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# Evaluation of chest ultrasound reports for pleural effusions

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# EVALUATION OF CHEST ULTRASOUND REPORTS FOR PLEURAL EFFUSIONS

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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, Tshililo Trevor Nefale**,** 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 T.T. Nefale

On this 16 day of August 2016

# Dedication

I dedicate this to Fhatuwani.

Thank you for encouragement, love and support you have shown me throughout.

# Publications and presentations

This work has never been published.

Poster was presented at the Witwatersrand University Research Day in Johannesburg on 30 September 2015 and RSSA-SORSA 2015 Neuroimaging Congress in Sandton on 10 October 2015.

# Abstract

Chest ultrasound is a frequent request in patients with suspected pleural effusion and for therapeutic planning in patients with known pleural effusion. Radiology reporting of such request has to be meaningful to the referring clinician.

**AIM:** To evaluate the report adequacy of chest ultrasound reports authored by various operators, determine if there is an association between the report adequacy and the level of experience of an operator.

**METHOD:** Retrospective study of chest ultrasound reports with pleural effusion. The reports of both diagnostic ultrasound request and therapeutic ultrasound request were evaluated using a designed data collection sheet based on the literature search. Each report was awarded a score of possible maximum 4/4 for diagnostic ultrasound and 8/8 for therapeutic ultrasound.

**RESULTS:** The mean adequacy score of diagnostic ultrasound reports was 3.01 ±1.05 SD (range 0-4) and for the therapeutic ultrasound reports was 4.32 ±1.81 SD (range 1-8). The therapeutic ultrasound components were poorly reported. There were only 5% reports with a maximum score of 8/8 for therapeutic ultrasound reports. The sonographers performed better than the radiologists and the registrars but there was no statistically significant difference with regards to level of ranks and adequacy score of the report.

**CONCLUSIONS:** The current reporting of chest ultrasound is sub-standard with therapeutic ultrasound of the chest being reported more poorly than the diagnostic ultrasound of the chest. A reporting template was designed for recommending to the department in order to improve reporting standard.

# Acknowledgements

I would like to thank the following people for the support, guidance, and making it possible for this study to come to completion with preparations, help and time they sacrificed for this project.

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# List of definitions

*Diagnostic US*

Simple effusion - anechoic effusion, effusion with no septations, no locutations, no stranding or internal debris/foci.

Complex effusion - anechoic effusion with internal debris, heterogeneous echo pattern, with septations or loculations.

Size of effusion - either a recorded measurement or any of the following words: - sliver, small, medium, large or a comment on whether the effusion is drainable or not.

Site of effusion - hemithorax with pleural effusion i.e. left or right.

*Therapeutic US*

Position of patient - position of the patient during the procedure i.e. sitting, semi-erect or supine.

Anatomical marked site for tapping (X-mark spot) - a mentioned anatomical landmark for tapping i.e. anterior axillary line, mid clavicular line, intercostal space.

Depth of effusion - measured depth from parietal pleura to visceral pleura.

Depth description - quantification of effusion i.e. a measured depth of effusion from skin to the centre of effusion or distance from skin to lung edge.

# 1. Introduction

## 1.1 Motivation and rationale for this study

Traditionally the role of chest ultrasound (US) has been limited to evaluation of pleural effusion and for thoracocentesis (1). This role has since changed with US now being used as a diagnostic tool for various conditions such as pulmonary embolism, consolidation, pneumothorax, chest wall masses and pleural diseases (1) , (2).

Hospitalised ill patients frequently present with pleural effusion (3). The imaging modality performed most commonly after the chest radiograph for diagnosing pleural effusion is transthoracic US (4). It is therefore important for transthoracic US report to convey relevant information and correct content to the referring clinician in order to expedite patient management (5). The proposed study will evaluate transthoracic US reports for adequacy of information provided for the diagnosis of an effusion and for planning diagnostic/therapeutic tapping.

## 1.2 Literature review

There are several indications for transthoracic ultrasound apart from detection of pleural effusion; these include the detection of pneumothorax, guidance for diagnostic and therapeutic tap as well as guidance for the placement of thoracostomy tubes (6). Ultrasound has the advantage of having the ability to perform portable, real time and dynamic imaging. Most importantly, it does not use ionizing radiation (7). Its major disadvantage is that it is a user

dependent technology, but this can be partially addressed through standardised positioning, image recording and reporting.

**Technical considerations**

A 5MHz or 3.5MHz low frequency convex transducer is required for sonographic examination of the pleura and the lung while 7.5MHz high frequency linear transducer can be used for superficial anatomical structures (1).

**Patient Positioning**

During thoracic ultrasound the patient can either be examined in a seated position (the dorsal application), or in a prone position (ventral application) (1)**.** The examination is usually performed during tidal breathing but maximal expiration or inspiration imaging can be performed in order to scan areas hidden by overlying bones. Patients can also be asked to place the hands on the head and elevate the elbows to make scanning easier (1).

**US appearances in Normal Subjects**

Sonographic images of the lungs have artefacts because of air preventing the transmission of the ultrasound beam. The sliding or gliding sign is seen during real time transthoracic US in healthy lungs when the visceral pleura and the lungs respiration dependent movement is visualised with respect to the parietal pleura and the chest wall (2), ( 7).

Band-like reverberation artefacts (comet tail artefacts, B-lines) are seen between pleura and ventilated lung during breathing movement (8). Parietal and visceral pleura are rarely visualised

on standard ultrasound images and less than or equal to 1mm in space should be present between these pleural layers in normal subjects (6).

**Pathological US findings**

Pleural effusion is the accumulation of fluid in the pleural space (9). This is detected on US as an echo-free zone. US is also a quick reliable bedside test for detecting pneumothorax for trauma patients (2), (8), (10). When pneumothorax is present there is absent gliding or sliding sign. There is a good ultrasonic window when consolidation is present due to presence of fluid, pus or cells within the alveolar space (11) ('hepatisation' of the lung).

**Pleural Effusion**

Pleural effusion is classified as either transudate or exudate. Transudative effusion is formed when there is imbalance in hydrostatic forces, which influence the formation and absorption of pleural fluid. Exudative pleural effusion results when the local capillary permeability or the pleural surface is altered. There are various causes of transudative pleural effusion and exudative pleural effusion (12).

US is better for evaluating pleural effusion and estimating the actual volume of pleural effusion than chest radiograph (4), (13). Ultrasound has also replaced CT guidance for aspiration and sampling of all lesions involving the pleura (and lung masses that are abutting the pleura) (9). Fibrous septations are also better visualised with ultrasound than with CT scan (14).

**Report Writing**

In radiology the critical science of art and science of medicine is communication (15), (16). The basic function of radiology report is to communicate information regarding the findings of the imaged study to the clinician and therefore the major role of radiology department is the production of reports (17), (18).

Radiology reports have to be relevant, accurate and have correct context (5), (15). The clinical significance of the report is lost when the report is verbose, rumbling and incoherent (5). A written report should be clear, respond directly to the clinical question asked, and contain a description of findings and a conclusion. One way in which this can be achieved is by use of standardised report template.

Standardised reports tend to increase the completeness of the report and the level of details required (19). In a survey study carried out by Swartz et al the results showed that referring clinicians and radiologists had better outcome and greater clarity with structured reporting than conventional reports (20). Powell et al found that most North American radiologist departments are using or experimenting with structured reports (21).

Most errors in diagnostic radiology happen as a consequence of inappropriate organisation or management process. Errors are described as either due to perception errors (failure to visualize abnormal radiological finding) or interpretation errors (failure to interpret correctly the pathology) (22). However, since radiological reports are now part of permanent patient's records, they also feature in litigation cases and radiologists have had to give explanations in court for the

incorrect reports also. The Radiology Society of North America (RSNA) Radiology Reporting Committee established an initial consensus of radiology report sections with components (23)(Appendix A).

