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Determination of the adequacy of cranial ultrasound requests and reports at Charlotte Maxeke Johannesburg Academic Hospital and Rahima Moosa Mother and Child Hospital

Dr N J Mutshutshu

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Medicine in Diagnostic Radiology

Johannesburg, 2016

Declaration

I, Dr Ntebogang Mutshutshu, declare that this research report is my own work. It is being submitted for the degree of MMed (Diagnostic Radiology) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

Dr N Mutshutshu



On this 23th day of October 2017.

To my husband Tendani my anchor, for always encouraging me to follow my dreams

Publications and presentations

Parts of this work was presented as an electronic poster at the annual Congress in Graz Austria European Society of Paediatric Radiologists, 2nd RSSA/SASPI paediatric imaging congress and published in Pediatr Radiol (2015) 45(Suppl 2): S247-S368 and South African journal of radiology Vol 21, No 1 (2017) 1 page. Doi: 10.4102/sajr.v21i1.1182

Abstract

INTRODUCTION: Cranial ultrasound is a cheap, effective and easy to use modality for the evaluation of cranial pathology in very sick paediatric population. It can be performed as a portable imaging investigation and repeated as many times as possible. New improvements in sonography equipment and technique make it possible for cranial ultrasound to compete with CT scanners in terms of identifying pathology.

AIM: To determine the adequacy of cranial ultrasound requests and reports at Charlotte Maxeke Johannesburg Academic (CMJAH) and Rahima Moosa Mother and Child Hospitals (RMMCH) with regards to their completeness, accuracy and clinical relevance.

METHOD: A retrospective review of 191 cranial ultrasound requests and reports was performed at two academic centres. A collection sheet (Appendix B) was developed by the principal investigator and supervisor guided by literature with regards to the information required within the cranial ultrasound report. A scoring method was then developed with a maximum score of 3 given for the request adequacy and of 14 for report adequacy.

RESULTS: Only 49.74 % of the requests met the criteria for an adequate request. The mean report adequacy score was 7.03 out of 14 with a standard deviation (2.02. Overall 50.26 % of the requests, scored average (2) and below average score. The most commonly reported variable was the presence or absence of hydrocephalus and the least reported was resistive index.

CONCLUSIONS: Results demonstrate that requests and reports of cranial ultrasound are not adequate at both centres. A cranial ultrasound template was therefore developed to assist with the standardization of reports.

Acknowledgements

My gratitude goes to the following people for their tireless efforts in making it possible for this study to be completed:

- My supervisor, Dr L T Hlabangana for her tireless efforts in making sure that this project is successful.
- Dr Susan Lucas, Prof Savvas Andronikou and Prof Victor Mngomezulu for encouraging research in the department and always being there to assist.
- Dr Tanya Pillay Paediatric Radiologist at Chris Hani Baragwaneth Hospital
- Dr Jayshree Naidoo Paediatric Radiologist at Charlotte Maxeke Johannesburg Academic Hospital
- Emery Nganamasana from Department of Statistics University of the Witwatersrand and
- Noleen Gordon, Senior Admin Assistant Department of Diagnostic Radiology.

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List of abbreviations

ANOVA: Analysis of variance

ACR: American College of Radiology

CT: Computed tomography

STATA: Data Analysis and statistical Software package

US: Ultrasound

1. Introduction

Cranial ultrasound is affordable, easy to perform and can be done at the patient's bedside. As it is an operator dependent investigation there is the possibility of differences in terms of findings and report quality. Referring clinicians rely on the radiology report for diagnosis and to assist in guiding further care and management. Reports therefore need to be adequately written and to specifically answer the questions raised by the clinician.

2.Literature review

Radiologists and radiographers commonly deal with inadequately completed radiology request form. Furthermore inadequate completion of a radiology request form risks both medical and legal consequences and can affect the quality of service rendered by the radiology department (1). In addition stating the reason for requesting the radiology study assists the radiologist to understand the clinical issues to be addressed by the radiology investigation (1) .

According to a study by De Filipo *et al*, the lack of a clinical question in a radiology request form limits the capability of the radiologist to produce a good report (2). Similarly the radiology report is an important, and in most cases, the only means of communicating with the referring doctor therefore it is important for the radiologist to write reports that clearly answer the clinical questions posed. Reports should include measurements and their significance. Normal ranges should also be mentioned. Reports with a conclusion and further recommendations regarding treatment or imaging add greater value to the referring clinician (3).

According to Poole and Goergen, the quality of the radiology reports has a direct influence on the safety and relevance of the decisions made regarding patient treatment and future investigations. The study participants in this study preferred reports that had structured and itemized format (4).

Often radiology trainees are not given templates or taught how to write reports but instead pick up report writing skills from their peers or seniors (5) .This often leads to incomplete or inadequate reports. Poor referrals and patient history also results in the generation of inadequate reports. This therefore highlights the need for better communication between clinicians and radiologists (2).

Cranial ultrasound abnormalities in low birth weight infants are the strongest indicators of cerebral palsy. A study by Pinto-Martin *et al* showed that enlarged ventricles, germinal matrix hemorrhage and echodensities in the brain parenchyma were associated with development of cerebral palsy. The presence or absence of the above should be included in all reports to assist in determining patient prognosis.

1.1. Evolution of ultrasound

There has been a vast improvement in sonographic imaging quality, cranial sonar technique as well as improvements in the equipment since the first ultrasound assessment of the cranium in 1995 (4). New techniques include the use of multiple fontanels as acoustic window, colour and spectral Doppler. These improvements have made ultrasound a highly accurate method for paediatric cranial assessment. In addition

to assessing brain structures, Doppler techniques have made it possible to measure resistive index, peak systolic and end diastolic velocities in different vessels. Cranial Ultrasound also poses no risk of radiation to the patients compared to other forms of radiological imaging (6).

1.2. Cranial ultrasound technique

Ultrasound is performed with a multi-frequency transducer of five to ten MHz for good resolution (7) . The technique of performing cranial ultrasound involves access through the anterior fontanel using the coronal and sagittal planes and then turning the transducer 90 degrees between coronal and sagittal for more images in the sagittal and parasagittal planes (8). To obtain images of the posterior fossa the mastoid fontanel can be used (6).

Combination of different acoustic windows e.g. mastoid, anterior and posterior fontanel can improve visualization of intraventricular haemorrhage, posterior fossa disorders and congenital malformations. (7).

1.3. Radiology reporting

The radiology report should include appropriate clinical information, findings and a conclusion (2). Most clinicians appreciate a radiology report that describes findings and provides a conclusion. The priority should be to address the requests and questions posed by the referring doctor (9). Guidelines set by the American College of Radiology (ACR) for general reporting still raised questions regarding what extra information is needed to be included in the report. Clarity is required if a report should mention findings that are

regarded as normal and whether one should go into detail in terms of description of findings (5). The ACR guidelines stressed that radiology reports must be short, clear, and relevant to the request. A study by Noumeir *et al* showed that referring clinicians prefer structured reports because they are simpler and quicker to read (10) . A radiology white paper on management of radiology report templates reports that radiologists using templates are more efficient than those not using them(11).

The radiology request form is an important instrument of communication utilized by hospitals and clinicians to refer patients for radiology investigations. Their value is often disregarded and they are in most cases not completed adequately. Satisfactory completion of these forms helps the radiologist to avoid misinterpretation of the patient's information and assist in patient management. The Royal college of Radiologists guidelines in terms of requests forms requires that they should be completed with accuracy and be legible and the reason for the request should be stated (12).

There is an increase in the rate of inappropriate radiology requests with most request forms lacking the clinical question and required clinical information. The clinician must also justify the requested radiology investigation. If investigations were done previously, they must also be mentioned in the request (2).

Cook *et al* states that the information given on request forms can determine the level of excellence in the radiology unit. Jumah et al evaluated 4122 requests and found that the patient 's age was the most omitted information (13).

