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Data Analysis of Brain MRI at a tertiary hospital in Sudan

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Abstract

Purpose This study aims at understanding the utilization of MRI in Sudan. The goal of the data analysis is to identify and analyze the different types of pathology diagnosed using brain MRI. Our goal is to understand the demographic age and gender distribution of patients, comparing the results with the literature, and finally correlating radiological findings with the histopathology diagnoses.

Study Design This is a retrospective, descriptive, analytical, study of a hospital database assessing brain MRI and corresponding histopathology reports. Brain MRI studies were performed in the period from January 2012 to January 2013 using a Toshiba aquilion 1.5 Tesla, 2008 (made in Japan) and corresponding histopathology reports were also obtained from same hospital records.

Findings A total of 1,540 patients underwent brain MRI during this period, of which 662 (43%) had brain pathology. These abnormal images were identified and subdivided into 322 (21%) clinically relevant and 340 (23%) with incidental findings with no obvious clinical relevance. The total number of brain tumours recorded in the series is 101 (7%), of which 34 (2%) are meningiomas. White matter pathology was recorded in 40 (3%) of brain images as the most frequently seen clinically relevant MRI finding. Paranasal sinus changes reported as sinusitis was seen in 120 (8%) representing (35%) of the incidental findings. Analysis of gender distribution of meningioma and sellar masses showed a Male:Female ratio of 1.3:1 and 1.2:1, respectively. A total of 87 histopathology reports on specimens obtained from surgical procedures performed on site were obtained. Sixteen patients with matched radiology (MRI) and histopathology diagnoses are obtained and presented.

Conclusion Brain tumours, white matter changes and sinusitis were most frequently reported in brain MRI studies, with the white matter changes being the most clinically relevant finding and sinusitis the most frequent incidental finding. Age distribution of identified brain pathology matches the literature. MRI was found to be utilized by males more than females, and the gender distribution of meningioma and sellar masses were found to be more prevalent in males in this series. Sample cases of brain MRI studies and histopathology reports are presented.

Introduction

The field of medical radiology has advanced extensively in recent years (Bandettini, 2009), with incredible advancements in imaging techniques, reporting skills and Tele-radiology taking place in developed countries (Thrall, 2007). Nevertheless, under-developed and developing countries, including Sudan, suffer from a lack of resources and major technical challenges; however, no major studies have been undertaken to reflect this. Sudan is a 188,200 square kilometre under-developed Sub Saharan African country, with a population of around 33,419,625 based on the 2008 census (UNDP, 2012). Healthcare services in Sudan are under-resourced and largely private, affecting coverage of the whole country and access of less advantaged patients to healthcare. According to the WHO, health infrastructure total density per 100,000-district/rural hospitals is 0.56, while density per 100,000 specialized hospital is 0.03 (WHO, 2012).

The Royal Care International Hospital (RCIH) is a 100-bedded leading tertiary care hospital in Sudan, which receives patients referred from all parts of Sudan and neighbouring African countries (South Sudan, Chad, Ethiopia, Eretria and Mali). In most circumstances, these are complex referrals with a high percentage of seriously ill patients and advanced medical conditions; this might explain the high percentage of abnormal brain images seen with advanced stages of brain pathology. RCIH adopted the use of the Electronic Medical Record (EMR) system and Picture Archiving and Communication System (PACS) in tandem with their growing use worldwide (OECD, 2007). A well planned EMR and PACS could have a substantial effect on the quality of medical services, through increasing radiology department workflow and improving the average hospital stay for each patient (Nitrozi, 2007). The EMR and image archiving systems also make healthcare information and patients records readily available for audit and research purposes, which is the case in our study.

Materials and methods

This study is a retrospective descriptive analytical study of hospital databases and records. All brain MRI studies were previously performed at RCIH during the period from January 2012 to January 2013, using a Toshiba Aquilion, 1.5 Tesla MRI 2008, made in Japan, images were retrieved and analyzed. Anonymous patients' data were collected, including the date the MRI study was performed, age and gender of patients, and the radiological diagnosis given in the MRI report. All histopathology reports of brain specimens from surgical procedures performed at the hospital during the period from January 2012 to January 2013 were obtained, recorded and analyzed. The information obtained from the histopathology reports were compared with data obtained from the brain MRI reports for the purpose of obtaining a histopathological and radiological correlation.

Results

There are 17 MRI machines in Sudan: 15 (88%) of them are present in the capital city, Khartoum. Only three diagnostic MRI centres, which are located in the capital, maintain a data archiving system where images and reports are filed and saved, with massive loss of images and reports in other centres.