**Transthoracic US Reporting Guidelines**

The best practice in radiology templates is identified and promoted by RSNA committee after being designed and approved by radiology practice, institutions and subspecialties (23). Templates serve as a resource for radiology residents who are seeking a starting point in their report writing improvement (23). Although the utility of transthoracic US for pleural diseases is well established, no current defined guidelines for reporting of transthoracic US for pleural diseases exist in the literature.

The echogeneity of the effusion is important regarding the nature of effusion. A study by Yang et al of 320 cases with pleural effusion, found that empyema's had homogenous echogenicity (24). The complexity of pleural effusion has to be explained further in a report because it has clinical implications. Chest drains are needed for longer period in patients with septated pleural effusions compared to those with non-septated effusions and the patients benefit more with fibronolytic therapy (7), (9), (25), (26).

It has been reported that measuring the size of pleural effusion is significant since this decreases the risk of visceral laceration when doing pleural tap (7). Change in patient position during pleural tap can result in significant shift of both pleural effusion and marked skin site for tapping (9). It is

for this reason that it is important to mention the position of patient during US examination and record the marked anatomical site in a report.

The adequacy and relevance of requesting and reporting practice for transthoracic US for pleural disease also does not appear to have been previously studied. This research therefore aims to evaluate the adequacy of reporting chest US with pleural effusion and to correlate results to the level of the experience of the operator with a secondary aim of creating a report template of chest ultrasound for pleural effusion for the department.

## 1.3 Aims and objectives

### 1.3.1 Aim

The aim of the study is to evaluate the adequacy of transthoracic US reports for pleural effusion in one department, correlate the adequacy with the level of experience of the US operator and create a standardised reporting template.

### 1.3.2 Objectives

1. To determine what constitutes a comprehensive transthoracic US report for pleural effusion as dictated by clinical demands for making a diagnosis and imaging features affecting management choices.
2. To determine adequacy of current reports of transthoracic US for pleural effusion for both diagnostic and therapeutic planning purposes and to subcategorise the adequacy of reports of chest US according to various levels experience of operators.

# 2. Materials and methods

## 2.1 Study design and study setting

This was a retrospective descriptive study of report quality for all transthoracic US with pleural effusion performed in the Department of Diagnostic Radiology, ultrasound section at Charlotte Maxeke Johannesburg Academic Hospital. The ethics clearance certificate M140402 was approved by Witwatersrand University Ethics Committee on the 01-April-2015 and is attached as Appendix B.

## 2.2 Data acquisition

Collected data is comprised of transthoracic US reports with pleural effusions authored by radiologist, trainee registrars and sonographers between 1 January 2012 and 31 December 2013. The reports considered were requested either for diagnostic purposes or therapeutic planning.

Since there is no current guideline or template for transthoracic ultrasound reporting for pleural effusion, we created a data collection sheet of the necessary components we used to evaluate the written reports based on information from our literature search. The reports collected were each awarded a score by the primary investigator using the data collection sheet. The data collection sheet for diagnostic US reports is attached as appendix D and that for therapeutic US report is attached as appendix E.

## 2.3 Inclusion criteria

1. All transthoracic US reports for adults (18 years and above), which were requested for making a diagnosis of pleural effusion or therapeutic planning of known pleural effusion.
2. This included any reports for US of more than one body system that included the chest i.e. 'US abdomen and transthoracic US'.
3. All transthoracic US reports authored by Radiologists, Radiology Registrars and Sonographers.

## 2.4 Exclusion criteria

1. Reports written by the primary investigator.
2. Illegible reports.

## 2.5 Analysis of data and scoring system

The spreadsheet was used to evaluate the following components in all reports: characterisation, size and site of the effusion. For therapeutic US reports, the additional four components evaluated were: anatomical site for diagnostic / therapeutic tapping, position of patient during examination, depth of effusion and the description of depth of effusion. A score of zero was awarded for each of the above components omitted from a report. The diagnostic US reports were evaluated and scored from a possible maximum adequacy score of 4. The therapeutic US reports were evaluated from a possible maximum adequacy score of 8.

Characterisation of effusion was awarded a score of 2. If an effusion was described as simple then a full award of 2 points was allocated. However, in cases of complex effusions, a further description for the nature of complexity was required for awarding the additional score of 1 for a total of 2. The rest of the components were awarded the score of 1 each as indicated in tables 1 and 2 below.

The report adequacy scores were graded into three grades as follows for diagnostic US reports, poor (score 0-1); average (score 2) and above- average (score 3-4). The therapeutic US report adequacy scores were also graded in three grades, poor (score 0-3); average (score 4) and above-average (score 5-8).

**Table 1 Different diagnostic US reporting components**

| COMPONENTS | POINTS<br>(possible maximum 4) |
|---|---|
| Characterisation of effusion<br>Simple effusion<br>OR<br>Complex septated /loculated /debris or internal foci | 2 |
| Size of effusion | 1 |
| Site of effusion i.e. left or right hemithorax | 1 |

**Table 2 Different therapeutic US reporting components in addition to the diagnostic US 4 points awarded components to make a total possible score of 8**

| COMPONENTS | POINTS<br>(possible maximum 4) |
|---|---|
| Marked anatomical site | 1 |
| Position of patient while scanning | 1 |
| Depth | 1 |
| Description of depth | 1 |

## 2.6 Statistical analysis

Stata13 (data analyses software system) was used to analyse the data for any association between the obtained report adequacy score and various ranks of level of experience applying the Fisher exact test (where frequencies were too small) and chi square tests. Values of $P < 0.05$ were considered significant in all tests.

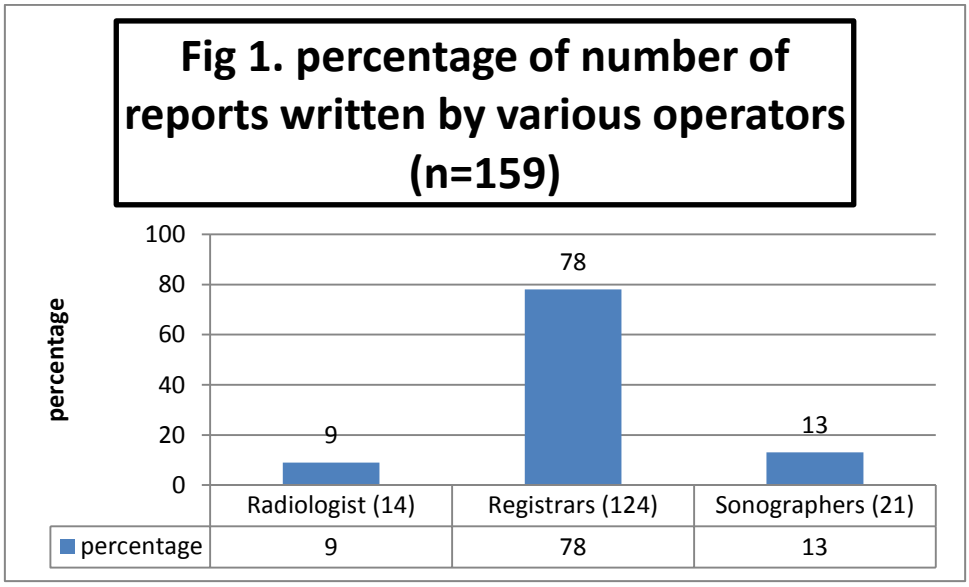
# 3. Results

There were 218 reports of transthoracic ultrasound performed for pleural effusion in total for the period of year 2012 and 2013. 59 (27%) reports were excluded not to bias the results, because they were illegible or had no operator name. The quality of reports was therefore evaluated from the 159 remaining reports. There were 99 (62%) males. The age range was 18 years to 88 years (average age 41 ±16.00 SD).