The following are components that should be included in the cranial ultrasound report: ventricles size / hydrocephalus, presence or absence of corpus callosum, germinal matrix haemorrhage, periventricular leukomalacia, cerebellum, surface sulci, resistive index and vascular pulsations. Ventricles should not measure more than 10 mm when measured in the transverse diameter of the frontal horns. Of note is that the patient ‘s position influences the size of the ventricles .The lateral ventricle on the dependant side when patient is lying on his side is smaller than the one on the up side. (6).

Common pathologies in paediatrics that can be diagnosed on cranial ultrasound include: subependymal intraventricular hemorrhage, periventricular leukomalacia, hydrocephalus and the absence of the corpus callosum. Subependymal intraventricular hemorrhage is considered the commonest hemorrhagic pathology in premature babies. Babies mostly at risk are those born younger than 32 weeks gestation and smaller than 1.5 kg of birth weight. Hemorrhage commonly occurs in the region of the caudothalamic groove (14) .

The following classification is used to grade germinal matrix hemorrhage:

- Grade I - confined to the germinal matrix
- Grade II - extension into normal sized ventricles
- Grade III - extension into ventricles with hydrocephalus
- Grade IV - involves grade III with parenchymal hemorrhage (15).

The prognosis for Grade I and II is better compared to grade III and IV. Poor outcomes in premature babies with grade III and IV germinal matrix hemorrhage include hydrocephalus, death and neurological impairment (16).

Periventricular leukomalacia is a form of brain injury in premature infants. It occurs in the periventricular white matter. Cranial ultrasound findings of periventricular leukomalacia are periventricular echodensities or cysts. It is a vital cause of mortality and morbidity in preterm infants therefore cranial ultrasound is helpful in follow up studies of this condition (16).

Resistive index (RI) is calculated as peak systolic velocity minus end diastolic velocity divided by systolic velocity (6). It evaluates alterations in the flow of blood within the brain. Acceptable values in premature and term babies are between 0.77 and 0.75. Values that are lower than this may suggest ischemia or hypoxia. Values higher than this may be suggestive of cerebral oedema(6). Resistive index is affected by the volume of blood, congenital heart abnormalities, peripheral vascular resistance and velocity of flow.(17).

1.4. Study objectives

1. To determine the quality and adequacy of cranial ultrasound reports at Charlotte Maxeke Johannesburg Academic and Rahima Moosa Mother and Child hospitals.
2. To determine the adequacy of the requests for cranial ultrasound

2. Materials and Methods

2.1 Study design

A retrospective review of cranial ultrasound requests and reports was performed at two academic training centres.

2.2 Study setting

Cranial ultrasound reports reviewed were from Rahima Moosa Mother and Child and Charlotte Maxeke Johannesburg Academic hospitals.

2.3 Study sample

Reports of all the cranial ultrasounds of paediatric patients with age as stated on request form done by radiologists between January 2008 and June 2014 were reviewed.

2.4 Methods

Cranial ultrasound reports were retrieved from the two hospitals archived records. The principal investigator read all cranial ultrasound reports. A data collection sheet (Appendix B) was developed by the principal investigator and supervisor guided by literature with regards to the information that needs to be assessed when performing a cranial ultrasound. Prognostic, diagnostic and management indicators were used to develop the data collection sheet.

The following data was collected to assess adequacy of the cranial ultrasound requests:

1. Appropriateness of request included age of patient. Patients less than the age of eighteen months were considered to be of the appropriate age for request.
2. Indications included: premature infants, requests to exclude intraventricular hemorrhage or pathology, history of seizures, birth asphyxia and increase in head circumference.

The assessed components (see Appendix B-Data collection sheet) were given a score of 1 if mentioned and 0 if not mentioned.

Images were not reviewed for diagnostic accuracy. The scores were entered into an Excel data sheet. The scores were compared, to assess if there is a difference in reporting quality between different ranks of radiology trainees. The (registrars) trainees were categorized as: Junior level registrars- 1 to 30 months and senior level registrars-31 months and above. The reports were assessed for presence of a conclusion and whether the clinician's question was answered.

2.4 Inclusion criteria

All Cranial ultrasound requests and reports of both male and female paediatric patients with age as stated on the request form.

2.5 Exclusion criteria

Trauma related requests were excluded from the study. Illegible reports were excluded. Requests for repeat cranial ultrasound, irrespective of the indication were not considered for the study.

2.6 Data collection

Data was collected from the cranial ultrasound requests and report forms retrieved from the archives of the two hospitals. Information from the reports was scored against a data collection sheet Data included the mention of hydrocephalus, germinal matrix haemorrhage, presence of corpus callosum, comments on the surface sulci, cerebellum, vascular pulsations, resistive index, periventricular leukomalacia, presence of a conclusion, whether the clinician ‘s question was answered, adequate further referral and whether the request was appropriate.

The appropriateness of the requests were assessed by using the following indications: age less than 18 months premature infant, increase in head circumference, presence of seizures, inability to do a CT scan due to patient being unstable and/or a request to exclude intracranial pathology.

2.7 Statistical analysis

STATA 13 (Data Analysis and Statistical Software) was used to investigate the adequacy of cranial ultrasound reports and requests. A one-way Anova test was used to investigate the difference in the mean score of the quality of reports between different ranks of

radiology trainees. Results were demonstrated as percentages and frequencies for categorical variables. Mean and standard deviation were also calculated with P values of < 0.05 considered significant. The Pearson coefficient of correlation was used to calculate the relationship between the total report adequacy and total request adequacy scores. A T-test (18) was used to evaluate whether the mean across the different components assessed was statistically significantly different.

2.8 Scoring system

The components that should be included in the cranial ultrasound report were assessed using Appendix B. For assessment of the reports adequacy, a score of one (1) was given if the component was mentioned and zero (0) if not mentioned. Two (2) points were given if further suggestion regarding management was provided, and 2 points if the clinical question was answered. The adequacy of the reports was graded using a possible maximum score of 14. The score is 14 and not 16 because although the reports mentioned the presence or absence of periventricular leukomalacia and germinal matrix haemorrhage, not all of them were positive for this finding to receive a grading. The points for the grading were calculated separately. In addition an extra point was given for answering the clinical question and extra point for further suggestion regarding management giving a total of 14.

Adequacy of the requests was assessed using the following 3 components:

1. Is the request adequate as evidenced by the following indications: age less than 18 months or, a request to exclude intracranial pathology, patient presenting with

seizures, increasing head circumference, and unstable patient therefore unable to do CT scan.

2. Presence of history or clinical information.
3. Presence of a clinical question.

The ultrasound requests adequacy scores were also graded in three grades, poor (score 0-1), average (score 2) and above - average (score 3).

2.9 Ethics

Ethics approval was obtained from the Human research and ethics committee (HREC) at the University of the Witwatersrand, clearance certificate number M140730 (Appendix A)

3. Results

A total of 197 cranial ultrasound reports and requests were retrieved from hospital records over six years. Six reports were excluded due to illegibility (no operator name or handwriting not readable). This resulted in a sample size of 191 patients.

A) Age

Age was not normally distributed due to the spread of the age range. The age range was 1 to 330 days old. The median age was 39 days with an interquartile range of 14 to 90 (76). Most of the participants were below the age of 150 days and more than 70% of the study population ‘s age was far from the mean of 60 days. Age was not recorded in 8 (4%) of the

request forms. Figure 1 below demonstrates the distribution of age of the study population.