During the study period, 1,544 brain MRI studies were performed, with the number of monthly studies ranging between 84-166, with a mean of 128 studies per month: all were reported and analyzed. Out of these, 882 (57.1%) were normal images and 662 (42.9%) were abnormal images. The 662 abnormal brain MRI studies were subdivided into clinically relevant findings, 322 (48.6%), and incidental findings, 340 (51.4%). As shown in Figure 1, the clinically relevant MRI findings were categorized according to diagnosis by order of frequency as follows: white matter changes (40), congenital malformations (35), meningioma (34), sellar masses (31), brain haemorrhage (27), primary brain tumours (24), other brain lesions (22), empty sella (22), infarction/ischemia (14), venous sinus thrombosis (13), post-operative changes (13), infectious causes (13), metastatic brain disease (12), sinusitis including fungal (9), cerebello-pontine angle masses (7), and orbital lesions (6).

In 340 (22%) of the images, incidental findings were found without clear relevance to the clinical presentation or the indication under which the brain MRI was initially performed. The 340 incidental findings were categorized in the order of frequency and illustrated in Figure 2 showing the distribution of radiological diagnoses of incidental findings appearing as follows: paranasal sinusitis (142), ischemic changes (140), brain atrophy (27), sinus polyps (23), and adenoid hypertrophy (8).

Age distribution of cases

The ages of patients recorded ranged from 4 months to 98 years. The categories used for ages of patients are: 0-10, 11-20, 21-40, 41-60 and > 60 years. The age distribution of clinically relevant brain MRI findings is detailed as follows: 43 in age group 0-10 years, 15 in age group 11-20 years, 98 in age group 21-40 years, 75 in age group 41-60 years, and 42 in age group of patients more than 60 years of age. As clearly illustrated and highlighted in Figure 3, the majority 98 (35%) of \\ brain MRI findings are reported in the 21-40 years age group.

Gender Distribution of Cases

Gender distribution of 283 brain MRI findings is detailed in Table 1, showing that 144 (51%) of findings were described in males while 139 (49%) were in females. Further analysis showed that some brain MRI findings displayed variation in male/female ratios. For instance, white matter disease is seen in 24 females compared to 12 males. For the congenital malformations, females were 12 compared to 22 males. Some other brain MRI findings did not show much difference between gender, such as meningioma with 18 males and 16 females, sellar masses with 17 males and 14 females. Brain haemorrhage displayed in 13 males and 1)female, primary brain tumours were equal with 12 for both males and females. Empty sella were 14 in females and 8 in males, venous sinus thrombosis 8 in males and 5 females, post-surgical findings

[1] Other brain lesions featured caudate atrophy, iron deposition, lipoma, angioma, dermoid cyst.
[2] Infectious causes featured tuberculosis lesion, hydated cyst, cysticercoids, and toxoplasmosis.

were 7 in females and 6 in males. Infectious brain causes were 8 in males and 5 in females, metastatic brain disease were 8 in females and 4 in males. Sinusitis including fungal infections were 6 in females and 3 in males. Cerebellopontine angle lesions were 4 in males and 3 in females and orbital lesions were 4 in males and 2 in females.

Furthermore, Figure 4 depicts the age distribution of sinus thrombosis and brain infections, including fungal infections, all showing a clear predilection for the age group 21-40 years. This has a major effect on the life style productivity and socioeconomics of this vital age group of the local community. Meanwhile, Figure 5 illustrates the overall gender distribution of all brain MRI findings reported in patients included in this study. Finally, Figure 6 shows an illustrative example of an MRI study performed on a 64 year old male, who presented to the neurology clinic with headaches and impaired vision for six months. A brain MRI with contrast showed a large pituitary tumour, and Figure 7 shows an MRI example of incidental white matter changes. Figure 8 shows an example of incidental sinusitis.