There were 85 (53%) diagnostic ultrasound reports and 74 (47%) therapeutic ultrasound reports. Trainee registrars had authored the majority of reports 124 (78%) (figure 1). Out of these 124

(78%) registrars reports, 1st and 2nd year trainee registrars were responsible for 71 (45%) reports and the 3rd and 4th year registrars for 53 (33%) reports.

**Figure1 Diagram demonstrating the percentage number of reports authored by various operators.**




The most frequent score awarded for diagnostic ultrasound reporting quality was 4/4. It was scored 38 times out of 85 diagnostic reports (45%). There was only one zero score report in the diagnostic ultrasound reports. Table 3 shows the detailed summary of scores obtained by different operators for diagnostic ultrasound reports. For therapeutic ultrasound reports the most frequent score was 5/8. It was scored 24 times out of 74 therapeutic US reports performed in total (32%).

There was no zero score for therapeutic ultrasound reports. The four highest scores for therapeutic reports of 8/8 were awarded to reports written by 3rd and 4th year trainee registrars and sonographers. The details of the frequency of scores for therapeutic ultrasound reports are shown in table 4.

**Table 3 Demonstrates the percentage of scores by various operators for Diagnostic US Reports. (Total reports (n=85)**

| Score | Radiologists (n=8) | 1st and 2nd year Registrars (n=37) | 3rd and 4th year Registrars (n=30) | Sonographers (n=10) | Total |
|---|---|---|---|---|---|
| Score of 0 | 1(12.5%) | 0 (0%) | 0 (0%) | 0(0%) | 1 (1%) |
| Score of 1 | 0 (0%) | 1 (2.7%) | 4 (13.3%) | 1 (10%) | 6 (7%) |
| Score of 2 | 2(25%) | 12(32.4%) | 6(20%) | 2(20%) | 22 (26%) |
| Score of 3 | 4 (50%) | 5 (13.5%) | 6 (20%) | 3 (30%) | 18 (21%) |
| Score of 4 | 1 (12.5%) | 19 (51.4%) | 14 (46.7%) | 4 (40%) | 38 (45%) |

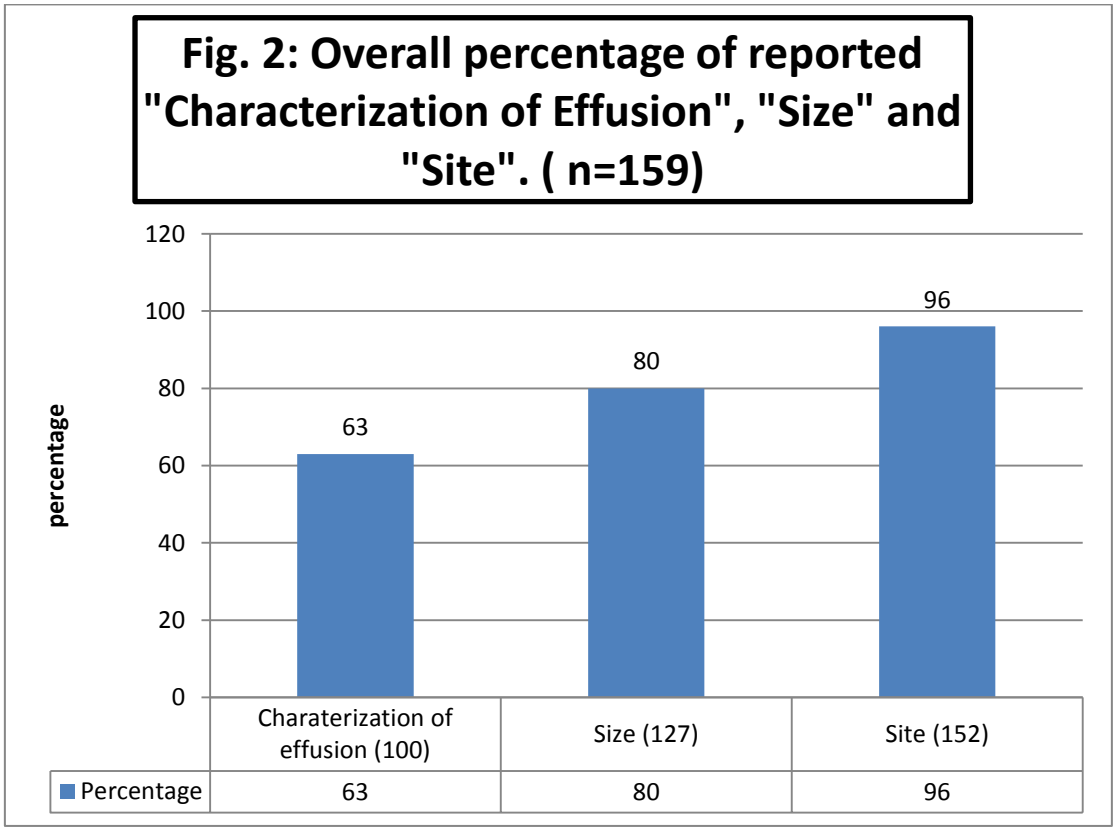
**Table 4 Demonstrates the percentage of scores by various operators for Therapeutic US Reports. (n=74)**

| Score | Radiologists (n= 6) | 1st and 2nd year Registrars (n=34) | 3rd and 4th year Registrars (n=23) | Sonographers (n=11) | Total |
|---|---|---|---|---|---|
| Score of 0 | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 |
| Score of 1 | 0 (0%) | 2 (5.9%) | 2 (8.7%) | 0 (0%) | 4 (5%) |
| Score of 2 | 2 (33.3%) | 6 (17.6%) | 3 (13%) | 1 (9.1%) | 12 (16%) |
| Score of 3 | 0 (0%) | 4 (11.8%) | 4 (17.4%) | 0 (0%) | 8 (11%) |
| Score of 4 | 0 (0%) | 6 (17.6%) | 3 (13%) | 1 (9.1%) | 10 (14%) |
| Score of 5 | 3 (50%) | 12 (35.3%) | 5 (21.8%) | 4 (36.4%) | 24 (32%) |
| Score of 6 | 0 (0%) | 2 (5.9%) | 4 (17.4%) | 2 (18.2%) | 8 (11%) |
| Score of 7 | 1 (16.7%) | 2 (5.9%) | 0 (0%) | 1 (9.1%) | 4 (5%) |
| Score of 8 | 0 (0%) | 0 (0%) | 2 (8.7%) | 2 (18.2%) | 4 (5%) |

The overall best reported component was the “site” of effusion in both diagnostic and therapeutic reports. “Site” was reported in 152 (96%) reports. Figure 2 shows the overall percentage of reported “characterisation of effusion”, “size” and “site” components by various operators.

This was followed in frequency by reporting of “size” of an effusion in 127 (80%) reports. The overall poorly reported component was the “anatomical site for tapping” in therapeutic ultrasound having been reported in only 19 (26%) reports. Figure 3 and Figure 4 show the summary of the percentage of reported components in Diagnostic ultrasound reports and Therapeutic ultrasound reports, respectively.

**Figure 2 Graph demonstrating the overall percentage of reported “Characterisation of effusion”, “Size” and “Site”.**



In 67 (67%) reports the character of effusion was identified as “complex “. Only in 50 (75%) of these was the complexity of the effusion was qualified further. The most frequent reported descriptor of complexity of the effusion was “loculated effusion” having been reported in 26 (39%) reports. Table 5 shows the summary of reported complexity of effusion by different operators. The depth of effusion was reported in 42 (57%) reports and was further qualified in 25 (34%) reports.