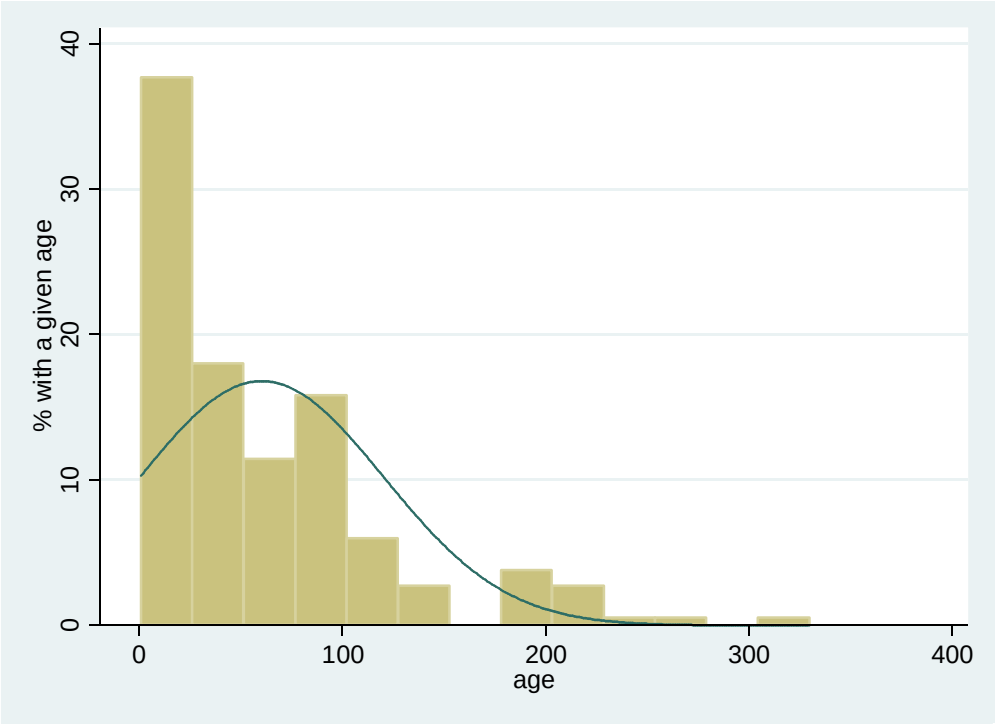


Figure 1: Age distribution (in days) of the study population

B) Gender

The gender of the study population was recorded as follows: 41.88% male and 38.22% female patients. Gender was not recorded in 38/191 (19,90%) of the reports. The study demographics are shown in Table 1.

Table 1: Study demographics

Study population (n)	191	
Gender	Males	80/191
		41.88%
	Females	73/191
		38.22%
	Unrecorded	38/191
		19.90%
Age range	1-330 days old	
Median age	39 days	
Interquartile range	76	
Mean	60	
Standard Deviation	60	

3.1 Analysis of the Requests

3.1.1 Request adequacy score

The study demonstrated that 2/191 (1.05%) cranial ultrasound requests scored 0 out of 3, 7 scored 1, 87/191 (45.55%) scored 2 (the average score) and 95/191 (49.74%) requests scored the maximum 3 points of 3. The two requests scored 0 out of 3 because clinical history, clinical question and patient age were not stated on the form. Clinical information or history was not recorded in 11/191 (5.76%) of the request forms. There was no clinical question in 91 /191 (47.64%) of the request forms.

The mean request adequacy scores are shown in table 2 below and summarized in figure 2.

Table 2: Requests adequacy scores

Request adequacy score	Number of forms and percentage
0	2 (1.05%)
1	7 (3.66%)
2	87 (45.55%)
3	95 (49.74%)

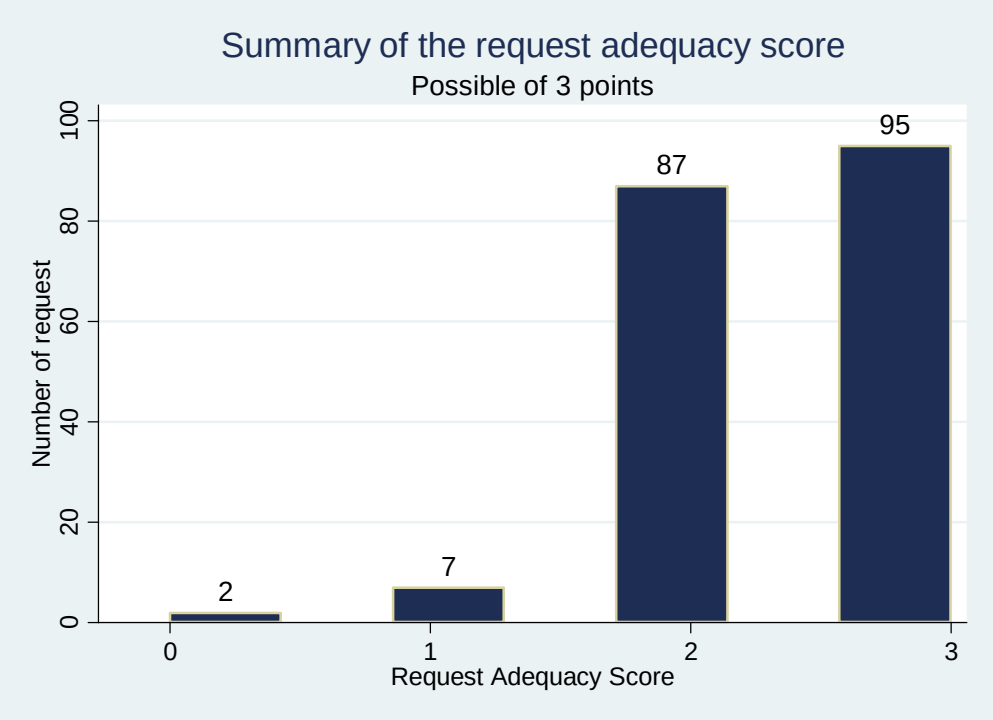


Figure 2: A Summary of the Request Adequacy Scores

The US requests adequacy scores were also graded into three grades, poor (score 0-1), average (score of 2) and above- average (score of 3). Figure 3 below demonstrates the grading of the ultrasound requests.

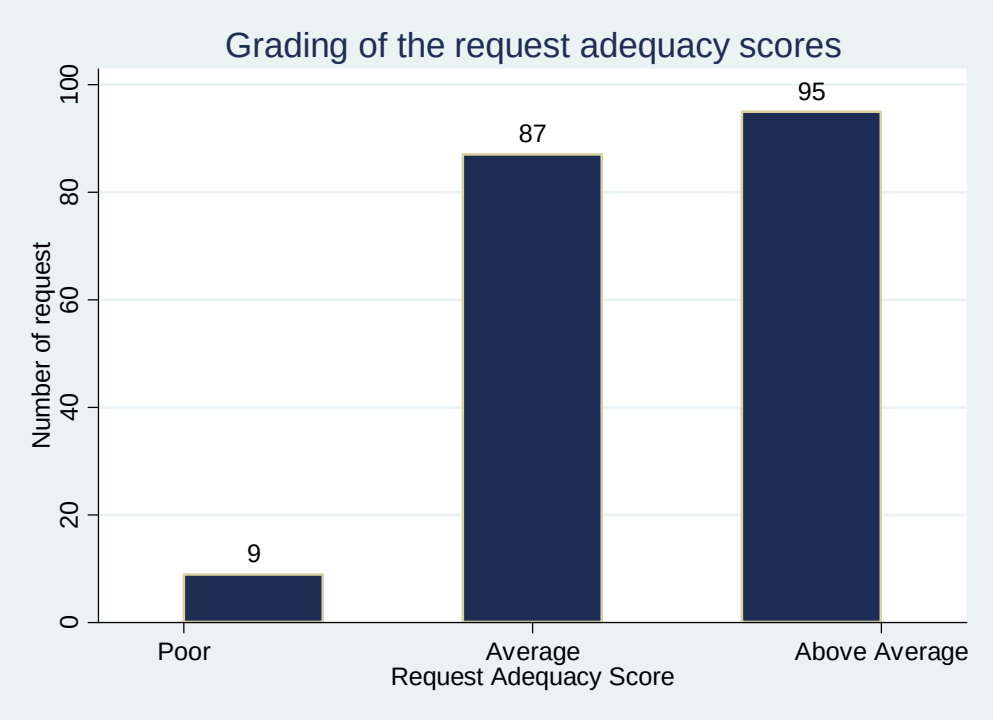


Figure 3: Grading of the ultrasound request scores

3.1.2 Distribution of reports by rank of cranial ultrasound operators

A total of 113 junior registrars (1 to 30 months of training), 51 senior registrars (31 months and above) and 27 specialist radiologists authored the cranial ultrasound reports as illustrated in figure 4 and table 3 below. Junior registrars performed the majority of the cranial ultrasounds.

