVAL OF HEAD OF DEPARTMENT: Yes

APPROVAL OF CRHS OF WITS UNIVERSITY:

SUPERINTENDENT PERMISSION:

Signature: [signature] DR. A N A... Date: 2003/9/2

Subject to any restrictions: Ethics Approval. No additional cost to hospital

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