Histopathology data analysis

Histopathology reports on all brain specimens obtained from surgical procedures, which were performed in the year 2012, were recorded. These totalled 86 histopathology reports and the content diagnoses of these reports are detailed in Table 2. The most frequently reported histopathological diagnosis was a pituitary adenoma seen in 33 patients followed by meningioma (17), pilocytic astrocytoma (12), oligodendroglioma (5), craniopharyngioma (3), brain cysts (3), glioblastoma multiforme (3) and haemorrhagic infarction (2). There were single reported diagnosis for each of the following conditions: schwanoma, tuberculosis brain disease, hydatid brain disease, lymphoma, primitive neuro-ectodermal tumour (PNET), metastatic adenocarcinoma likely from a primary in the gastrointestinal tract, plexiform Neurofibroma, choroid plexus papilloma and chordoma. The 86 histopathological reports that were analysed were then compared with the radiological diagnoses of the brain MRI findings, of which 16 (18%) were matched and confirmed as belonging to the same patient (Table 3). The fully matched radiological and histopathological diagnoses shown in Table 4 comprise 7 pituitary adenomas, 3 meningiomas, 2 oligodendrogliomas, 2 astrocytomas, 1 tuberculosis of the cerebellum, and 1 lymphoma.

Discussion

Sudan is a large country in the Sub Saharan Africa region where health services are mainly provided in most main cities, but obviously concentrated in the capital city of Khartoum. There are a total of 17 MRI machines in Sudan, which serve in a ratio of 0.5 MRI machine per 1 million people.

A study conducted in 2007 by the Organization for Economic Cooperation and Development (OECD) showed that there are 7,810 MRI machines in the USA, serving in a ratio of 26 MRI machines per 1 million people. From the same study, in Turkey there are 395 MRI machines serving in a ratio of 5.6 MRI machines per 1 million people (OECD, 2007).

No published studies on the subject of this research from the Sudan have been found. However, in a similar study from the Radiology Department at the University of Cincinnati College of Medicine University Hospital during the period from 2001 to 2005, a total number of 62,823 MRI studies were performed (Rankey et al., 2008). In our study the utilization of brain MRI was slightly higher in males (144) compared with females (139). Another study in 2002 by the Ontario Ministry of Health found that, across all ages, females had an overall higher utilization of MRI studies than males (Squires, 2011). The higher utilization of MRI studies in females included all types of body MRI studies, except those for the neck and extremities in which males had higher rate of utilization of MRI. It is also indicat-

ed in this study that the ratios of the brain MRI studies performed were 557 females and 402 males per 100,000 individuals. MRI findings of white matter changes with different stages of hypomyelination and demyelination were more prevalent in females of the age group 21-40 years, with a female to male ratio of 2:1. Another study reported gender difference with a female to male ratio of 3.2:1, and concluded that the results might be related to a higher number of female to male birth rates (Squires, 2011).

Our study shows that meningioma is a more prevalent brain condition in patients over 65 years of age, which matches the literature (Davis et al., 1999). It is known that meningioma is more prevalent in females, with a female to male ratio ranging between 1.4:1-2.8:1. However, in our study meningioma is found to be slightly more prevalent in males with 1:1.3 female to male ratio, which might need more attention in future studies. Sellar masses were the second highest number of brain tumours diagnosed with brain MRI, with a gender distribution of a marginal male predominance with a ratio of 1.2:1. In another study by Mindermann and Wilson of the Department of Neurological Surgery, School of Medicine, University of California, San Francisco (Mindermann and Wilson, 1994), it was reported that the prevalence of pituitary adenomas varies greatly according to age and gender of patients. In this study, it has been indicated that various types of adenomas distinctly peak in different age groups and display great variation in gender distribution. For instance, it was found that prolactinomas peak in the second to fifth decade of life, while endocrine-inactive adenomas peak in the fourth to eighth decade. A study by Khalid Farooq et al. from Lahore in Pakistan, described the mean age for pituitary adenoma to be 42.92 years with a male to female ratio of 1.4:1 (Farooq et al., 2010). In our study, overall, primary brain tumours were more prevalent in the period between 41-60 years of age, with a female to male ratio of 1:1.

A study by Faith G. Davis et al., at the Division of Epidemiology and Biostatistics, School of Public Health, University of Illinois at Chicago, reported a prevalence of primary brain tumours of 37.1 males to 30.2 females per 100,000 population, giving a female to male ratio of about 1.2:1 (Davis et al., 1999). A higher incidence of malignant tumours was described, however, a higher prevalence of benign tumours was reported. In our study, primary brain tumours are more prevalent in the age group 21-40 years, however the gender distribution was similar to the literature with a slight male predominance of 1.2:1. A study done by the Office of National Statistics (cancer statistics), from the registration of cancer patients in England (Cancer Research in UK, 2012) found that over half (54%) of all malignant brain tumours and other CNS tumours occurred in people aged 60 years and over. Males and females displayed similar incidence up to about the age of 35 years, after which there are slightly higher male incidence rates. The overall male to female ratio was 13:10. In 2010 in the UK, 54% of brain, other CNS and intracranial tumours were malignant, and 46% were of benign and uncertain or unknown behaviour types. However, there was a noticeable difference in the occurrence of these types of tumours between the sexes; malignant brain, other CNS and intracranial tumours were more common in males (male:female ratio of around 14:10), whilst benign and uncertain or unknown types were diagnosed more often in females, with a male:female ratio of around 7:10.