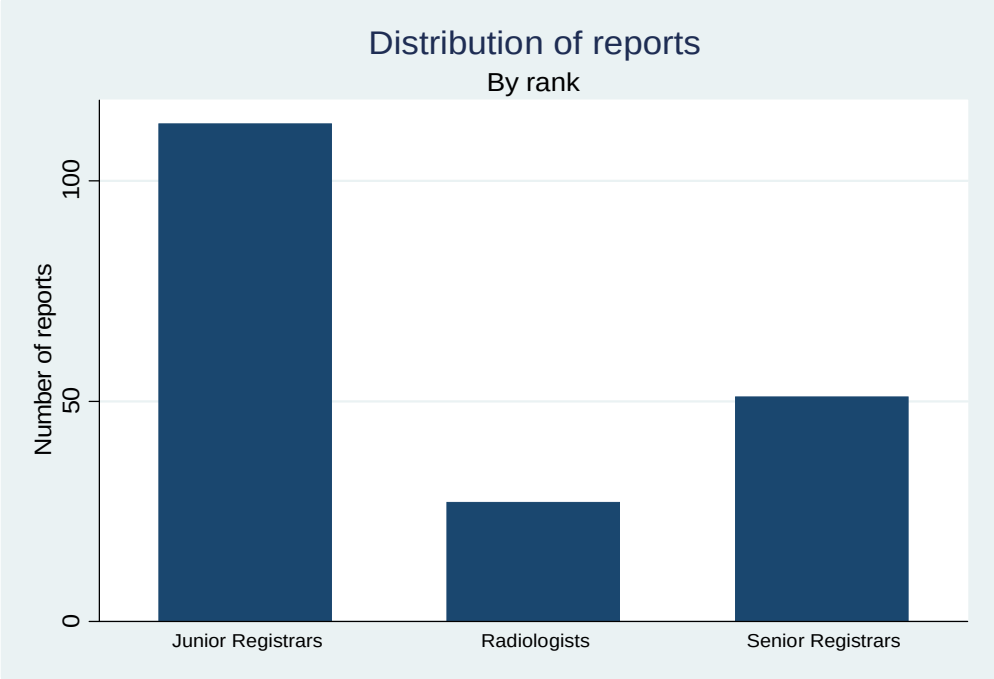


Figure 4: Diagram demonstrating the distribution of reports by rank

Table 3: The number of reports written by different ranks

Group	Junior Registrars	Senior Registrars	Specialist radiologist	Total
Number of forms	113 (59.1%)	51(26.7%)	27(14.1)	191

3.1.3 Analysis of the reports

A) Reported variables

The majority of reports mentioned the presence or absence of hydrocephalus or the state of the ventricles; this was mentioned in 174 out of 191 (91.10%) of the reports. The presence or absence of germinal matrix haemorrhage was mentioned in 82.72 % of the reports (158/191) and the presence or absence of the corpus callosum was stated in 127 of the 191 (66.49 %) reports. The least reported variables were the resistive index and choroid plexus. They were only mentioned in 9 out of the 191 reports (4.71%) and 22 out of 191 reports (11.58%) respectively. The table 4 demonstrates the percentage of reported components.

Table 4: Reported variables with percentages

Characteristics	Total (N=191)	
		Percentage (%)
Surface sulci	60/191	31.41
Corpus callosum	127/191	66.49
Choroid plexus	22/191	11.52
Resistive Index	9/191	4.71
Vascular pulsation	44/191	23.04
Ventricles	174/191	91.10
Cerebellum	126/191	65.97
Germinal matrix hemorrhage	158/191	82.72
Periventricular leukomalacia	95/191	49.74
Conclusion	191/191	100.00
Clinical question answered	92/191	48.17
Further management suggestions	32/191	16.75

B) Analysis of the Report Adequacy Score

The report adequacy score was rated out of a possible maximum score of 14.The score is 14 and not 16 because although the reports mentioned the presence or absence of periventricular leukomalacia and germinal matrix haemorrhage, not all of them were positive for this finding to receive a grading which is an additional one point each. The points for the grading were calculated separately.

The overall mean adequacy score was 6.81 for the junior registrars compared to a score of 7.03 by the senior registrars. The P value was 0.39. The mean adequacy score of different ranks is illustrated in table 5 and figure 5.

Table 5: The mean Report Adequacy Score achieved by various operators for the US Reports.

Rank of reporter	Mean (SD)	P-values
Specialist Radiologist	6.44 (2.28)	
Junior registrar	6.81 (2.02)	0.39**
Senior Registrars	7.03 (2.02)	

: t-test used unless otherwise indicated. *** One-way anova

The mean reports adequacy scores by rank of operators is shown in figure 5.

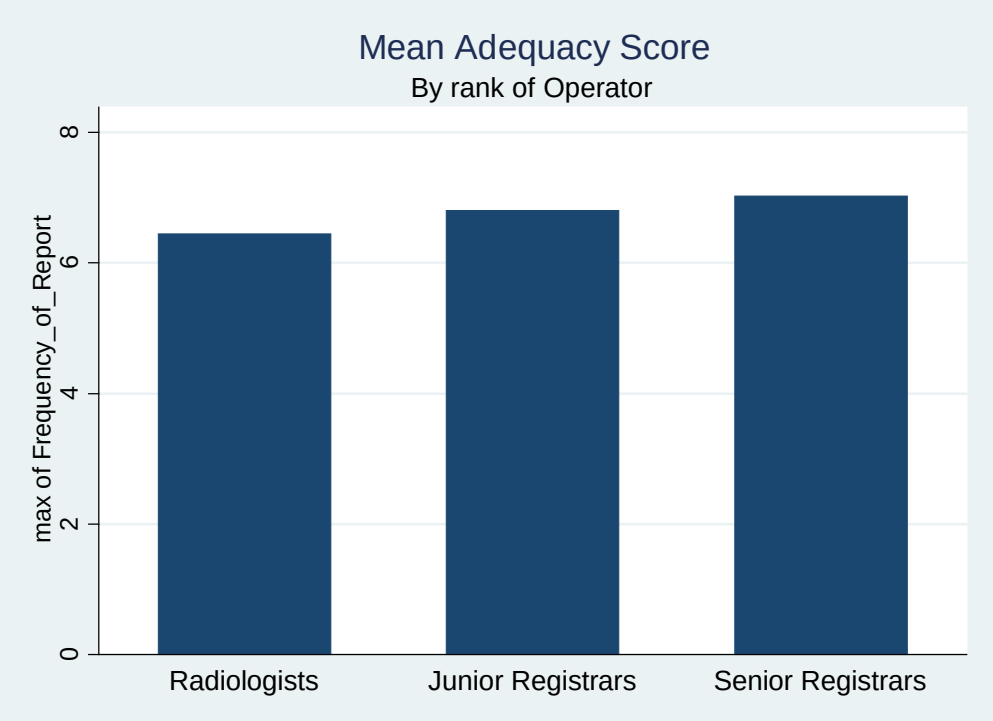


Figure 5: Mean report adequacy score by rank of operator

The one –way anova test was used to investigate the difference in the mean score of the quality of reports between different ranks of radiology registrars (trainees). ANOVA (the one way analysis of variance test) is a test used to measure whether there is a notable difference between the means of three or more unrelated groups. The study demonstrated that there was no statistical difference in the quality of reports between different ranks of radiology as demonstrated by the P-value of 0.39.

The report adequacy scores were graded into three grades as follows: poor (score of 0-6), average (score of 7 to 9) and above- average (score of 10 to 14). Figure 6 below shows the grading of the report adequacy scores.

