Common findings of thoracic ultrasound performed by respiratory specialists

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Introduction

Thoracic ultrasound (TUS) is increasingly considered an important investigational technique for the respiratory physicians (1,2). For this reason, the use of thoracic ultrasound (TUS) in the UK has become a part of the clinical practice. Thoracic ultrasound was initially used mainly by the radiologists. However, over the recent years it has acquired increasing use by the respiratory physicians. Due to the size and the portability of the equipment, thoracic ultrasound can be used in an out patient settings as well as at the bed side assessment tool (3). Using thoracic ultrasound as 'at the bed side' assessment tool allows for the clinical decision making, real time procedure guidance and assessment of response to the treatment (4,5). This wider use of thoracic ultrasound extended its initial diagnostic role to more clinically relevant applications. The wider use of thoracic ultrasound is related to the development in ultrasound technology, which now provides high quality portable units. The other important aspects that expanded its use are related to the fact that respiratory trainees in the UK are required to gain thoracic ultrasound competencies as part of the Respiratory Medicine curriculum (1,6). This resulted in a wider number of respiratory physicians being able to use thoracic ultrasound in their clinical practice. One of the main drivers behind this was the National Patient Safety Alert in 2008, which identified a number of deaths and iatrogenic complications following the insertion of Seldinger chest drains. This report made compulsory the use of thoracic ultrasound for intervention for pleural fluid management. In this report we describe our experience in performing thoracic ultrasound by respiratory specialists for clinical use.

Methods:

Retrospective review of findings of the thoracic ultrasound performed by respiratory specialists. A database of anonymised patients who underwent thoracic ultrasound performed by respiratory specialists were analysed with regards to the presence of a pleural effusion, its size and location, and their aetiology and other findings. The findings were then divided according to their aetiology into 11 major groups: no effusion, malignancy, inflammatory/trauma, infection, cardiac, post-CABG, renal, liver, pleural disease, miscellaneous and idiopathic. The pleural effusion was quantitated to size, based on an arbitrary definition of small (≤ 1cm in depth), medium (> 1cm but < 5cm in depth) and large (≥ 5cm in depth).

Findings/results:

Overall thoracic ultrasonography findings were analysed form 1159 anonymised patients. Pleural effusion was the most common characteristic identified on thoracic ultrasound reported in 999 (86.2%) of cases. Malignancy was the most common aetiology for pleural effusion found in 44.9% cases. The other aetiology of pleural effusion included infection reported in 25.5% of cases with inflammatory/trauma reported in 9.9% cases, cardiac causes in 7.1% of cases. The other less common aetiologies of pleural effusion reported on thoracic ultrasound included asbestos pleural disease (3.9%), post-CABG (1.7%), liver disease (1.6%), renal disease (1.1%), idiopathic (1.2%) and miscellaneous (1.1%). In 21 (2.1%) cases, more than one underlying disease was identified as a possible aetiology for the pleural effusion. In 160 (13.8%) cases there was no pleural effusion identified on the thoracic ultrasound. In this group, infection and malignancy were both the most common aetiology for cases without pleural effusion (35.0% each), followed by asbestos pleural disease (11.9%), inflammatory/trauma (9.7%), cardiac (3.1%), miscellaneous (1.7%) and post-CABG (1.1%). In 4 cases (2.5%) were follow-up procedures that were completely normal.

Overall, large pleural effusion was the most common finding. Amongst 448 malignant pleural effusions was reported in 216 (48%) of examinations, medium size in 155 (35%) examinations and, small in 77 (17%) examinations. In 254 examinations where underlying cause was infection, 68 (27%) reported large pleural effusion, 117 (46%) medium size and 69 (27%) small size pleural effusion. In 99 pleural effusions due to inflammatory causes 17 reported large pleural effusion, 63 medium size and 19 small size. Of the 71 ultrasounds where cardiac causes were identified 24 reported large pleural effusion, 41 medium size and 6 small pleural effusion.