**Figure 3 Diagram illustrating the percentage of reported components for “Diagnostic US Reports”.**

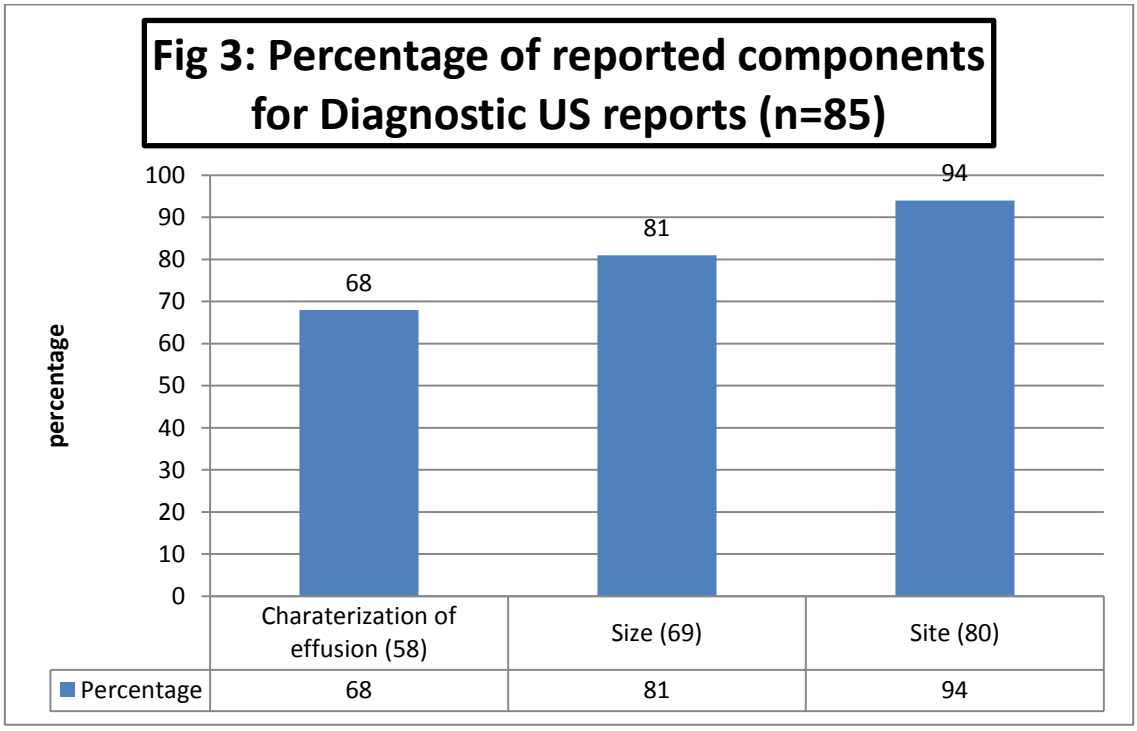


**Figure 4 Diagram illustrating the percentage of reported components in "Therapeutic US Reports". (n=74)**

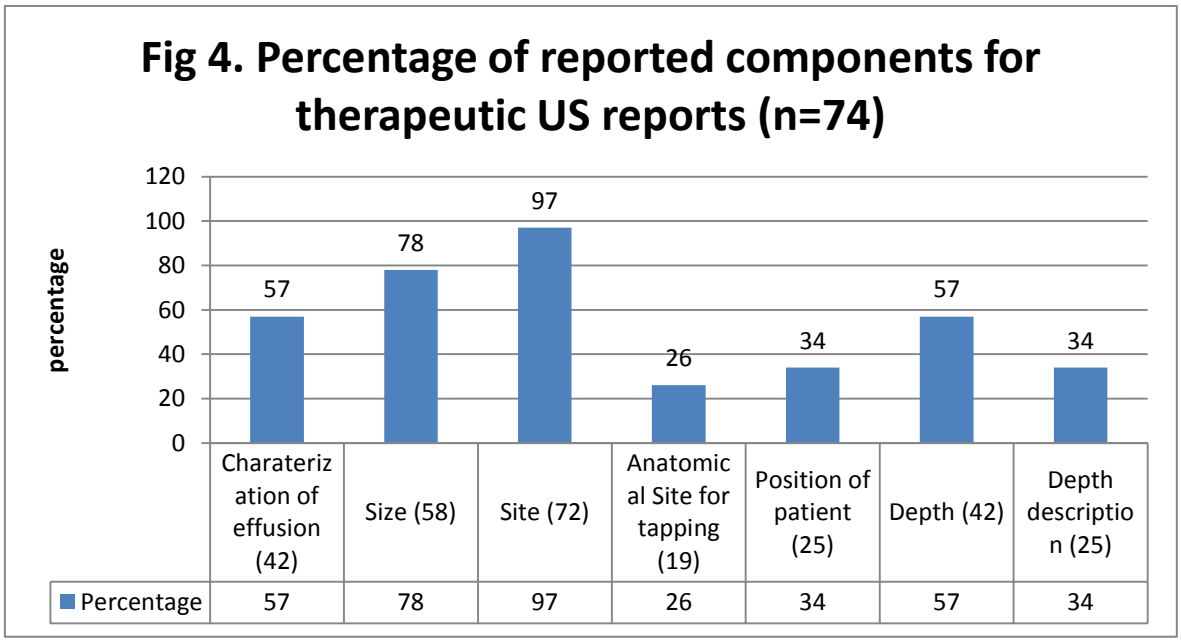



**Table 5 Demonstrates the overall reported complex effusion by various operators (n=67).**

| Complex effusion (n=67) | Radiologists (n=7) | Registrars (n=50) | Sonographers (n=10) |
|---|---|---|---|
| Loculated effusion (26) | 2 | 16 | 8 |
| Septated effusion (14) | 1 | 13 | 0 |
| Internal debris/ foci (10) | 2 | 8 | 0 |
| Total 50 (75%) | 5 (71%) | 37 (74%) | 8 (80%) |

The overall diagnostic US reports mean adequacy score was 3.01 ± 1.05 SD (range 0-4) and for therapeutic US reports was 4.32 ±1.81 SD (range 1-8). Table 6 and Table 7 show the reports overall mean adequacy scores by various operators for diagnostic US and therapeutic US reports, respectively.

There was no statistically significance difference between the report adequacy score and various operators for both diagnostic and therapeutic US reports (Chi-square test, *P*= 0.712 for diagnostic US and *P*= 0.437 for therapeutic US reports). Fisher exact test was used also where the cell frequencies were few (*P*=0.596 for diagnostic US and *P*= 0.492 for therapeutic US reports adequacy scores). The level of significance used to these statistical analyses test was 0.05.

**Table 6 The mean "Report Adequacy Score" achieved by various operators for the Diagnostic US Reports.**

| Rank | Mean Score | Range |
|---|---|---|
| Radiologists | 2.5 (±1.19 SD) | 0-4 |
| 1st and 2nd year Registrars | 3.15 (±0.97 SD) | 1-4 |
| 3rd and 4th year Registrars | 3 (±1.11 SD) | 1-4 |
| Sonographers | 3 (±1.05 SD) | 1-4 |

**Table 7 The mean "Report Adequacy Score" achieved by various operators for the Therapeutic US Reports.**

| Rank | Mean score | Range |
|---|---|---|
| Radiologists | 4.33 (±1.96 SD) | 2-7 |
| 1st and 2nd year Registrars | 4 (±1.59 SD) | 1-7 |
| 3rd and 4th year Registrars | 4.21 (±1.97 SD) | 1-8 |
| Sonographers | 5.54 (±1.75 SD) | 2-8 |

Figure 5 and Figure 6 demonstrate the percentages of the graded scores of various operators and the average percentage of each grade for diagnostic US and therapeutic US reports, respectively.