In our study, empty sella is more prevalent in the age group 41-60 years with a female predominance, giving a

female to male ratio of 1.75:1. In a study by Marinis et al. (2005), a female preponderance with a female to male ratio of 4:1 was reported in the diagnosis of empty sella. Meanwhile, the mean age for patients at the time of diagnosis was 51.8 (±2.1) years. In this study, the peak incidence of empty sella was found to be between 30-40 years, with earlier onset in women than in men in this specified age group (Marinis et al., 2005).

In our study, cerebral venous sinus thrombosis was found to occur more in females with a ratio of 1.6:1 in the age group 21-40 years, while Ameri and Bousser's study (1992), found a female to male ratio of 1.29:1. Ferro et al. conducted a prospective study from 1995 to 1998 (Ferro et al., 2004), which revealed similar observations to those of Ameri and Bousser (Ameri and Bousser, 1992). Another study, Siddiqui et al. from the Agha Khan University Hospital Karachi, found that cerebral venous sinus thrombosis was a major cause of stroke in younger patients with a mean age of 32.27 years (Orton et al., 2007). It was therefore concluded that cerebral venous sinus thrombosis should be considered in all young patients with stroke or similar neurological symptoms given the appropriate clinical setting.

Regarding congenital malformations, our study found a higher male than female ratio of 1.8:1. A study from India reported overall higher congenital malformations among new born males 1.63:1 (Taksande et al., 2010), while an international registry of congenital malformations reported higher neural tube defects among females (Lisi et al., 2005)

In our study, infectious brain conditions, including tuberculosis, encephalitis, cystcercosis and hydatid, were higher in males in the age group 21-40 years with a ratio of 1.6:1. It is worth mentioning that the WHO indicated a 1.5:2.1 female to male ratio for tuberculosis infection in all regions of the world (Thorson et al., 2001).
Regarding incidental brain MRI findings in our study, the following results were obtained. Out of 1,544 brain MRI studies, 142 patients (9.2%) showed sinusitis or infection in various paranasal sinus locations: 140 patients (9.0%) were reported to have ischemic changes. Furthermore, 27 patients (1.74%) with brain atrophy were reported as possible age-related changes, 23 (1.5%) with paranasal sinus polyps, and finally 8 brain MRI studies (0.51%) with adenoid hypertrophy.

Katzman et al. (USA) conducted a retrospective study of incidental findings on brain MRI of 1,000 asymptomatic or healthy volunteers performed between 1996 and 1997 (Katzman et al., 1999). This study reported that out of the 1,000 volunteers, 18% of brain MRI studies were abnormal. Paranasal sinus disease totalled 13.2%, which was attributed as possibly being associated with the spring season. Age related brain atrophy was found in 1.2% and mastoid petrous fluid in 0.4%. The finding of T2 hyper-intensity change or unidentified bright objects (UIBO) was reported in 8 brain MRI studies, a percentage of 0.8%.

In our study brain haematoma was found in a 13:1 male to female ratio, while a study by Ganti et al. (2013) showed a slightly higher number of females 125 vs. males 120 presenting with brain haemorrhage.

We found that the peak age of patients utilizing MRI was between 21-40 years. This finding might be associated with the socioeconomic status (SES), as a study by Demeter et al. (2005) showed a strong association between utilization of expensive radiology studies and the

socioeconomic status. However, the same study showed that people in the age range of 55-65 years with a moderate to high SES utilized MRI the greatest.

All the data collection efforts for this research lead to forming a digital registry of cases according to diagnosis, so all reports and images of MRI performed in 2012 can now easily be located. Many software programs were developed for the same purpose worldwide, those programs, when used properly, lead to the affluence of data collection for research and teaching purposes (Iron et al., 2003; Kahn, 2006).

In our study, it was observed that the histopathology reports were higher in number than the radiological reports made for the brain MRI studies on the records. This was probably because those patients have had an inter-hospital transfer for neurosurgery and had specimens taken, procedure or surgery at RCIH.