Discussion

This study reported on the findings of thoracic ultrasound performed by the respiratory specialists. The most common causes of plural effusion were malignancy, infection and inflammatory causes. Other less common causes included, pleural thickening, pleural effusion due to liver or renal diseases or post CABG surgery. This provides information on the spectrum of disorders that respiratory specialists are utilising thoracic ultrasound for their clinical practice. Over the recent years, the use of thoracic ultrasound has become a more practice for respiratory specialists. Thoracic ultrasound is used both to manage in patients with pleural disorders as well as managing patient on ambulatory pathways. Thoracic ultrasound is also gaining increasing role as a point of care diagnostic and monitoring tool in emergency departments and intensive care units. A recent systematic review revealed that the use of thoracic ultrasound resulted in 34% diagnostic changes in the emergency department settings and 44% in the Intensive Care Units (ICU) (5). In addition, 48% of thoracic ultrasounds resulted in substantial management changes in emergency department and 42% in ICU. Similarly, respiratory physicians have extended the role of thoracic ultrasound form the initial assessment of pleural effusion. Thoracic ultrasound can be used now to assess the chest wall, parietal pleura, pleural effusion, lung parenchyma, pneumothorax as well as the assessment of the diaphragm and its motion. The guidance of pleural procedures in clinical setting remains one of the other important uses of thoracic ultrasound. From technical aspect majority of operators use a low frequency probes of 2 to 5 Hz, which offers adequate tissue penetration for visualisation the required structures. When visualisation of chest wall or parietal pleura is of importance, the use of a high frequency linear probes of 5 to 10 Hz may be more appropriate (4,7). The combination of those two types of probes allows for a comprehensive assessment using thoracic ultrasound.

Although thoracic ultrasound is an useful clinical tool for assessing the chest wall and parietal pleura, overall computed tomography (CT) and magnetic resonance imaging may be more accurate here (8,9). When using thoracic ultrasound there are number of important aspects that would need to be taken into consideration. During thoracic ultrasound examination, visceral and parietal pleura and intercostal muscles are seen as pleural line and in healthy person it forms what is called lung sliding sign. In addition, some of the rare benign pleural tumours such as fibroma or lipomas may be detected on the thoracic ultrasound as well as asbestos pleural plaques, which can produce prominent acoustic window (8,9). In addition, thoracic ultrasound can detect parietal pleura thickening. Moreover, thoracic ultrasound is of particular use in detecting malignant pleural nodularity, chest wall invasion or associated pleural effusion (8). This is where the high frequency probe may be of greater relevance. However, the most common use of thoracic ultrasound is in the context of pleural effusion. The use of low frequency probes allows to locate the pleural effusion and determine its depth. The use of thoracic ultrasound settings may be of help here especially by adjusting the depth and gain. Historically pleural effusion appearances can be described as anechoic, complex non septated, complex septated and homogenous echogenic as described by Yang et al (10). Although there are certain characteristics that may help in differentiation between exudate and transudate on thoracic ultrasound none of them are specific enough to rely solely on ultrasound characterisation. For example, transudate may be anechoic but a proportion of transudate pleural effusions can be echogenic. However, exudate pleural effusion will show echogenicity and may appear complex (12). Similarly, malignant pleural effusion may show characteristics of exudate but these are not specific to make diagnosis with confidence (13).

Infective pleural effusion may show complex appearances with septation and “suspended microbubble” sign which was reported in frank empyema (14). However, pleural fluid sampling is required to confirm pleural infection. Thoracic ultrasound frequently complements or can be used in conjunction with other modalities such as computed tomography, positron emission tomography or magnetic resonance Imaging (15, 16).