**Figure 5 Graph of the graded percentage of "Diagnostic US Report Scores" by various operators.**

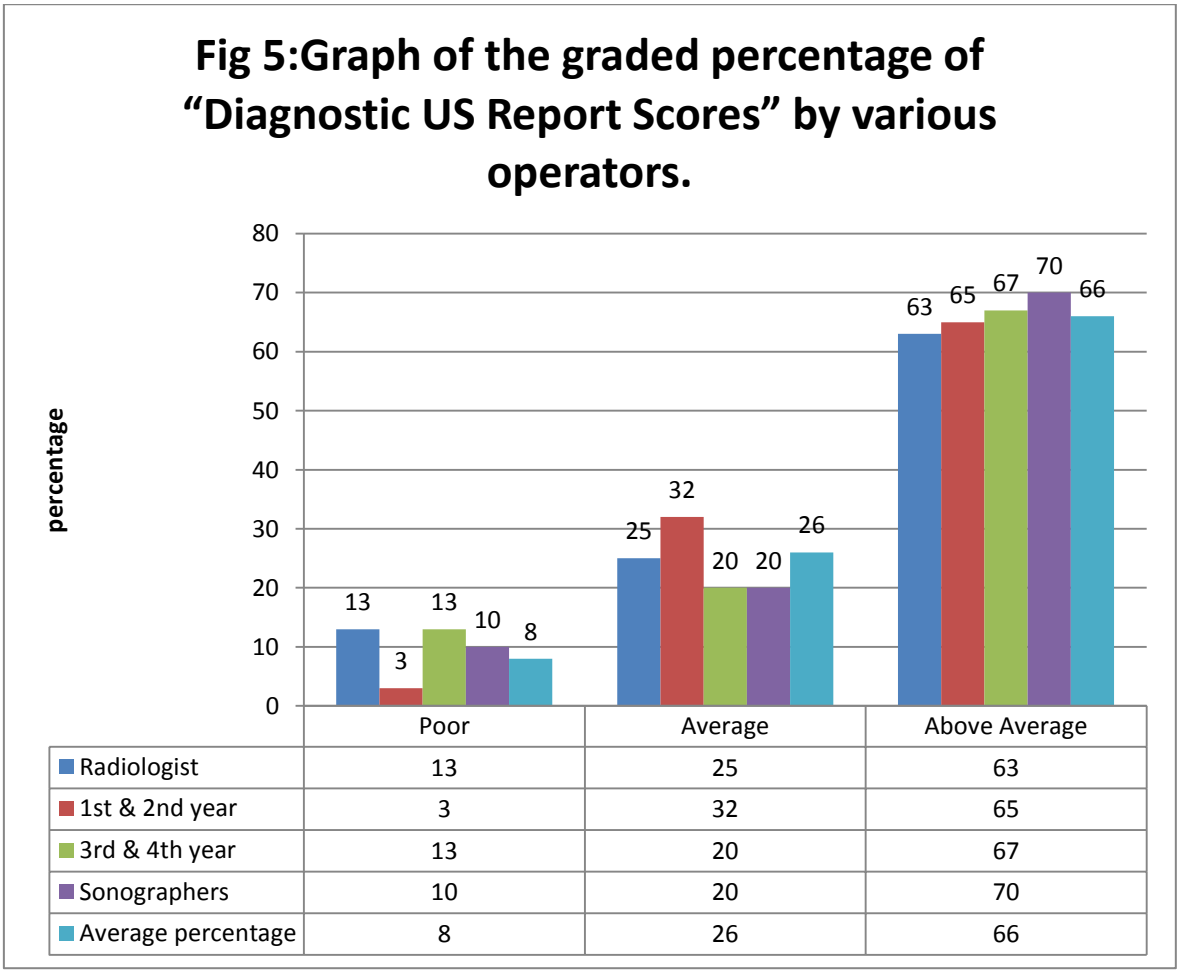
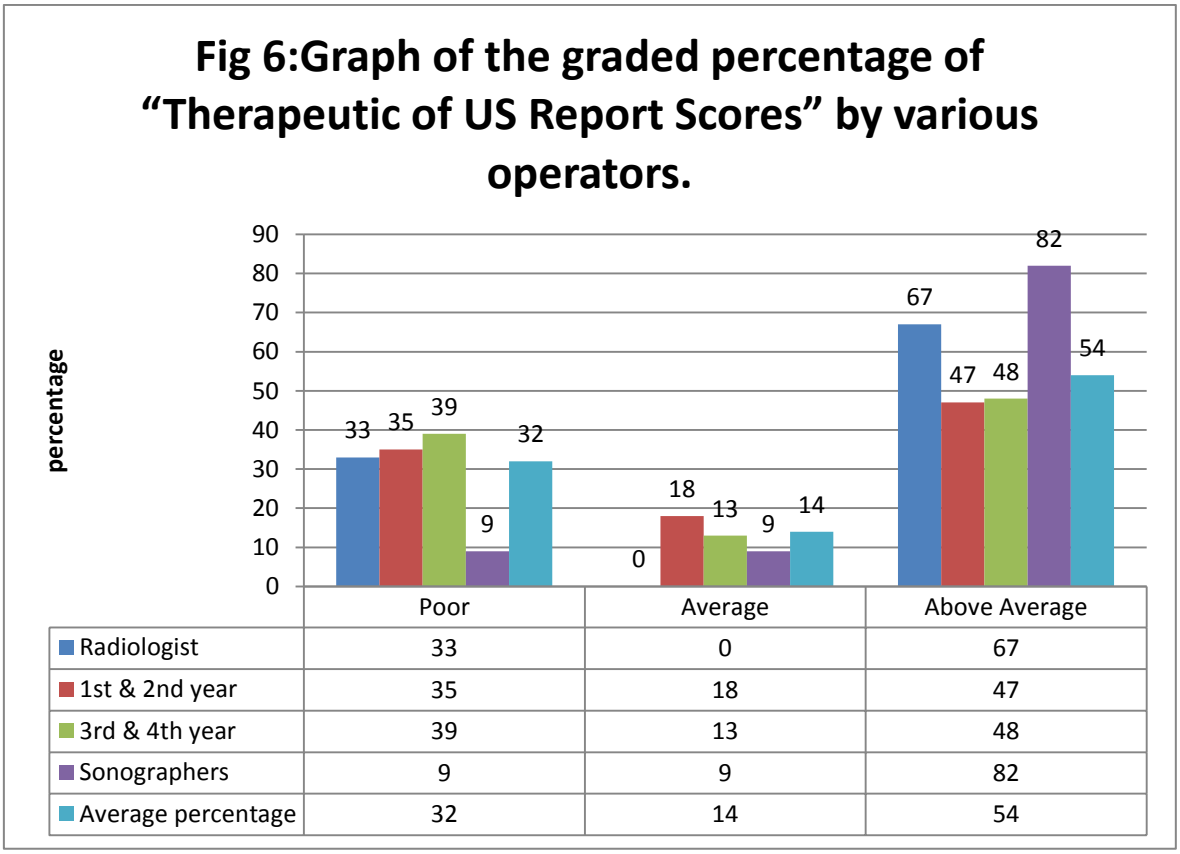


**Figure 6 Graph of the graded percentage of "Therapeutic of US Report Scores" by various operators.**




# 4. Discussion

## 4.1 Results in context

Transthoracic US still remains operator-dependent modality whereby an operator should be able to acquire images and interpret them simultaneously while performing the examination (7). Pleural effusion is encountered commonly in hospitalised patients and transthoracic US is therefore requested frequently for diagnosing and localizing of an effusion for tapping (3).