Considering the distances many patients usually travel to reach RCIH and other tertiary care hospitals in the capital Khartoum, telemedicine is a principle technology that might allow better access to specialists for patients seen in peripheral regions; these specialists are based at the major referral centres in the capital. However, this observation and recommendation requires further studies into feasibility and suitability coupled with provision of necessary infrastructures. An example of tele-radiology was successfully established between Afghanistan and Pakistan to cater for rural areas where radiologists are completely lacking (Mirza, 2008). Tele-radiology requires major resources in the form of trained personnel, national effort aimed at provision of MRI units to major peripheral hospitals or cities of Sudan, as well as the necessary equipment and continuous maintenance. The provision of MRI units in peripheral hospitals or cities of Sudan might aim at achieving one MRI machine in every state in Sudan.

Conclusions

The paucity of published papers, and hence similar studies from Sudan, highlights the need for further studies regarding the radiological services and the nature and prevalence of brain disorders in the country. The gender distribution of meningioma, sellar masses, congenital malformations, and haematoma is more prevalent in males, different from patterns described in the literature. This might be explained by the fact that RCIH as a tertiary care hospital receives rather advanced and complex conditions for patients referred from a wide catchment area inside and outside Sudan. However, the findings also suggest the need for further attention and research. The systems for medical record keeping and picture archiving databases require extensive improvements, which would possibly boost patient care and assist in further audit and research. In our study, 15 out of 17 (88%) of MRI machines in Sudan are in the capital Khartoum: they serve a ratio of 0.5 MRI machine per 1 million people, amongst the lowest worldwide. We highly recommend a study of tele-radiology as a possible solution to the distance and the limited resources in our country.

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Tables

Table 1. *details the gender distribution of patients with brain MRI findings, in the order of the most frequently seen radiological diagnoses.*

	Brain MRI diagnoses	Male	Female	Total
No	Number of diagnoses per gender	144	139	283
1	White matter changes	12	24	36
2	Congenital malformations	22	12	34
3	Meningioma	18	16	34
4	Sellar masses	17	14	31
5	Brain haemorrhage	13	1	14
6	Primary brain tumours	12	12	24
7	Other brain lesions	8	7	15
8	Empty sella	8	14	22
9	Venous sinus thrombosis	5	8	13
10	Post-surgical findings	6	7	13
11	Infectious causes	8	5	13
12	Metastatic brain disease	4	8	12
13	Sinusitis including fungal	3	6	9
14	CP angle masses	4	3	7
15	Orbital lesions	4	2	6

Table 2. *details the diagnoses according to the histopathology reports obtained for the specimens supplied from brain surgical procedures and are listed in order of frequency.*

Cases	No
Total	86
Pituitary adenoma	33
Meningeoma	17
Pilocytic astrocytoma	12
Oligodendroglioma	5
Carniopharingeoma	3
Brain cyst	3
Glioblastoma multiforme	2
Haemorrhagic infarction	2
Schwanoma	1
Brain TB	1
Hydatid	1
Lymphoma	1
Primitive neuroectoderm	1
Adenocarcinoma	1
Plexiform neurofibroma	1
Choroid plexus papiloma	1
Chordoma	1

Table 3. *shows the matched radiological and histopathology diagnoses.*

Total number of patients	No
Patients diagnosed radiologically with clinically significant findings	322
Patients diagnosed histopathologically	87
Patients matched with radiological and histo-pathological diagnosis	16

Table 4. *shows details of 16 matched with radiological and histopathology diagnosis*

Histopathological diagnosis	Total 16
Astrocytoma	2
Cerebellar TB	1
Lymphoma	1
Meningioma	3
Oligodendroglioma	2
Pituitary adenoma	7

Figures

Figure 1. *shows the brain MRI findings reported on patients with clinical presentations significantly relevant to these radiological diagnoses.*