Thoracic ultrasound skills are overall relatively straight forward to acquire. Training for thoracic ultrasound has been undertaken for a number of years now. The initial training was based on the curriculum of the Royal College of Radiologists (RCR) guide recommending Level 1 thoracic ultrasound, which was adopted by the Joint Royal Colleges of Physicians Training Board (JRCPTB) Respiratory Medicine Curriculum. The parameters used included the recognition of normal anatomy of the pleura and the diaphragm, pleural thickening, echogenicity of pleural effusion, colour and Doppler flow, identification of the heart, liver and the spleen, pleural anatomy, differentiation of the pleural effusion and consolidation and the use of thoracic ultrasound to guide the thoracocenthesis and a chest drain insertion. Moreover, theoretical knowledge of physics and technology of ultrasound was included. The current standards for training in thoracic ultrasound have been published with conjunction with the British Thoracic Society (1). This document provides description of different levels of competency including emergency, primary, advanced and expert operators. The standards use the Entrustable Professional Activities (EPAs) as tools for assessment to recognise eligibility of independent practice. The emergency operator should be able to recognise a large pleural effusion and to distinguish major organs and recommend a suitable site for a safe aspiration or drainage (1). Primary operator should be able to practice independently to allow identification and characterisation of pleural effusion and to enable safe pleural procedures (1). The trainees should complete training course covering basic understanding of the ultrasound principles, modes, sonographic anatomy of thoracic cavity. In addition they should be able to identify pleural fluid and its depth, pleural thickening and malignancy, normal sliding lung sign, echogenicity of the pleural effusion, septation and loculation, diaphragmatic movement and recognition of paralysis and to identify site for safe aspiration or drainage of pleural fluid. Majority of operators will be within the primary operator competency. However, there will be a smaller number of respiratory specialists, who may achieve competencies for the advanced and the expert operator. For the advanced operator competencies, an individual would be expected to practice at the level of primary operator for at least 2 years. In addition, they would be expected to determine a number of thoracic ultrasound findings such as absence of lung sliding sign, which may be present in cases of pneumothorax or pleurodesis, to be able to assess for diaphragmatic paralysis, to perform a real time pleural fluid aspiration or chest drain insertion, to be able to use thoracic ultrasound for an indwelling pleural catheter insertion and to demonstrate that they participate in the annual review and appraisal of their practice (17). For the expert operator over 70 thoracic ultrasound procedures are required to be undertaken each year. The operator requires to be able to correctly interpret the advanced modes such as M mode, colour and Doppler, accurately assess diaphragm function, safely obtain pleural biopsies under the ultrasound guide, use ultrasound to assess if induction of pneumothorax at thoracoscopy can be achieved and to demonstrate annual review and appraisal. Thoracic ultrasound operators would be required to maintain their competency. The requirements for maintenance of competency for the emergency operator level include performing at least 5 thoracic ultrasound scans with pleural effusion per year. Those for the primary level operator include undertaking at least 20 thoracic ultrasound scans pear year. Advanced level operator would be expected to perform 30 scans per year and expert level operator would expect 70 scans per year. Although these number are only a guide.

In our report, we described the use of thoracic ultrasound performed by respiratory specialists for managing patients with pleural disorders. Thoracic ultrasound is radiation-free, low-cost, rapid, and portable, allowing real-time examination of pulmonary structures (16). The use of thoracic ultrasound assists with the initial assessment of patient with pleural disorders. Moreover, thoracic ultrasound helps in performing pleural procedures. Overall, the use of thoracic ultrasound by respiratory specialists provides improved care for patients with pleural disorders. Moreover, the use of thoracic ultrasound has been shown to improve safety of pleural procedures. The structured training and the inclusion of thoracic ultrasound in the Respiratory Medicine Curriculum will help to maintain the use of thoracic ultrasound by the respiratory specialists. The publication of the national thoracic ultrasound training standards should assure the quality. This report therefore, supports the use of thoracic ultrasound by the respiratory specialists and describes the range of conditions for which there was a clinical application of thoracic ultrasound. The use of thoracic ultrasound remains an important skill for the respiratory specialists and will remain an important tool for managing patients with pleural disorders.

The Covid 19 pandemic has had a significant effect on the health systems around the world 1. Health care systems had to adapt in order to meet the needs of the Covid 19 pandemic and to continue to deliver non-pandemic related care 2. The new Omicron Covid 19 surge reached the UK at the end of year 2021. It rapidly became apparent that the hospitals were facing challenges not only in relation to the increase in demand resulting from the admissions due to Covid 19, but also due to the workforce shortages in relation the staff sickness 3. During the initial waves of the Covid 19 pandemic in 2020, the hospitals employed different strategies including reduction in outpatient and elective services, development of COVID and non-COVID care pathways and wards, large-scale redeployment of health work, and expansion of telemedicine. However, during the Omicron Covid 19 surge the service requirements remained to continue with both Covid 19 and non Covid activities. The main challenges were to manage the increasing staff sickness and the large numbers of Covid 19 admissions 4. Therefore, it was not possible to employ the approaches such as a large scale redeployment and more targeted strategies were required in order to manage the Omicron Covid 19 surge. In this report, we describe an approach undertaken in a large University Teaching hospital based on an effective management of staff sickness due to Covid 19 pandemic utilising a co-ordinated approach through a designated workforce co-ordination group.

