New cost-effective pleural procedure training

Manikin-based model to increase the confidence and competency in trainee medical officers

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Title Page

A new cost-effective pleural procedure training-mannequin-based model to increase the confidence and competency in trainee-medical-officers

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Authorship: SH, DS, SHM designed the study. SH organized the survey, collected the data and has full access to all of the data in the study. SH, DV helped in development of the mannequin. DV helped in writing the mannequin description and supplied images. SUM, SH

and HF contributed to the interpretation of data and wrote the manuscript. SH, SUM contributed to the literature review. SUM, SH, SHM, DS and HF revised the manuscript for intellectual content and approved the manuscript to be published.

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Key Message

Pleural procedures are commonly performed and can be associated with complications, especially when performed by less experienced medical practitioners. Traditional apprenticeship model has paved a way to structured training, such as use of training mannequin and procedural skills workshop. However, high costs associated with the above may be a hurdle for some institutions. We hereby describe a new, cost-effective training model using a simple mannequin developed in our institute and provide an effective way to document skill acquisition and assessment among trainee medical officers.

Abstract:

PURPOSE OF THE STUDY: Pleural diseases are common in clinical practice. Doctors in training often encounter these patients and are expected to perform diagnostic and therapeutic pleural procedures with confidence and safely. However, pleural procedures can be associated with significant complications, especially when performed by less experienced. Structured training such as use of training mannequin and procedural skills workshop may help trainee doctors to achieve competence. However, high costs involved in acquiring simulation technology or attending a workshop may be a hurdle. We hereby describe a training model using a simple mannequin developed in our institution and provide an effective way to document skill acquisition and assessment among trainee medical officers.

STUDY DESIGN: This was a prospective observational study. The need for training, competence and confidence of trainees in performing pleural procedures was assessed through an online survey. Trainees underwent structured simulation training through a simple mannequin developed at our institute. Follow-up survey after the training was then performed to access confidence and competence in performing pleural procedures.

RESULTS: Forty-seven trainees responded to an online survey and 91% of those expressed that they would like further training in pleural procedure skills. 81% and 85% of responders respectively indicated preferred method of training is either practicing on mannequin or performing the procedure under supervision. Follow-up survey showed improvement in the confidence and competence.

CONCLUSION: Our pleural procedure training mannequin model is a reliable, novel and cost-effective method for acquiring competences in pleural procedures.

Introduction:

Pleural diseases (pleural effusion and pneumothorax) are common clinical problems worldwide. Very often doctors in training encounter these patients and are expected to perform diagnostic and therapeutic pleural procedures with confidence and safety.[1,2] However, pleural procedures such as diagnostic and therapeutic pleural aspiration, chest drain insertion, and pleural biopsy can be associated with significant adverse events, especially if performed by less experienced personnel.[1-3] Previously, National Patient Safety Agency (UK) and other clinical audits/studies have shown that serious harm to patients and even deaths have been reported following pleural procedures and the vast majority of complications were the result of inexperience, inadequate training, and/or related to poor technical skills.[1,3-7] Therefore, it is recommended that all personnel managing patients with pleural procedure should have adequate training prior to performing one on their own.[3]

Traditionally, procedure skills are learnt through self-directed learning or by observing one performed by more experienced colleagues and performing one on their own (see one, do one, teach one).[8] Unfortunately, the apprenticeship model may be unfeasible for many doctors in training due to lack of opportunities and supervision. In addition, it can be a serious risk for patient safety. Studies have shown that doctors in training are compromised in performing pleural procedures with confidence due to lack of experience, opportunity, supervision, guidance, time and fear of complications being identified as the main reasons.[8-10] However, the risks of complications from pleural procedures can be avoided and confidence and competency can be achieved with appropriate clinical training. Procedure skill competence can be achieved through structured training by utilising training modalities such as training mannequin and through procedure skills workshop. This will enable doctors in training to perform procedures more independently with decreasing level of supervision.[8,11,12]

Studies have demonstrated that procedure skill workshop especially during the first year of training increases the confidence and competence among junior medical doctors.[13]

The costs involved in acquiring simulation modules and opportunity to attend dedicated training workshops may be a hurdle for some institutions. In this article we share our experience with a simple pleural procedure training mannequin model 'Daisy' by providing a way to document acquisition of skill, guided individualized teaching, and assist with the assessment of the adequacy in pleural procedure skills among doctors in training.

Methods and Results:

Background

All doctors in training were invited through the trainee medical officer unit to participate in an on-line survey to understand the current knowledge and training needs on common day-to-day procedure skills. This is a usual practice in our institution to conduct an audit on training needs of trainee medical doctors every year. There was an overwhelming response of the trainees in the desire to gain more training in pleural procedures (see results below). A pleural procedure training module was developed in collaboration with the Respiratory Medicine service and medical simulation lab at our centre. The local Ethics Committee approved the study.

Survey outcome

Forty-seven early career medical officer trainees responded to an on-line survey about the current knowledge and training needs on common day to day procedural skills. Of them 30 (63%) were interns, 13 (28%) were basic physician trainee (BPT; Year 1-3) and 4 (8%) were other registrars (Year 1-3). Nine (19%) were overseas trained doctors. Twenty-seven (57 %),

10 (21%) and 10 (21 %) were currently working under medicine, surgery or another speciality, respectively. The average clinical experience varied anywhere between one month to 10 years. Forty-three out of the 47 responders (91%) expressed that they would like to have training in pleural procedure skills. These included diagnostic and therapeutic pleural drainage and chest tube insertion. About 47%, 53% and 55% of the responding trainees indicated that they had not performed diagnostic pleural tap, therapeutic pleural drainage and chest tube insertion, respectively, in the past (Diagram 1).