In this study there were 218 requests from 01 January 2012 to 31 December 2013. Transthoracic US has the following advantages: it is relatively inexpensive; it is mobile i.e. it can be performed at

the bedside; it has no radiation and has short time of examination (7). Out of 159 reports analysed, 85 reports of those were for diagnostic purposes, to confirm the presence or absence of pleural effusion. (27).

It seems that reporting scores were quite poor overall and that the sonographers seemed to do better than doctors. Sonographers had a second highest report mean adequacy score of 3 ±1.05 (1-4), the highest being 3.15 ±0.97 (1-4) scored by 1st and 2nd year registrars for diagnostic US reports (Table 6). Sonographers obtained the highest therapeutic US report mean adequacy score of 5.54 ±1.75 (2-8), second being 4.33 ±1.96 (2-7) obtained by radiologists (Table 7).

Results also showed that sonographers had the highest percentage for above-average graded score for both diagnostic and therapeutic US reports. The average percent for diagnostic above-average graded score was 66%; sonographers had 70% as the highest percentage (Fig. 5). Similarly to the diagnostic US reports, sonographers had the highest therapeutic above-average graded percentage score of 82% higher than 54% for the overall average percent (Fig. 6).

**Radiology reporting style**

There is no adopted designed template for reporting of chest US for pleural effusion in the setting of this study. Report writing skills are acquired through the registrar training program in various working stations in the department during training period. Only 5% of the therapeutic US reports had a maximum score of 8/8 and 45% of diagnostic US reports had the maximum score of 4/4.This could be due to number of factors, one of which being that the operators have inferior training with chest ultrasound. The poor reporting standard showed by our results can be improved by

having dedicated sessions on general radiology reporting in our department. The study authored by Bosmans et al showed that 92.4% of clinicians and 94.7% of radiologist supported that learning to report should be well structured during registrars training whereby every registrar is obliged to learn it (28).

The results of this study showed a lot of deficiencies in the components of therapeutic US, which are important for the clinicians to carry out the draining procedure (Figure 4). As a consequence this may result in patient management delays. This could be as a result of not using a comprehensive structured reporting in our department.

Structured reporting can have the following benefits; rapid reporting turnaround time, reduces reporting costs, improves communication, satisfaction of the reporting provider and it simplification of quality and comprehensiveness of reporting (29). The Management of Radiology Report Template (MMRT) templates allow radiologists to share best-practice templates across organisations (30).

It has been shown in a study authored by Grieve et al that templates are preferred by majority of referring clinicians (16). Swartz et al in a study of titled "Improving communication of diagnostic radiology findings through structured reporting" indicated that that template improves accuracy, improves communication and reduces certain types of errors (20). This reporting inadequacy in our department can be improved by use of reporting templates.

**Operators**

**Sonographers**

Our results demonstrate that sonographers appear to write 'better' reports than both registrars and radiologists. They had both highest average percentages for the diagnostic US reports (70%) and therapeutic US reports (82%). They also had only 10% of their reports which were 'poor' for diagnostic US and 9% which were 'poor' for therapeutic US. This could be as a result of their systematic training program they receive before they qualify. They are trained over two years as fulltime students in ultrasound focused only this modality, and have continuous assessments over this period.

Sonographers also often present their cases to the attending radiologist when they are unsure of their examination findings and may therefore be motivated to produce more structured examinations and subsequently more structured reports. Sonographers were found to report better when it came to complex effusions by further qualifying the complexity of effusion (Table 5). Only 20% of complex pleural effusions were not further qualified by sonographers.

**Radiologists**

Radiologists are not always present in ultrasound department in the setting of this study, which is a busy, large, tertiary referral hospital in a developing country. This is reflected in this study where radiologists only authored 9% of US chest reports. Consultants often supervise more than one working station and they spend more time in MRI, CT scans and CT/PET scan reporting. This is similar to the study of adequacy of paediatric renal US reports in the same institution by Govender et al in 2011 where radiologists authored 8% of reports (31).

Radiologists had the lowest percentage (63%) of the above-average graded scores for diagnostic US reports. In therapeutic US reports they have the second highest graded above-average percentage (67%) following the sonographers who had 82%. This is contrary to the level of training and experience of the two types of operators where one would expect the radiologists to be authoring better reports than sonographers. Radiologists may not be recording complete findings in their reports, possible because they are in hurry to move to the next station or because of the shear number of reports they have to author / authorise per day.

Radiologists had one zero score in diagnostic US reports and had the lowest mean report adequacy score of 2.5 for diagnostic ultrasound reports (Table 3) and (Table 6). If structured reporting is used, it may also succeed in forcing radiologist to use acceptable terms and avoid vague and verbose reports which are not meaningful to the clinician (32). This can result in improved adequacy of reports by radiologists.

**Registrars**

Registrars are the ones who performed the majority of imaging studies in the department. They authored the majority (78%) of the ultrasound reports. This is because they are present in the ultrasound department to fulfil the requirements to fulfil of their training program in their 1$^{st}$ and 2$^{nd}$ years of training. 3$^{rd}$ and 4$^{th}$ year registrars are not always at ultrasound department because towards their completion of their studies they spend time in specialised rotation for MRI, interventional radiology and mammography. 3$^{rd}$ and 4$^{th}$ year registrars only contributed two

reports (8.7%) with the total score of 8 out of 23 (31%) reports they authored for therapeutic chest US

**Diagnostic and Therapeutic US reports**

Based on the literature search we created data collecting sheet for both diagnostic and therapeutic ultrasound that we used to evaluate reports for the possible maximum "**report adequacy score**". In this study only 4 reports (5%) had the maximum report adequacy score of 8 for therapeutic US reports (Table 4).

Generally the reporting of the transthoracic ultrasound in the setting of the study was sub-standard. The diagnostic US studies were better reported than the therapeutic US studies - the mean adequacy score of the diagnostic US reports was 3.01 ±1.05 SD (range 0-4) compared to that of therapeutic US which was 4.32 ±1.81 (range 1-8). This could be the result of not allowing more time for these studies which require more effort to scan the patient, during the busy schedule.

Our results also shows that the characterization of effusion, size and site of effusion was reported better than the four components of the therapeutic US which are "anatomical site for tapping" (X-mark spot), "position of patient during examination", "depth" and "the description of depth" (figure 4).

Attention needs to be focused on therapeutic US reporting standard in the US department. This must aim to improve operators in Ultrasound department who will scan the patient, provides

optimal images, make the appropriate “X-marks the spot” and author a relevant helpful radiology report to the referring clinician.

Some of the individual components evaluated in reports are discussed below:

**Characterisation of effusion**

In this study characterisation of effusion was not mentioned in 37% of reports. In those instances where the character of the effusion was reported (n=100) the analysis shows that 67 (67%) of those were reported as complex. It is possible that operators may not have been reporting on the character of an effusion when it was simple, anechoic effusion. When the pleural effusion was reported to be complex, only in 50 (75%) out of 67 reports the complexity of effusion was further qualified.

Reporting the character of effusion is of clinical significance because it has management implications. The effusion can have the following descriptions based on US appearances: anechoic; complex non-septated; complex septated and homogeneously echogenic (7). Patients with complex septated pleural effusion require longer hospital stays, longer duration of indwelling chest drain, fibronolytic therapy and even surgery to expedite their clinical recovery (25).