Methods

The Hull University Teaching Hospitals NHS Trust delivers secondary and tertiary services to a large geographical area of both urban and rural population for Hull, East Yorkshire, parts of North Lincolnshire and North Yorkshire. In December 2021, a small Medical Workforce Co-ordination Group was formed with the aim to co-ordinate workforce issues during the Omicron Covid 19 surge. The core members of the team included the Director of Outpatients chairing the group, Divisional General Managers from the health groups of Surgery, Medicine, Women's and Children Health, Deputy and Chief Medical Officers, Director of Medical Education and the Manager of Medical Education. The group's purpose was set to focus the medial workforce where it was required with the priority provided to the core services. The operational team was providing daily information on the priority areas and the available staff. This in turn allowed the workforce co-ordination group to make the full and appropriate use of the staff resource available with the priority given to the core services. The core services were identified as follows: staff and patient testing services, vaccination services, essential digital services, site management and discharge services, Emergency Department, Assessment and Ambulatory Care units, acute direct admission pathways, Critical Care, inpatient wards and theatres for acute and urgent care, adult and paediatric acute clinical work across medical, surgical and cancer services, emergency and trauma services in categories P1a and P1b, all clinically urgent services in categories P2, all high priority cancer treatment services, all high priority outpatient treatment services including 2ww clinics and HOT clinics, all high priority diagnostic services.

The Medical Workforce Co-ordination Group met every day at 9.30 in the morning between 23rd of December 2021 and 4th of February 2022. The meetings were also attended by the clinical representatives mainly consultants on call, who had up to date information on the sickness and absence numbers for each health group. These data were collected at 9am each morning by which time junior and senior doctors would be expected to report to the wards or report their sickness, therefore allowing for the accurate information on the actual sickness and absence levels. The impact of sickness and absence were reviewed from the hospital's priority areas therefore facilitating the decisions about the emergency and planned redeployment and provided a rapid and effective method for escalation of requests for mutual help. Moreover, this system was supported by the effective processes of prioritisation of PCR testing to assess whether they can safely return to work.

Results

The daily staff sickness rates at HUTH NHS Trust in the week starting the 5th of December 2021 were between 97 and 163 per day and started to gradually increase through December with sickness levels in the last week of December 2021 being reported between 350 to 386 per day. For example, on the 21st of December 2021 in HUTH NHS Trust there were 55 Covid 19 positive inpatients and 199 staff absent due to Covid 19. The reported infection rates were

491.7 and 502.3 in Hull, and the East Riding respectively with the R Rate of 1.0 to 1.2. This has increased further and on the 7th of January 2022, when the HUTH NHS Trust recorded 89 Covid 19 in patients, 658 staff absent due to Covid 19 with the staff absence of 1027 representing 11.31% of staff. The week starting 10th of January 2022, the reported R rate was 1.3 to 1.6 for North East and Yorkshire. On the 10th of January 2022, in our institution, there were 94 Covid 19 in patients and 827 (9.1%) staff absent due to sickness of which 510 were due to Covid 19. The sickness leave for that week were reported between 942 to 1066 per day and started to slowly decrease with the numbers on the 20th of January 2022 showing total sickness of 589 (6.5%) with 277 due to Covid 19 and 126 of in patients with Covid 19.

Overall the absences due to Covid 19 at consultant level were covered internally by the consults within the same specialty. The junior doctors' absences were co-ordinated through the each health group. However, a small group of junior doctors had to be redeployed. This included 2 junior doctors from ophthalmology and 1 from dermatology who supported the neurosurgical and acute admission wards. Additional 5 Internal Medicine doctors were moved for short periods of time from their ICU placement to support respiratory HDU. 17 January, 29 Medical staff absence due to Covid 19 and 30 for other sickness. On the 2 February 2022, 38 absence due to Covid 19 and 34 due to other sickness. When reviewing the reasons for absence in 14 days prior to 2 February 2022 was as follows: lateral flow device positive 110, diagnosed with Covid 19 31, self-isolation due to co-habitor symptoms 24, self-isolation extension 21. Table 1 shows daily, weekly and total Covid and non-Covid related staff absences within our organisation for the period between 5/12/2021 and 15/05/2022.