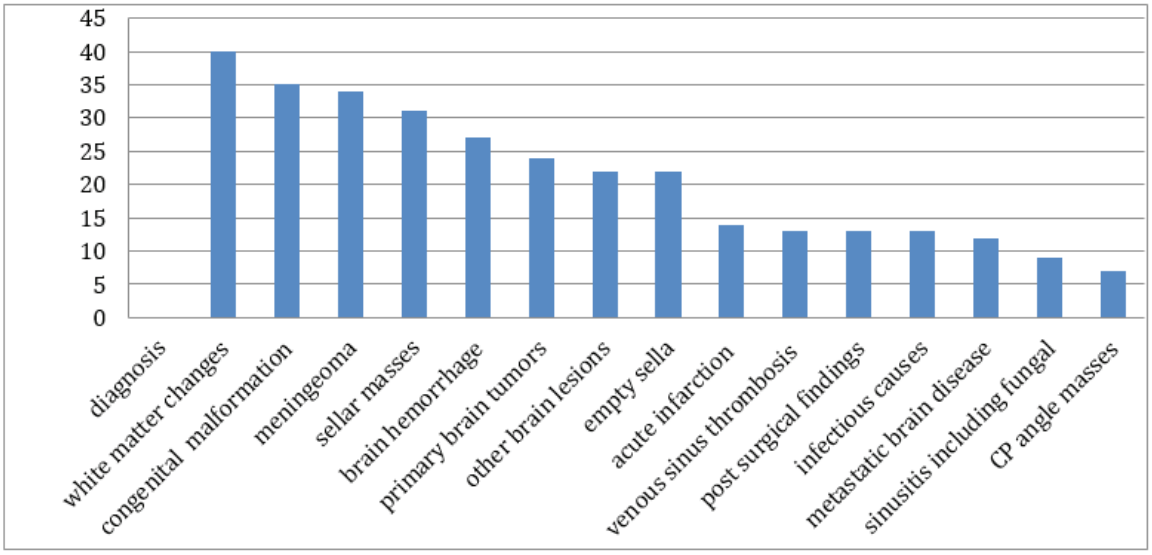


Figure 2. *shows the incidental findings reported on brain MRI studies for patients with no significant clinical relevance to these radiological diagnoses.*

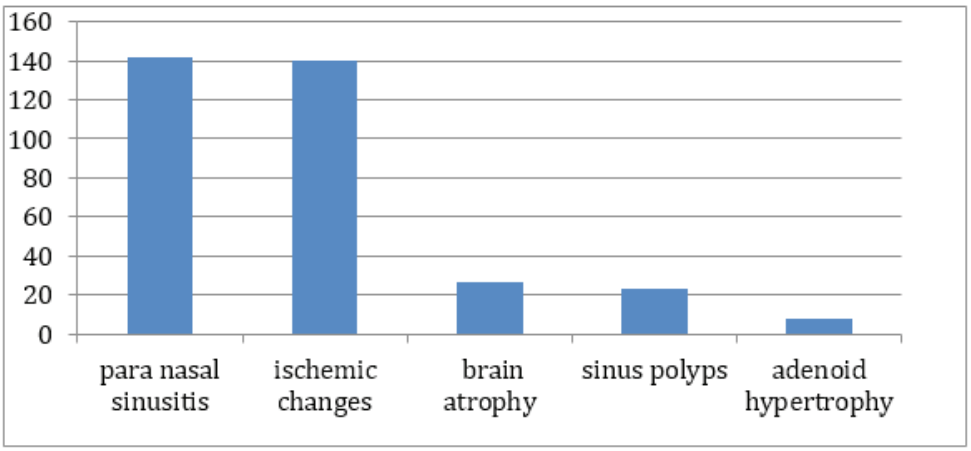


Figure 3. *shows age distribution of patients with radiological reports of clinically significant findings. The pie chart on the top side sub-stratify the age distribution of meningiomas with over half of patients being over 60*