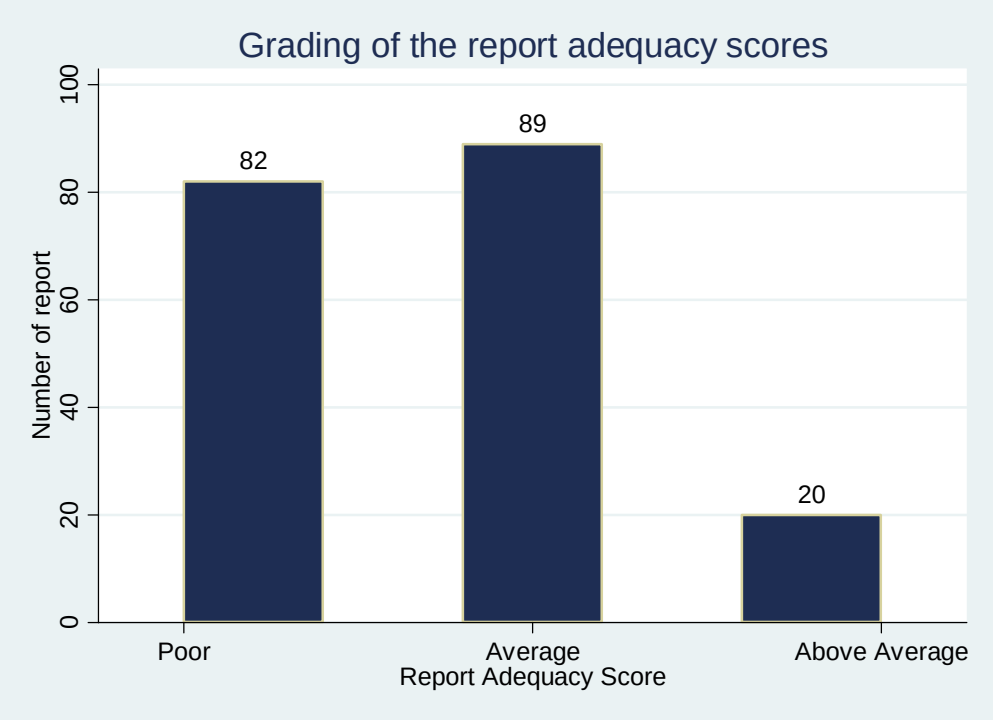


Figure 6: Grading of the Report Adequacy Scores

A comparison of the mean and P values of the components that were repeorted on was made. The statistically significant P value of the adequacy scores between reported and unreported variables showed that if a component on the data collection sheet was reported, the adequacy score was high compared to if it was not reported. The difference in the mean and P values of various variables is compared in table 6.

Table 6: Comparison between the mean and P values of reported versus unreported components

Variables	Mean (SD)	P-values
Unreported Surface sulci (mean, SD)	6.27 (1.83)	0.001
Reported Surface sulci (mean, SD)	8.22 (1.90)	
Unreported Corpus callosum (mean, SD)	5.63 (1.92)	0.001
Reported Corpus callosum (mean, SD)	7.52 (1.82)	
Unreported Choroid plexus (mean, SD)	6.74 (2.09)	0.009
Reported Choroid plexus (mean, SD)	7.95 (1.43)	
Unreported Resistive Index (mean, SD)	6.75 (1.99)	0.001
Reported Resistive Index (mean, SD)	9.67 (1.32)	
Unreported Vascular pulsation (mean, SD)	6.29 (1.82)	0.001
Reported Vascular pulsation (mean, SD)	8.89 (1.45)	
Unreported Ventricles (mean, SD)	5.82 (1.29)	0.001
Reported Ventricles (mean, SD)	6.99 (2.09)	
Unreported Cerebellum (mean, SD)	6.02 (1.87)	0.001
Reported Cerebellum (mean, SD)	7.33 (2.01)	
Unreported Germinal matrix hemorrhage (mean, SD)	5.15 (1.98)	0.001
Reported Germinal matrix hemorrhage (mean, SD)	7.25 (1.88)	
Unreported Periventricular leukomalacia (mean, SD)	5.80 (1.74)	0.001
Reported Periventricular leukomalacia (mean, SD)	7.98 (1.76)	
No clinical question to answer (mean, SD)	6.05 (1.95)	0.001**
No clinical question answered (mean, SD)	5.86 (.121)	
Clinical question answered (mean, SD)	7.79 (1.82)	
No Further management suggestions required (mean, SD)	6.29 (1.94)	0.001**
No Further management suggestions given (mean, SD)	7.17 (1.91)	
Further management suggestions given (mean, SD)	8.38 (1.83)	

Note: t-test used unless otherwise indicated.

*** one-way anova

C) Relationship of total report score and clinical history being provided

A T-test (a statistical investigation of 2 population means) (18) was used to assess if the mean between the total report score was different if clinical history and clinical question were provided on the request forms.

The study demonstrated that the total report score was higher at 6.98 when clinical history was provided in the requests forms compared to 5.27 when clinical history was not provided. This was statistically significant. Figure 7 shows the total report scores by clinical history present.

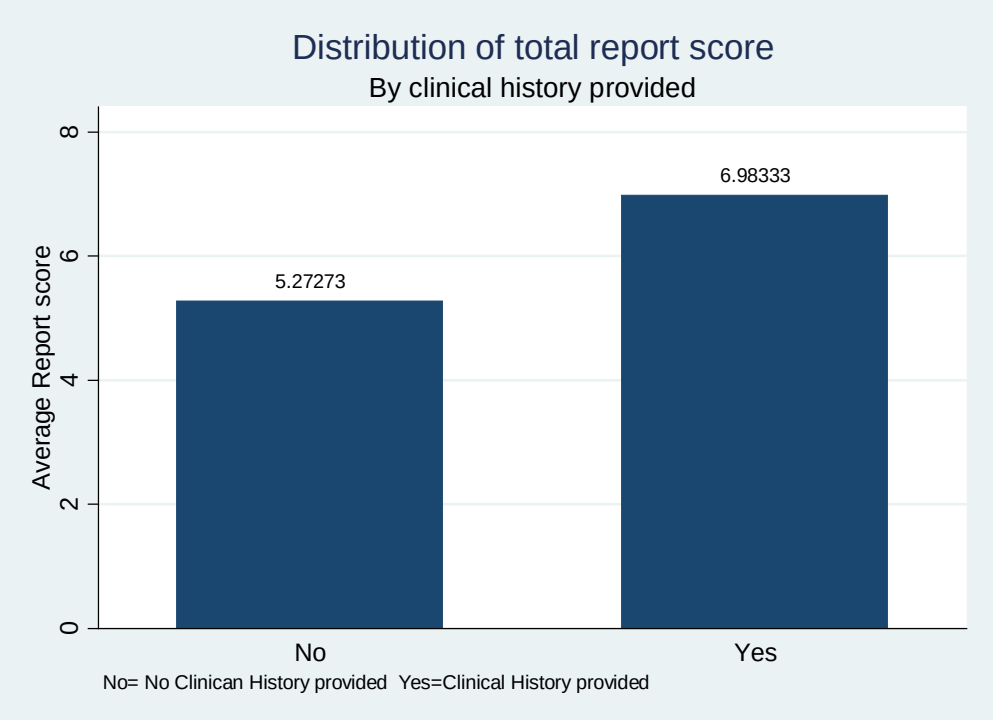


Figure 7: Total Report Score by Clinical history provided

D) Relationship of total report score and clinical question being present

The study also showed that the score was higher at 7.26 when clinical question was provided compared to 6.47 when clinical question was not provided. This was statistically significant. Figure 8 shows the total report scores by clinical question present.