**Size of effusion**

There is no current standard system for grading the size of an effusion. Often the words small, moderate and large are used to qualify the size of an effusion. Balik et al performed a study for estimating the size of pleural effusion for practical purposes (33). In their study, the separation

distance of an effusion between the lung and the outer parietal pleura was measured in millimeters and multiplied by 20 as indicated below:

**Effusion size (cc) = 20 x separation distance (mm)**

In our study, the size of effusion was mentioned in 79% of reports but there was not always a measurement provided. Mentioning the size of an effusion it is important because the radiologist can recommend that thoracocentesis be performed under US guidance when small. In a study authored by Usta et al, thoracocentesis was only performed in the patients with an inter-pleural distance of equal or more than 3cm (34).

**Site of effusion**

Site was reported in 152 out of 159 (96%) in this study. It is the overall best reported component. It is important to note the site of an effusion because often patients present with bilateral pleural effusions while at other times the referring clinician fails to indicate the site of the effusion on the referral note.

In a study authored by Miller et al, there were fourteen cases of wrong-side thoracocentesis and the most common causes of the wrong-side thoracocentesis were deficit in training and education (35). Human beings can have difficulties correctly identifying right and left laterality (36). A recent chest radiograph is therefore useful to confirm the indication and side of the pathology before the transthoracic US examination is performed.

**Anatomical site for tap and (x-mark spot)**

The worst reported component in the therapeutic US reports was the failure to report the "anatomical site for tap" (26%). Reporting the site of effusion or at least the site of marking the chest are important, especially in cases where the patient's "X mark spot" no longer be clearly visible. It is for this reason that Diacon et al discourages marking of a puncture site when the patients are going to be transferred to another hospital for the puncture or drainage procedure (9). It is recommended rather that patients be tapped in the ward on the same day (or following day) after the thoracic ultrasound has been performed. For radiologists it is therefore important not only make a mark on the patient's skin (x-mark spot) but to also document where the mark exactly is located anatomically.

Absence of "X-mark spot" within a sterile field was also found to be contributory factor in a study authored by Miller et al for wrong-side thoracocentesis (35). Furthermore, with regard to record keeping, should a radiology report required in future for reference regarding thoracocentesis performed, the recording of the X-mark spot will be actively looked for within the report, to serve as evidence.

In most reports for therapeutic US, it was only documented that patient marked on the skin for thoracocentesis with no further details provided to guide the clinician or to serve as a record. It is important for the operator to be familiar with the chest anatomy when performing the chest ultrasound study and mentioning the "X-mark spot" in a report (37). This will enable the operator to identify a safe location and document the correct surface anatomical site marked for thoracocentesis.

**Position of patient during examination**

The “position of the patient” during ultrasound examination was reported in 25 of 74 (34%) therapeutic ultrasound reports (Figure 4). A thoracocentesis procedure can result in potential complication when performed over the “X-mark spot” without taking into account the patient’s position during the therapeutic US examination. This is because slight change in patient position can result in both shift of pleural effusion and the X-mark spot (9).

No standard position is documented in literature for various indications of chest ultrasound (9), however patients are best scanned on a sitting position more especially for posterior chest wall effusions (7). The sitting position also helps with the gravity effect of the effusion. In intensive care unit patients often this is not possible. An experienced should ask the radiologist about the position of patient when it is not mentioned in a report before carrying out the procedure, but a complete therapeutic US reports should contain this information.

**Depth of effusion**

“Depth of effusion” was reported in 42 (57%) of therapeutic ultrasound reports. This is the only component in therapeutic US reports with the report adequacy score above 50%. When a pleural effusion has been identified, the radiologist has the opportunity to suggest to the referring clinician whether it can be tapped. Sikora et al referred the depth of effusion as the safety zone simple because that’s where needle should be positioned when performing thoracocentesis (38).

**Description of depth from the tissue surface**

While the depth of the effusion was reported in 42 (57%) out of 74 reports, it was further qualified in 25 (34%) reports. Qualifying the depth of effusion will help to avoid dangers of blind pleural procedures. Patients can have the same depth of effusion but different subcutaneous tissue thickness. It gives a referring clinician an idea with regard to advancement of the needle distance into the effusion.

To avoid complications related to thoracocentesis a description of the distance from the skin to the center of effusion can also be mentioned in a report. This will also guide the referring clinician with regard to the length of the needle to use for tapping an effusion.

## 4.2 Limitations of the study

This was a retrospective descriptive study of transthoracic US for pleural effusions in the setting of one hospital where various trainee registrars rotate on monthly basis. There were only few radiologists (9%) and sonographers (13%) reports with a majority (78%) of trainee registrar's reports.

In the report if one component was not mentioned we did not assume that it was deemed normal by the operator and as a result a zero score was awarded. This may seem like a harsh assessment of the quality of the thoracic ultrasound performed but it should be considered in the light that the study was designed to assess quality of reports which convey information to clinicians and also remain as a major legal record of what has been done and seen. Failure to

record important information even when not present or not seen is not sufficient to record normality or abnormality.

This study was not assessing the ability of an operator to diagnose pleural effusion nor to be able to interpret the correct ultrasonographic findings. Reports not legible were excluded from the study. This is an important exclusion to note because illegible handwriting technique may also represent inferior reporting technique. However this cannot be assessed without having the author of the report read this out for evaluation. These results only represent the reporting standard of one particular department therefore the results cannot represent the reporting standard of the whole department.

## 4.3 Ideal transthoracic US: future reports for patients with a pleural effusion

The RSNA has designed many templates of various imaging procedures to guide the radiologists and trainee registrars on writing reports for those studies. However the is no transthoracic ultrasound template availability internationally currently. These reporting templates were created by RSNA in order to improve radiology reporting.

The Reporting Initiative of the RSNA has offered validated best practices radiology report templates in the new management of radiology report templates (MRRT) (39). In a survey study authored by Bosmans et al titled “The Radiology Report as Seen by Radiologists and Referring Clinicians: Results of the COVER and ROVER Survey” it was shown that 84.5% (592 of 701) of clinicians preferred structured reports consisting of templates in which separate headings for different organ systems were indicated (28).

Therefore standardised template resulting from this research will assist the department in which this study was conducted and other radiologists around the world to improve their report writing and possibly also improve their transthoracic US technique through providing the images and techniques that support the ideal report. A recommended designed guideline template, which is based on the above literature search and inspired by the results of this study is provided as Appendix F.

## 4.4 Future studies

Future research should investigate the failure and success rate of US-guided thoracocentesis post transthoracic ultrasound and correlate this with the level of experience of the operator in the radiology department. Prospective research to investigate success of pleural tapping after transthoracic ultrasound performed in a standardised manner will evaluate the use of the template prospectively. A survey assessing the satisfaction of the referring doctors with regards to the reports they receive from radiology department will also drive corrective measures towards standardised reporting.

# 5. Conclusion

The transthoracic US is a frequent request for diagnosing of pleural effusion and for therapeutic planning in patients known to have pleural effusion. The written report should be clear, respond directly to the clinical question asked, and contain a description of all the important positive and negative findings and provide a conclusion. The report should guide management but making an

adequate recommendation and in the case of therapeutic chest US the information needed to place the thoracocentesis needle appropriately and safely should be provided.

Transthoracic US reports from the department investigated are currently substandard and in particular, therapeutic planning transthoracic US reports are the most poorly reported.

The mean report adequacy score for diagnostic ultrasound reports was 75% adequate (3.01 ±1.05 SD, range 0-4) and for the therapeutic ultrasound reports was only 54% adequate (4.32 ±1.81 SD, range 1-8). Only 38 (45%) diagnostic ultrasound reports had a perfect total report adequate score (of 4/4) compared to 4 (5%) of the therapeutic ultrasound reports with a perfect total report adequacy score (of 8/8).

Sonographers reported better when characterising an effusion and qualifying it when it was complex. Making use of provided standardized reporting template is proposed to help to improve the reporting standard.