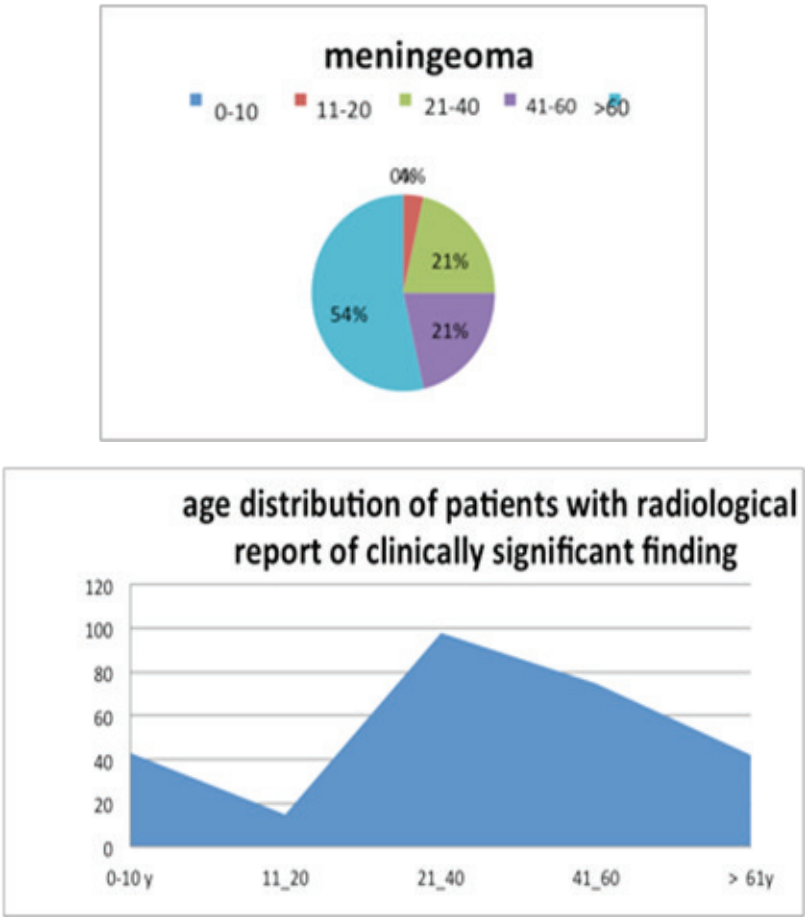


Figure 4. *shows three pie charts depicting age distribution of sinus thrombosis (left), brain infectious conditions (middle) and fungal infections (right). All three conditions show predilection for age group 40-21 years reflecting the impact of these brain diseases productivity and life style of this vital and productive age sector of the local community.*

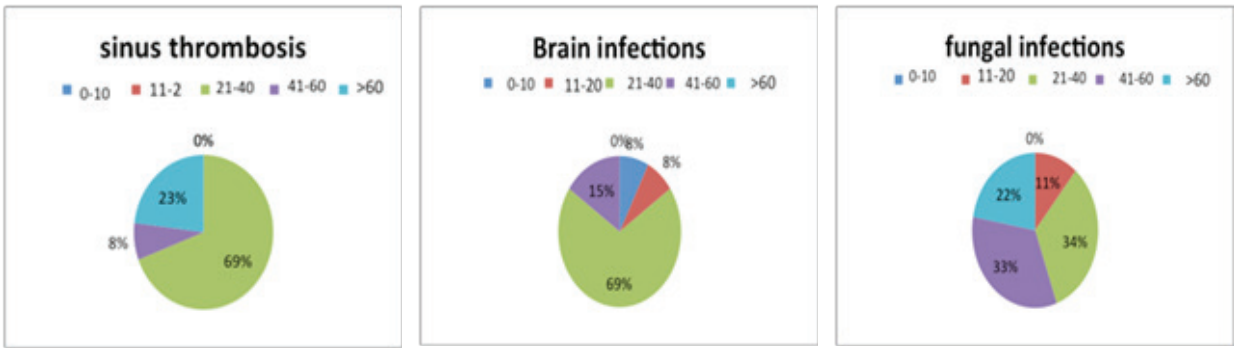


Figure 5. *shows an example MRI study performed for a -64years old man presented with headache and visual impairment. In T1 sagittal view (7a), there is a large sellar mass, which enhances very well on injection of Gadolinium shown on an enlarged T1 with contrast pituitary view (7b).*