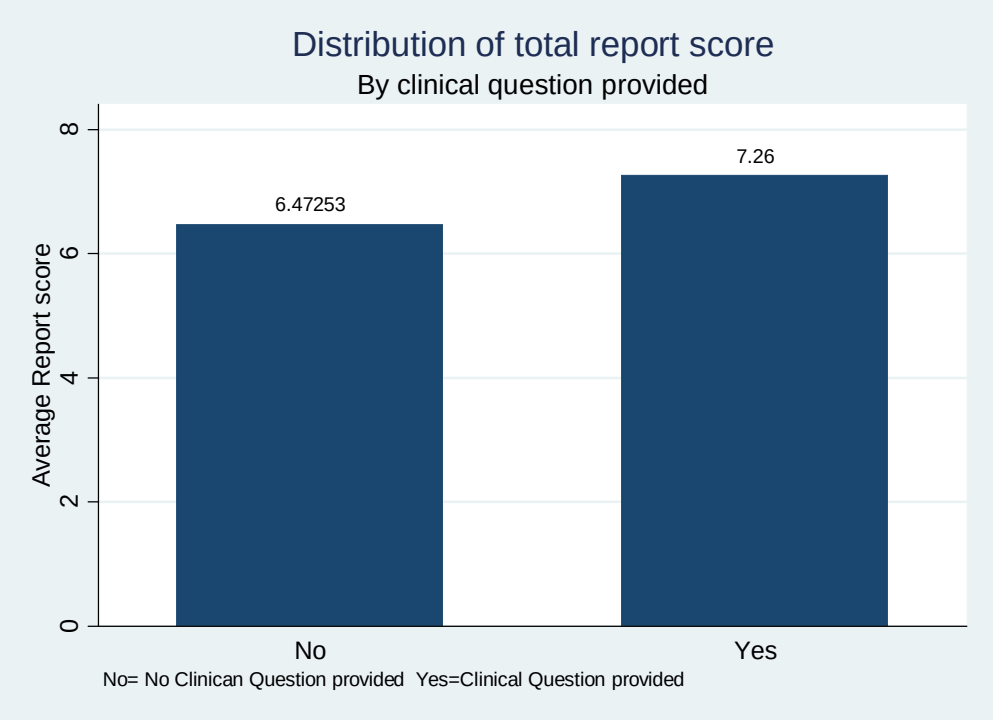


Figure 8: Total Report Score by clinical question present

E) Analysis of the assessment or conclusion

All the reports in the study had a conclusion.

F) Suggestions regarding further management

The percentage of reports that gave suggestions regarding further management and investigations to clinicians based on their cranial sonar findings amounted to 32/191 (16.75 %) with the mean of 8.38 and P value of 0.001, which was statistically significant. There were 110/191 normal cranial ultrasounds that did not require suggestions regarding further management.

G) Specific comments

Out of 191 reports, 13 were positive for germinal matrix hemorrhage and 12 out of the 13 reports graded the haemorrhage. Five of the 191 reports were positive for periventricular leukomalacia but none of the 5 reports graded it. The commonest indication for the ultrasound was to exclude intracranial pathology at 27.2%. (52 request)

Of note is that the basis of this research was to assess that the reports noted the presence of components to be assessed for pathology not to confirm if pathology was present or not. None of the operators scored the maximum 14 points hence not reflected in figure 9 below. The total report adequacy scores are shown in figure 9.

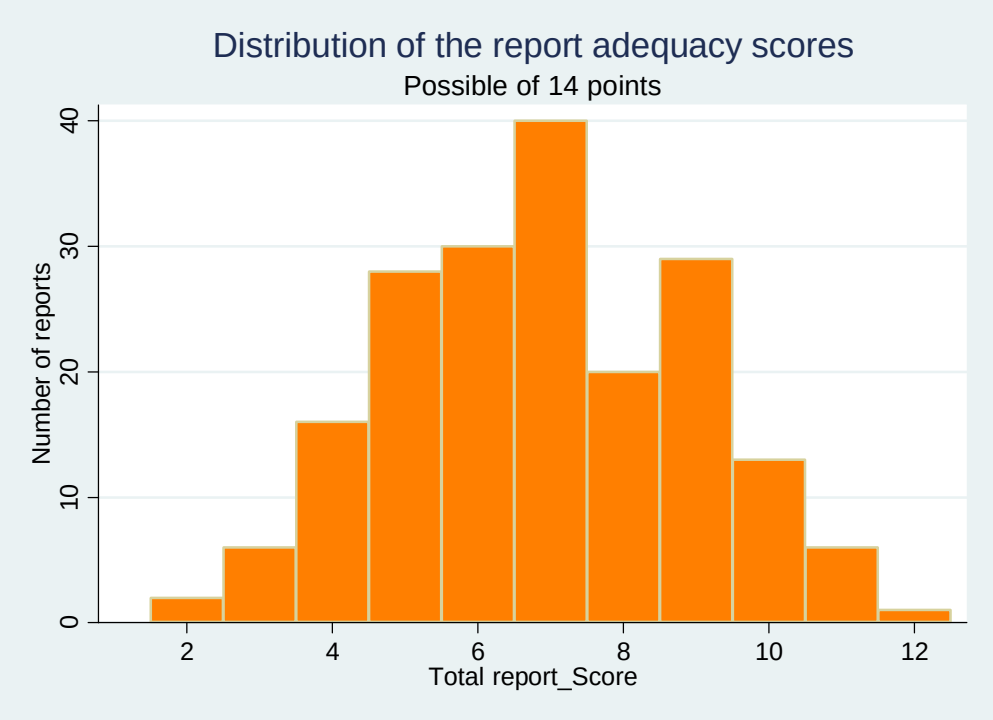


Figure 9: Total Report adequacy scores

H) Correlation between report and request adequacy scores

Comparison between the report and request adequacy was tested using Pearson coefficient of correlation. The Pearson coefficient is a statistical measure of the strength of a linear association between two variables. If the association is not linear the correlation coefficient does not sufficiently represent the extend of the relationship between the variables (19) .This was represented using a quantile quantile plot (a probability plot which is represented in a graph to contrast distributions by plotting their quantiles against each other).

The Pearson coefficient of correlation in this study of 0.3359 indicates a weak positive relationship between the request adequacy score and the reports adequacy score. This

suggests that the increase in report scores is less proportional to the increase in request score, meaning that for the report score to increase one needs to increase the request adequacy score (better requests, better reports).

Figure 10 below, shows the relationship between total requests and reports adequacy scores.

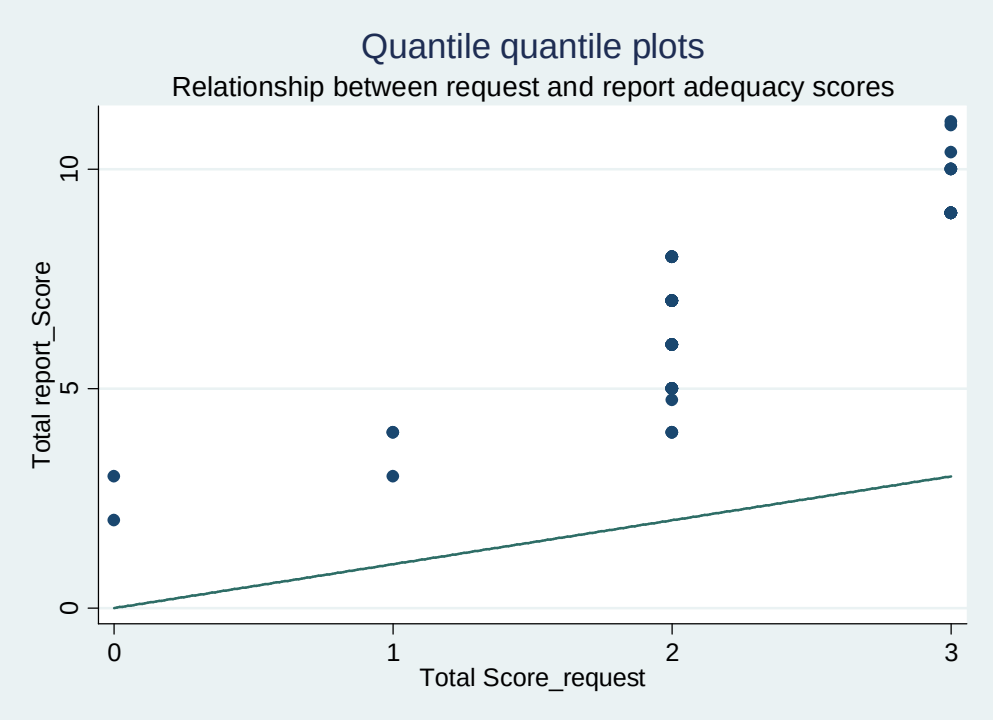


Figure 10: Quantile quantile plot demonstrating relationship between request and report adequacy scores

4. Discussion

Cranial ultrasound is a non-invasive low cost method of assessing pathology in paediatric

patients. It is often requested for very sick paediatric or neonatal patients therefore it is important that reports are comprehensive and of assistance to the clinicians.