## 6. References


(1) Reissig A, Kroegel C. Transthoracic ultrasound of lung and pleura in the diagnosis of pulmonary embolism: a novel non-invasive bedside approach. Respiration; international review of thoracic diseases. 2003 Sep-Oct;70(5):441-52.

(2) Sartori S, Tombesi P, Trevisani L, et al. Accuracy of transthoracic sonography in detection of pneumothorax after sonographically guided lung biopsy: prospective comparison with chest radiography. AJR American journal of roentgenology. 2007 Jan;188(1):37-41.

(3) Bateman K, Downey DG, Teare T. Thoracic ultrasound for pleural effusion: delays and cost associated with departmental scanning. Respiratory medicine. 2010 Apr;104(4):612-4.

(4) Vignon P, Chastagner C, Berkane V, et al. Quantitative assessment of pleural effusion in critically ill patients by means of ultrasonography. Critical care medicine. 2005 Aug;33(8):1757-63.

(5) Wallis A, McCoubrie P. The radiology report--are we getting the message across? Clinical radiology. 2011 Nov;66(11):1015-22.

(6) Beckh S, Bolcskei PL, Lessnau KD. Real-time chest ultrasonography: a comprehensive review for the pulmonologist. Chest. 2002 Nov;122(5):1759-73.

(7) Koegelenberg CF, von Groote-Bidlingmaier F, Bolliger CT. Transthoracic ultrasonography for the respiratory physician. Respiration. 2012;84(4):337-50.

(8) Alrajhi K, Woo MY, Vaillancourt C. Test characteristics of ultrasonography for the detection of pneumothorax: a systematic review and meta-analysis. Chest. 2012 Mar;141(3):703-8.

(9) Diacon AH, Theron J, Bolliger CT. Transthoracic ultrasound for the pulmonologist. Current opinion in pulmonary medicine. 2005 Jul;11(4):307-12.

(10) Ianniello S, Di Giacomo V, Sessa B, et al. First-line sonographic diagnosis of pneumothorax in major trauma: accuracy of e-FAST and comparison with multidetector computed tomography. La Radiologia medica. 2014 Jan 28.

(11) Yang PC, Luh KT, Chang DB, et al. Ultrasonographic evaluation of pulmonary consolidation. The American review of respiratory disease. 1992 Sep;146(3):757-62.

(12) Abramowitz Y, Simanovsky N, Goldstein MS, et al. Pleural effusion: characterization with CT attenuation values and CT appearance. AJR American journal of roentgenology. 2009 Mar;192(3):618-23.

(13) Eibenberger KL, Dock WI, Ammann ME, et al. Quantification of pleural effusions: sonography versus radiography. Radiology. 1994 Jun;191(3):681-4.

(14) Maskell NA, Butland RJ. BTS guidelines for the investigation of a unilateral pleural effusion in adults. Thorax. 2003 May;58 Suppl 2:ii8-17.

(15) Pinto F, Capodieci G, Setola FR, et al. Communication of findings of radiologic examinations: medicolegal considerations. Seminars in ultrasound, CT, and MR. 2012 Aug;33(4):376-8.

(16) Grieve FM, Plumb AA, Khan SH. Radiology reporting: a general practitioner's perspective. The British journal of radiology. 2010 Jan;83(985):17-22.

(17) Gunn AJ, Alabre CI, Bennett SE, et al. Structured feedback from referring physicians: a novel approach to quality improvement in radiology reporting. AJR American journal of roentgenology. 2013 Oct;201(4):853-7.

(18) Reiner BI, Knight N, Siegel EL. Radiology reporting, past, present, and future: the radiologist's perspective. Journal of the American College of Radiology : JACR. 2007 May;4(5):313-9.

(19) Naik SS, Hanbidge A, Wilson SR. Radiology reports: examining radiologist and clinician preferences regarding style and content. AJR American journal of roentgenology. 2001 Mar;176(3):591-8.

(20) Schwartz LH, Panicek DM, Berk AR, et al. Improving communication of diagnostic radiology findings through structured reporting. Radiology. 2011 Jul;260(1):174-81.

(21) Powell DK, Silberzweig JE. State of structured reporting in radiology, a survey. Academic radiology. 2015 Feb;22(2):226-33.

(22) Olivetti L, Fileni A, De Stefano F, et al. The legal implications of error in radiology. La Radiologia medica. 2008 Jun;113(4):599-608.

(23) Kahn CE, Jr., Langlotz CP, Burnside ES, et al. Toward best practices in radiology reporting. Radiology. 2009 Sep;252(3):852-6.

(24) Yang PC, Luh KT, Chang DB, et al. Value of sonography in determining the nature of pleural effusion: analysis of 320 cases. AJR American journal of roentgenology. 1992 Jul;159(1):29-33.

(25) Chen KY, Liaw YS, Wang HC, et al. Sonographic septation: a useful prognostic indicator of acute thoracic empyema. Journal of ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine. 2000 Dec;19(12):837-43.

(26) Barthwal MS, Deoskar RB, Rajan KE, et al. Intrapleural streptokinase in complicated parapneumonic effusions and empyema. The Indian journal of chest diseases & allied sciences. 2004 Oct-Dec;46(4):257-61.

(27) Kalokairinou-Motogna M, Maratou K, Paianid I, et al. Application of color Doppler ultrasound in the study of small pleural effusion. Medical ultrasonography. 2010 Mar;12(1):12-6.

(28) Bosmans JML, Weyler JJ, De Schepper AM, et al. The Radiology Report as Seen by Radiologists and Referring Clinicians: Results of the COVER and ROVER Surveys. Radiology. 2011 2011/04/01;259(1):184-95.

(29) Langlotz CP. Structured radiology reporting: are we there yet? Radiology. 2009 Oct;253(1):23-5.

(30) Kahn CE, Jr., Genereaux B, Langlotz CP. Conversion of Radiology Reporting Templates to the MRRT Standard. Journal of digital imaging. 2015 Mar 17.

(31) Govender N, Andronikou S, Goodier MD. Adequacy of paediatric renal tract ultrasound requests and reports in a general radiology department. Pediatric radiology. 2012 Feb;42(2):188-95.

(32) Bosmans JM, Peremans L, Menni M, et al. Structured reporting: if, why, when, how-and at what expense? Results of a focus group meeting of radiology professionals from eight countries. Insights into imaging. 2012 Jun;3(3):295-302.

(33) Balik M, Plasil P, Waldauf P, et al. Ultrasound estimation of volume of pleural fluid in mechanically ventilated patients. Intensive care medicine. 2006 Feb;32(2):318-21.

(34) Usta E, Mustafi M, Ziemer G. Ultrasound estimation of volume of postoperative pleural effusion in cardiac surgery patients. Interactive cardiovascular and thoracic surgery. 2010 Feb;10(2):204-7.

(35) Miller KE, Mims M, Paull DE, et al. Wrong-side thoracentesis: lessons learned from root cause analysis. JAMA surgery. 2014 Aug;149(8):774-9.

(36) Ofte SH, Hugdahl K. Right-left discrimination in male and female, young and old subjects. Journal of clinical and experimental neuropsychology. 2002 Feb;24(1):82-92.

(37) Havelock T, Teoh R, Laws D, et al. Pleural procedures and thoracic ultrasound: British Thoracic Society Pleural Disease Guideline 2010. Thorax. 2010 Aug;65 Suppl 2:ii61-76.

(38) Sikora K, Perera P, Mailhot T, et al. Ultrasound for the Detection of Pleural Effusions and Guidance of the Thoracentesis Procedure. ISRN Emergency Medicine. 2012;2012:1-10.

(39) Hempel JM, Pinto dos Santos D, Kloeckner R, et al. [Reporting initiatives. An update on treatment in radiology]. Der Radiologe. 2014 Jul;54(7):696-9.