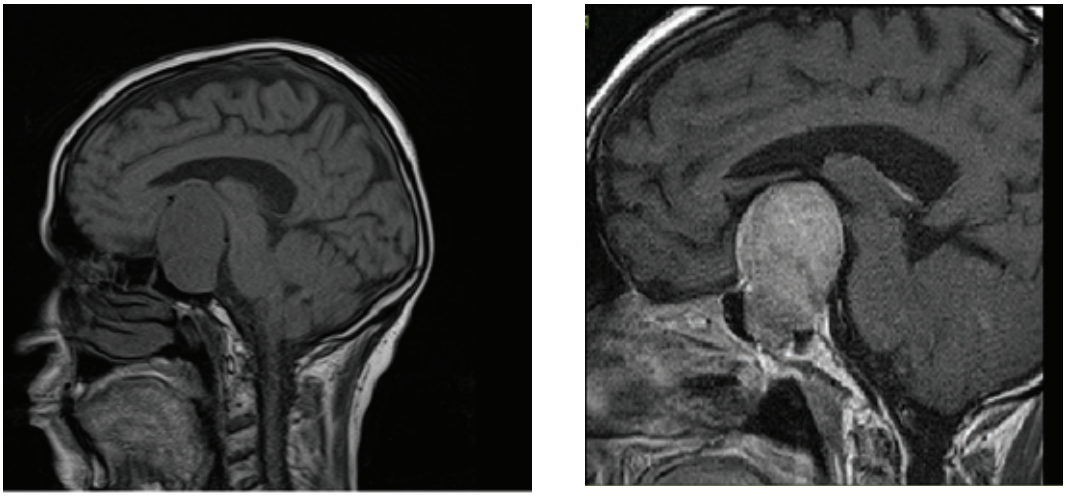


Figure 6. *shows an example MRI study performed for a -47years male present with headache and chronic hypertension MRI reveals the following white matter changes most obvious in the post limp of internal capsule and periventricular areas.*

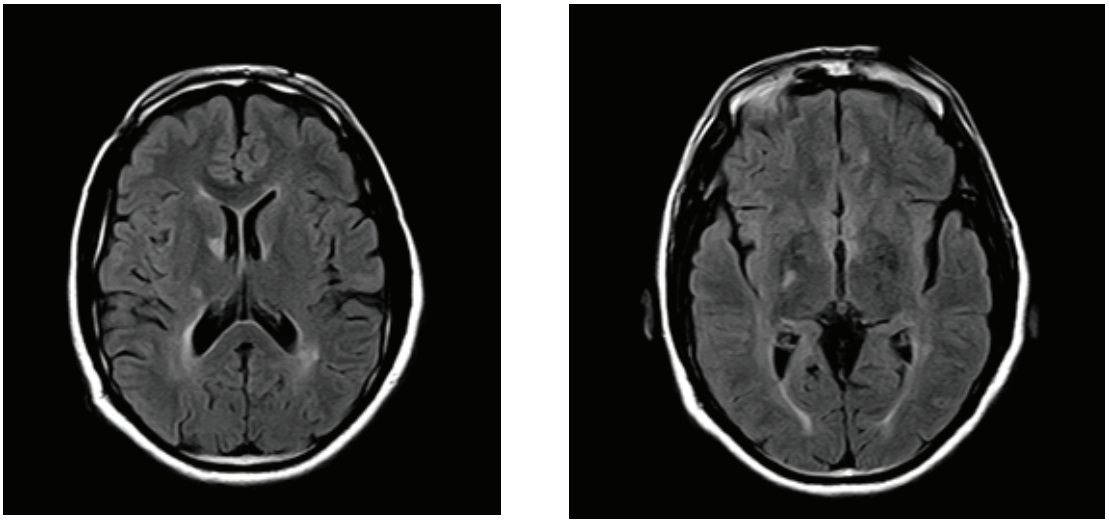
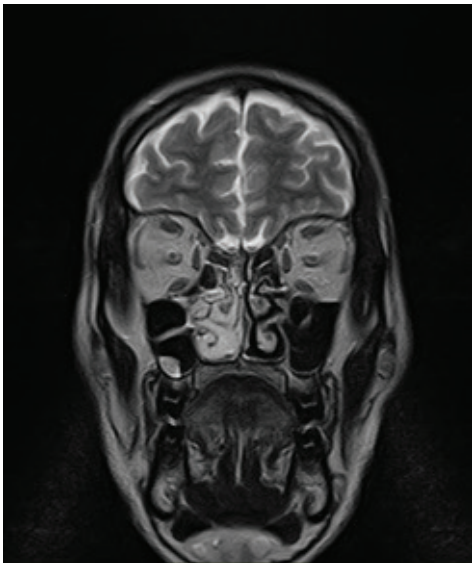


Figure 7. *shows an example of incidental maxillary sinusitis found in 27 year old female.*



About the authors

Radya Osman MD was born and raised in Khartoum, Sudan. She graduated from Khartoum University in 2008. She is proud to be the first Sudanese medical graduate ever accepted for a radiology residency training position at Indiana University, USA, and will be starting this in July 2015. Dr Osman represented Sudan at the Radiological Society of North America, Chicago, USA 2013 and presented the only presentation from Sudan. Dr Osman is passionate about medical research, public health, and volunteering. Her passion for research started when she was a medical student. In 2005, she conducted a malnutrition survey project in IDP camp in Darfur in collaboration with UNICEF. Last year she worked in five research projects with Indiana University that will also be presented at RSNA, Chicago, 2014. She also has a publication with University of Wisconsin, USA. Currently she is an internal medicine resident at Oakwood hospital, Michigan, USA.

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