The point of our project was to evaluate the adequacy of cranial ultrasound reports and requests at the two hospitals .To come up with an answer to our question we developed a tick sheet from current literature that was used to assess components that should be included in the cranial ultrasound report. There has not been much specific literature with regards to the adequacy of cranial ultrasound reports and requests therefore comparison with the rest of the world proved to be difficult.

Often requests from clinicians are illegible and may not contain important information like clinical information, clinical question, and indication for the study. In the same breath radiology reports may be inadequately reported, therefore unhelpful to the referring clinician. Our study demonstrated that most of the reports did not have complete information.

A study by Afolabi *et al* states that radiology requests forms are an important form of communication with the clinicians (20). The referring doctor is required to provide the indication for study in order for the radiologist to be better informed of the patient's condition, in turn be able to provide the appropriate investigation. Furthermore radiology request forms should provide the clinical information about the patient. This study demonstrated that inappropriate requests yield inappropriate studies (20).

4.1 Appropriateness of the Request

Cook *et al* conducted a pilot study to audit the quality of the reports leaving their radiology department and the appropriateness of the requests received from clinicians. This study demonstrated that the information given to the radiology department when requesting an investigation is one of the determinants of excellence in that department (13).

A) Patient Age and gender

The age range in our study was 1 to 330 days with average age of 39 days. Standard Deviation for age was 60 with the mean of 60 however it cannot be reported because age was not normally distributed. Only the interquartile range and the median were reported. In a study by Afolabi *et al* 202 request forms were assessed. Patients age were not completed correctly in 101 (50%) and not recorded in 12(5.9%) of the requests forms and 8 of the request forms did not record patient gender (20). This was echoed in our study with gender not recorded in 38/191 reports and age not recorded in 8 request forms.

B) Presence or absence of Clinical information or history

A study by Irurhe *et al* demonstrated that 13% (39/300) left the clinical history component in the request forms blank (21). This was also demonstrated in our study with inadequate request information being provided or inadequate completion of the request forms. Our study showed that clinical information/history was not recorded in 11/191 (5.76%) of the request forms. In the study by Afolabi *et al* there was no clinical information in 10.4 % of the requests forms and only 131(64.9) completed the clinical information adequately (20).

This poses a difficulty for the reporting radiologist when attempting to answer the clinical question and matching presenting history and examination to the study findings. It also poses a difficulty in suggesting further investigations, and patients can be exposed to unnecessary and expensive investigations.

Studies have demonstrated that inadequate requests yield inadequate reports therefore it is imperative that the requesting clinicians supply adequate clinical information.

C) Presence or Absence of a Clinical question

In our study 91 /191 (47.64%) had no clinical question recorded on the request forms and 100 (52,35 %) request forms provided a clinical question. A study by Oswal *et al* demonstrated that 17 % of the 400 request forms studied did not record the clinical question that needed to be answered (1). De Filipo *et al* conducted a study that evaluated the relevance of 500 radiology request forms and their reports. This study demonstrated that 110 out of the 500 (22%) of the request forms did not record a clinical question (2). This is important because when clinicians request investigations, they do so with a question in mind and the answer that the radiology department provides can assist them in narrowing their differential diagnosis.

Oswal *et al* demonstrated that 138 out of 500 (27.6 %) of the request forms did not fulfil a criteria for an appropriate request (1). In our study only 95/191 (49.74%) fulfilled the criteria for an appropriate request.

4.2 Adequacy of the Reports

A) The most reported components

The state of the ventricles was the most mentioned variable, stated in 91% (174/191) of the reports. This is a very important variable because when diagnosis is made it can explain patient symptoms and treatment can provide relief of those symptoms. The presence of germinal matrix hemorrhage was also the most reported variable mentioned in 158/191 (82 %) of the reports. This is very important when it comes to litigation. Parents and clinicians often want to know who was negligent when patients present with birth asphyxia. The appropriateness of the requests in terms of clinical information and question also becomes relevant when one has to account when questions arise regarding possible causes that is intrapartum versus post partum.

B) Answer to the clinical question or is the clinicians question answered?

In our study 100/191 (52,35%) requests had a clinical question and 92/100 (48.17%) of the reports answered this question with a statistically significant P value of 0.001. De Filippo *et al* also demonstrated this in a study where 362 requests had an appropriate clinical question and 22 were not given a clear answer by radiology (2).

Out of the 362 requests, 285 met the criteria for appropriate requests and of these 47.85% (135 /285) reports confirmed the suspected pathology (2). Confirming or refuting suspected pathology that the clinicians are concerned about is a very helpful finding to the clinicians.

C) Suggestions regarding further investigations

De Filipo e*t al* demonstrated that the radiologist did not report or suggest further investigations in 60 % of the reports written in their study (2), compared to our study

where 81(43%) reports needed further suggestions to be given but only 32 reports (16.75%) gave suggestions regarding further investigations or management.

This is a very important omission because it can guide the clinician in terms of management of patients and reduce unnecessary and expensive investigations. Suggestions regarding further investigations or management also serve to reduce hospital stay and expenses. There were 110/191 normal cranial ultrasounds that did not require suggestions regarding further management.

C) Presence of an assessment or conclusion

A succinct conclusion is an important part of the radiology report and it might be the only portion that referring clinicians read therefore it must be comprehensive and summarise the study. In the study by De Filipo *et al* a conclusion was mentioned in 9% of the reports (2) compared to our study where 100 % (191/191)of the reports had a conclusion or assessment. This was a positive finding in our study.

Slovis *et al* showed that abnormalities of the ventricular and paraventricular system results in 12 patients detected by ultrasound were reproducible by CT scan with findings such as holoprosencephaly, arachnoid cysts and posterior fossa cysts. This confirms that cranial ultrasound is as adequate as CT scan or MRI in identifying pathology. Therefore it is important to write reports properly so that studies are not ordered unnecessarily especially in sick neonates that will prove difficult to transport to the Radiology department.

There was a weak positive relationship between the request adequacy scores and report adequacy scores. This illustrated that in order to produce good reports, clinicians needed to write good requests.

The tables below compare previous literature with the current study. There was no one literature that investigated all the components in our study hence the tables are spread out for different components that were evaluated in each different study.

Table 7: Comparison of reviewed previous literature with the current study with regards to appropriateness of the requests

Topic	Compliance rate of Adequate Filling of Radiology Request Forms in a Lagos University Teaching Hospital	Audit of Completion of radiology Request Form in a Nigerian Specialist hospital	Current study
Year of Publication	2012	2012	Not yet published
Study Type	Retrospective	Retrospective review	Retrospective
Country	Lagos Nigeria	Nigeria	South Africa
Study Population	300	202	191
Age not noted in the requests	6/300 (2%)	12/202 (5.9%)	8/191 (4.2%)
Gender not noted in the requests	1/300 (0.3%)	8/202 (4%)	38/191 (20%)
No Clinical history present	39/300 (13%)	21/202 (10.4%)	11/191 (5.76%)

Table 7.1: Comparison of reviewed previous literature with the current study with regards to appropriateness of the requests

Topic	Critical Issues In Radiology Requests and Reports	Current study
Year of Publication	2011	Not yet published
Study Type	Retrospective	Retrospective
Country	Italy	South Africa
Study Population	500	191
No Clinical question present	110/500 (22%)	91/191 (47.64%)

Table 7.2: Comparison of reviewed previous literature with the current study with regards to completeness of the reports

Topic	Critical Issues In Radiology Requests and Reports	Current study
Year of Publication	2011	Not yet published
Study Type	Retrospective	Retrospective
Country	Italy	South Africa
Study Population	500	191
Presence of a Conclusion	49/500 (9.48%)	191/191 (100%)

Table 7.3: Comparison of reviewed previous literature with the current study with regards to completeness of the reports

Topic of study	Critical Issues In Radiology Request and Reports	Current study
Further suggestions given regarding management or investigations	37/75 (49.3%)	32/191 (16.75%)

4.3 Current applications

A reporting template was designed to assist in more accurate and relevant reporting. This will results in ease of reporting. See appendix C.