Discussion

Our report describes an organisational changes introduced, within a large University Teaching Hospital delivering secondary and tertiary services and employing over 600 junior doctors, to manage doctors sickness resulting from Omicron Covid 19 pandemic. The introduction of a workforce co-ordination group allowed for an effective approach to a rapidly changing gaps in service delivery due to the staff absences resulting from Covid 19 sickness. The group had an accurate up to date information on the doctors' absence levels and an overview of the areas with the high staff sickness. As the major stakeholders were represented, the decisions were made in a timely fashion and information was transferred efficiently. Moreover, the decisions were made early in the day allowing for the plans to be made for both day and night shift work. Each day the available workforce was identified and arrangements were made to secure activities for the priority areas. This was a different approach to that adapted during the previous waves of Covid 19 pandemic in order to meet the demands of the of patients, increase capacity and prevent in-hospital infection. Many institutions introduced changes in the work patterns, their rotas and a large scale redeployment 5, 6. These changes significantly affected the work within the hospitals, working conditions, wellbeing; especially the frontline healthcare teams, training and education. This contrasted with the approach described in this report, which was based on more co-ordinated strategies involving precise distribution of the workforce with maintaining tertiary hospital function and maintaining essential services.

In the NHS in England prior to Covid 19 pandemic in January 2020, the overall sickness levels were 4.8% and for the doctors 1.5% 3. The reports have suggested that in April 2020 5.7%

sickness rates for doctors, although the rates might have been much higher Ref 8. In the first few weeks of January 2022 there were over 80 thousand NHS staff absent from work each day of which more than two fifths (over 35 thousands) were absent due to Covid 19 infection or isolation. The figures for sickness in the North East and Yorkshire were over 16 thousand, of which over seven thousand were due to Covid 19. In January 2022 at least 24 of the 137 Trusts in England declared critical incidents 6, 7. Many trusts declared critical incidences defined as principally an internal escalation response to increased system pressures/distribution to services that are or will have detrimental impact on the organisation's ability to deliver safe patient care. The staff absences due to Covid 19 surges have put many acute care hospitals under pressure. Whilst the situation started to improve by the end of January 2022, the national data for the week ending 30th of January 2022 in England revealed that there were 28,000 hospital trust staff absent from work due to Covid 19 5. This represented 40% of total absences. The surveys have revealed that the NHS staff in workplaces that have been affected by staff shortages. 71% reported that staff were working extra shifts and overtime, 38% that agency staff were used and 36% reported redeployment from nearby locations to assist 5. Therefore, the challenge remained for the acute care hospitals to make sure that there was enough staff to run the services. The situation was confounded by the fact that the absences were taking place in unplanned manner due to the nature of the pandemic with staff members being absent due to being tested positive for Covid 19 or because of impact of isolation. The system introduced in our institution helped to streamline sickness reporting amongst the doctors. This was supported by the fast track and access to the PCR testing for the staff with suspected Covid 19 infections.

The workforce co-ordination group allowed to identify the individual doctors who required the rapid access to the PCR testing and facilitated the testing through the help desk co-ordinating the appointments for the Covid 19 testing. We identified that certain specialities such as Family and Women's health and Radiology due to more specialised nature of their worked managed to cover the vacancies within their own services. Services such as General Medicine or Emergency Medicine received support from other specialties. The workgroup allowed for an overview of medical staffing during the Covid 19 Omicron surge. As the group was meeting on a daily basis the changes were regularly assessed.

Junior' hospital doctor is a term which refers to all doctors who have completed a medical qualification but have not reached consultant or specialist grade. Previous reports suggested that staffing matters for junior hospital doctors. Research has shown that improvement to workplace relationships, collaboration, access to clinical support and workplace morale resulting in improved quality of working life 8. The workforce daily meetings forced us to assess more proactively our staffing levels. This was achieved through the improved communication with the junior doctors. There was a system introduced of daily emails to the Resident Medical Officers (RMOs). This was of particular importance for the overnight duties cover. The clinically safe staffing plan and staffing shortages were addressed and gaps that could not be covered were organised so that the most vulnerable and important areas were covered. Moreover, face to face meeting with the lead RMO or their deputy took place, which received a very good feedback.

Covid 19 pandemic posed challenges on the health system and a degree of personal risk to the healthcare workers 2, 9. Those risks are perceived on two levels; firstly at the personal level with over 400 workers in the UK dying in 2020 form Covid 19 and secondly due to the effects of workforce absence due to Covid 19 has on the individual organisations 4. There are a number human factors, which were highlighted in a British Medical Association survey, that affects staff sickness such as anxiety, depression, stress and burnout form Covid 19 pandemic work 4, 5. The organisations therefore are encouraged to undertake prevention strategies to reduce the risks to the staff from Covid 19 surges such as primary prevention strategies focusing on basic needs and secondary prevention strategies supporting traumatised staff including peer support and access to formal professional support 4, 5. As a result of Covid 19 surges the health care system would require to centre on how to protect the patients as well as the staff. This would affect issues such as patients flow and social distancing, testing policies including rapid access to polymerase chain reaction (PCR), point of care testing 9. Many hospitals undertook widespread redeployment to areas managing Covid 19 patients. Our model relied on carefully managed limited redeployment of a small number of staff to cover sickness within the areas and departments which were hardest hit by sickness or the areas which were most fundamental for running the hospital such as medicine and emergency departments. Therefore, our model of daily workfare co-ordination allowed to adapt to this unplanned staff absence and to co-ordinate the workforce in order to deliver services within a large tertiary referral teaching hospital. As a group, we worked so well in setting up a system or process, a good model of communication and the amount of collaboration that you've seen here, has been good and we need to capture good practice.

The group also provided a support system for junior doctors which reduced the negative effects of Covid 19 pandemic on well-being and allowed to maintain their morale. The consultants and junior doctors worked closely with the management teams to fulfil the common aim of maintaining hospital services. The strong leadership from all the stakeholders allowed to maintain safe levels of staffing despite the challenges of the Covid 19 surge. In conclusion, the formation of the workforce co-ordination group formed an effective model of managing clinical services and staff absences during the omicron Covid 19 pandemic.

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Table 1

Daily, weekly and total Covid and non-Covid related staff absences within our organisation for the period between 5/12/2021 and 15/05/2022

	7 Day Average									
w/e	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Covid	Sickness	All Absence
05-Dec	97	142	163	149	148	171	143	145	300	445
12-Dec	125	160	157	161	154	167	151	154	316	470
19-Dec	128	157	180	222	179	224	205	185	352	537
26-Dec	194	202	246	285	280	252	240	243	363	605
02-Jan	265	320	404	493	547	595	559	455	350	805
09-Jan	607	615	691	696	658	587	546	629	349	977
16-Jan	510	435	375	323	304	251	229	347	346	692
23-Jan	218	252	225	227	224	225	221	227	363	590
30-Jan	189	213	244	234	220	212	195	215	375	590
06-Feb	194	227	211	217	206	201	161	202	382	584
13-Feb	152	156	150	151	136	123	95	138	385	523
20-Feb	89	109	98	107	102	94	79	97	394	491
27-Feb	92	110	104	100	116	122	99	106	388	494
06-Mar	83	104	107	132	120	149	124	117	410	527
13-Mar	104	117	116	147	141	186	155	138	425	563
20-Mar	122	158	182	201	208	278	245	199	422	621
27-Mar	209	248	281	298	305	300	304	278	414	692
03-Apr	242	274	287	277	282	314	269	278	441	719
10-Apr	218	228	235	282	224	255	219	237	487	724
17-Apr	174	186	199	207	243	208	175	199	433	632
24-Apr	139	131	162	157	162	176	151	154	410	564
01-May	120	120	118	116	113	103	100	113	420	532
08-May	87	80	90	83	78	75	61	79	430	509
15-May	48	53	51	48	42	42	35	46	443	488