4.4 Limitations of the current study

The study is limited to two institutions. One at a mother and child institution where most of the studies were done after a paediatric radiologist came into the practice. This might not be representative of all the years compared to the other larger institution. Illegible reports were excluded; this could have led to good reports being excluded.

Cranial ultrasound performed by neonatologists at both centres limited the study sample. We were unable to retrieve neonatologist reports as often only a note is written in the patient file.

Not all studies are printed in the chosen hospitals due to paper not being readily available therefore images where not assessed. The study observers relied on the reports and not images to confirm that the components of the cranial ultrasound were assessed.

4.5 Future applications

A template (Appendix C) was developed to standardise reporting and for use when training registrars. Regular workshops for reporting can be conducted to train radiology trainees on the procedure and on what should be included in the report to standardize reporting.

A retrospective study can be performed to assess clinician satisfaction with radiology reports before and after the use of the reporting template and to assess whether the reports assist with decision-making and patient management.

5. Conclusion

Cranial ultrasound has the advantage of being portable hence its ability to be used in very sick paediatric patients. It also is a reliable tool and can produce accurate results in capable hands. It is also relatively cheap and easily available.

The study reveals that cranial ultrasound reports and requests in our setting are not adequate. This has been demonstrated by a low mean adequacy report score of 7.03. The results showed that only 87/191(45.55%) reports had an average score, and only 49.74% (95/191) of the requests forms scoring maximum request adequacy score of 3. A template was then designed by the principle investigator and supervisor to assist in standardizing reports and highlighting the important elements that need to be included.

We also concluded that radiology request forms at both institutions were inadequately completed. This has a major impact in the quality of service offered by the radiology department and can potentially affect management of the patient by the clinicians. Therefore the treating clinician should be encouraged to complete the request forms adequately to avoid misinterpretation of results and differential diagnosis. This can be achieved by encouraging multi-disciplinary team meetings with radiology department and continued professional /medical education of clinicians by the radiology department.

Our study demonstrated that the reports generated were inadequate. This could result in unnecessary requests for CT scans or other investigations in very sick patients who are at risk of complications when being transported out of ICU. There is an added risk of radiation exposure, which should be avoided at all costs especially in children. As radiologists we play an important role in the patient management chain. Our role is to add value therefore our reports need to communicate the findings of an investigation to the patient and the referring clinician. The radiology report is a legal, teaching and research document and must therefore be easy to understand, precise and comprehensive (22).

Appendix A: Ethics Clearance Certificate

R14/49 Dr Ntebogang Mutshutshu

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M140730

NAME: (Principal Investigator)	Dr Ntebogang Mutshutshu
DEPARTMENT:	Radiology Charlotte Maxeke Johannesburg Academic Hospital Rahima Moosa Mother and Child Hospital
PROJECT TITLE:	Determination of the Adequacy of Cranial Ultrasound Reports at Charlotte Maxeke Johannesburg Academic Hospital and Rahima Moosa Mother and Child Hospital Hospital
DATE CONSIDERED:	25/07/2014
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr Linda Hlabangana
APPROVED BY:	Professor Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	19/11/2014

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**.

Principal Investigator Signature Date 25/7/2015

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix B: Data collection sheet

STUDY NUMBER
DATE OF STUDY
GENDER
AGE

COMPONENT	YES	NO
REPORTS ADEQUACY		
SURFACE SULCI		
CORPUS CALLOSUM		
CHOROID PLEXUS		
VASCULAR PULSATIONS		
VENTRICLES/HYDROCEPHALUS		
CEREBELLUM		
RESISTIVE INDEX		
GERMINAL MATRIX HAEMORRHAGE		
IF GERMINAL MATRIX HAEMORRHAGE PRESENT ,IS IT GRADED		
PERIVENTRICULAR LEUKOMALACIA		
IF PERIVENTRICULAR LEUKOMALACIA PRESENT ,IS IT GRADED		
IS THE CLINICAL QUESTION ANSWERED		
PRESENCE OF A CONCLUSION		
SUGGESTIONS REGARDING FURTHER MANAGEMENT		
REQUESTS ADEQUACY		
IS THE REQUEST APPROPRIATE		
EVIDENCED BY THE FOLLOWING :		
AGE LESS THAN 18 MONTHS		
UNABLE TO DO CT BRAIN ,UNSTABLE PATIENT		
INDICATION AS FOLLOWS:		
PREMATURE INFANT		
TO EXCLUDE INTRACRANIAL PATHOLOGY		
INCREASED HEAD CIRMFERENCE		
SEIZURES		
IS THERE CLINICAL HISTORY		
IS THERE A CLINICAL QUESTION		

Appendix C: Cranial Ultrasound template

Department of Radiology Cranial Ultrasound Report

Patient Name:		Hospital Number:	
Date of Study		Time of Study:	
Indication:			
Radiologist:			

Surface sulci: N Abn Corpus callosum: N Abn Cerebellum: N Abn Ventricles: N Abn

Ventricular index: _____

Choroid plexus: N Abn

Germinal matrix haemorrhage: N Abn If yes, Grade: _____

Periventricular leukomalacia / cysts: N Abn If yes, Grade: _____

Vascular pulsation: N Abn

Resistive index: _____

RI = (PSV – EDV/PSV)
0.55 or less = N
0.78 = Abn

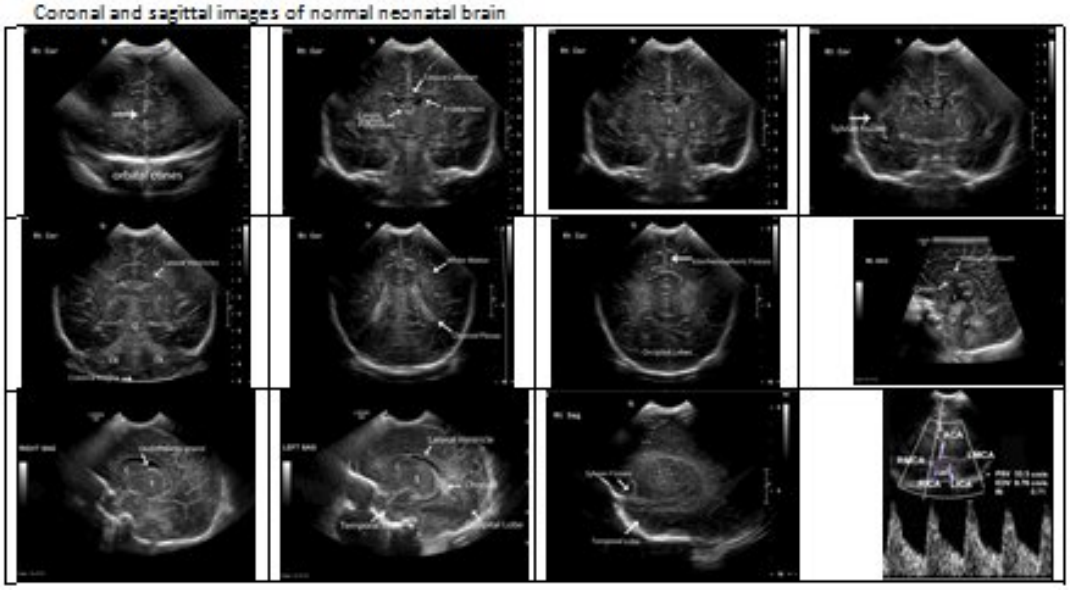
Additional information

Conclusion

Suggestions regarding management

Signature:	

Coronal and sagittal images of normal neonatal brain



Designed by: Dr P Mutshutshu and Dr L T Hlabangana (2015) Please use as a reference: Fickenscher K, Bailey Z,Saettele M,Dahl A ,Lowe L , "Pediatric Cranial Ultrasound Techniques ,Variants and Pitfalls "2012 http://www.intechopen.com/books/neuroimaging-methods/pediatric-cranial-ultrasound-techniques-variants-and-pitfalls

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