Table 1 shows the questions and average response on a scale 1 to 5 (1 being least and 5 being maximum). Similarly, knowledge and competency were assessed on a scale of 1 to 5 (Table 1) (1 being strongly agree and 5 strongly disagree). About 81% and 85%, respectively, of responders indicated that their preferred method of gaining confidence in pleural procedure was through either practicing on a pleural procedure training mannequin or performing the procedure under supervision, respectively.

Training Mannequin

A mannequin nicknamed ‘Daisy’ was developed in collaboration with SHARP Dummies Pty Ltd, Adelaide, South Australia, Australia and Industrial Design Engineering, Delft University of Technology TU Delft, The Netherlands. The mannequin consisted of removable rib block to fit into approximately 3 rib spaces (Figure 1Panel a). A 40-mm layered structure to mimic the chest wall and pleura was created (Figure 1Panel b and c). Silicones of varying rigidity or softness were used to biofidelically mimic different anatomically normal body layers. The layers included were to mimic skin, fat, intercostal space, connective tissue and parietal pleura. Each layer had a specified feel and was developed and tested independently. In addition, each layer had different thickness, which contributed to the overall feel of the module to give real time effect. The module was tested repeatedly for feel and performance

by the procedural medical specialist. In addition, there was a reservoir created inside Daisy's torso for either air or fluid which could be aspirated. Two block spaces were created on the torso, one posteriorly for pleural aspiration training and another in the anterior axillary space (safe triangle) for chest tube insertion training (Figure 1 Panel d). Furthermore, an external water container was created to refill the fluid into the Daisy's torso reservoir (Figure 1 Panel e). Finally, there was a layer that represented the collapsed lung. Daisy was created in such a way to simulate realistic skin thickness, subcutaneous tissue and pleural membrane, so that the trainees feel the giveaway sensation while penetrating the pleura while inserting chest tube.

All trainees were provided with access to gain knowledge on pleural procedures skills via the trainee medical unit portal prior to undergoing training in the Medical simulation lab. This included theoretical knowledge (Power Point presentation) and video demonstration of pleural procedure.

Training in the medical simulation lab

A total of 35 trainees participated in the training. A group of three trainees were enrolled to attend the medical simulation lab for training on mannequin on each session. Various types of pleural catheters and chest drains, including Seldinger technique models currently used in our centre were demonstrated to all participants. Role-play was performed on each other taking consent, examination, reviewing radiology imaging, aseptic precautions and explaining the complications of the procedure prior to performing the procedure on the training mannequin. Trainees performed simple plural aspiration on the posterior side, while the mannequin was placed upright and inserted a chest drain on the mannequin placed in supine position. The mannequin was also secured firmly with bolt and screw on to the table (Figure 1), so that it is

stabilized and does not move while performing the procedure. All participants were under the guidance/supervision of an experienced respiratory physician.

Trainees experienced aspiration of fluids from the training module to have a positive real experience that pleural effusions were correctly aspirated. For chest tube insertion a 20-Fr chest tube was used adopting blunt discussion technique at the safety triangle. Operative tube thoracostomy method as described in standard procedure manuals was followed for placement of Large-bore (LB) intercostal tube. Trocar method was no longer practiced in our centre due to possible potential serious operator related complication. A 3-cm incision was made in the chest block that was extended to fascia overlying the intercostal muscle, and then blunts dissection with a haemostat was done, until the intercostal interspace was identified. Parietal pleura was then, penetrated by pushing a blunt-tipped haemostat through it. The operator enlarged the hole with the index finger. A haemostat was used to guide the tube into the pleural space as the operator's finger was withdrawn. Seldinger catheter insertion technique was not used during this training.

Post training survey

All trainees who participated in the simulation were invited to participate in the post trainings survey, approximately three months following the training. The parameters assessed are shown in Table 2. Out of the 35 trainees attended 23 responded (66%) to the post training survey and of them 26% were interns, 61% were BPT (Year 1-3) and 13% were registrars (Year 1-3). Post survey (Table 2) demonstrated that the knowledge and confidence in performing pleural procedures was better (Diagram 2). Moreover, the current training module was close to a realistic experience. However, some participants reported that after the training they did not encounter patients requiring pleural procedures (Diagram 2 and Table 2).

Other comments of the trainees

1. It would have been good if the draining fluid simulated blood or pus
2. Blood stains on incisions would look realistic
3. Certainly, increased my confidence
4. Useful training, but skills lost through lack of opportunity to observe/perform procedure on real patients
5. Simulation seemed to be abbreviated. Should have performed procedure from start to end with sterilization, draping, finding anatomical land mark etc., instead of just told basics, cut or insert needle here etc. However, some simulation is better than none. However, having supervision on real patient cannot be beaten for quality or learning
6. It was good; however, I think the best training is on live patient with supervision.

Discussion

The training module demonstrated in this study included a pre and post training survey on knowledge, experience and confidence levels of junior medical staff in performing pleural procedures. It also trialled a simple cost-effective simulation model. Given the cost involved in acquiring simulation modules for training in many institutions, this could be a more cost-effective alternative. The model presented here could easily be incorporated into chest tube insertion training programs elsewhere.

The incidence of patients presenting with pleural disease is increasing worldwide. These patients will be seen by a variety of specialists and doctors in training, both surgical and medical, with varying level of training and experience.[3] Pleural procedures are commonly performed and include thoracentesis, chest drain placement, tunneled intra-pleural catheter placement and pleuroscopy. Procedures, such as thoracentesis have even been identified as a core competency for hospitalists.[14] However, residency training in internal medicine may not

provide hospitalists with the skills to safely perform such necessary procedures.[15] Pleural procedures can be associated with serious complications and are more commonly noted when performed by less trained personnel[16] and without use of ultrasound.[17] Given the increasing number of patients with pleural disease and the limited published data on complications of pleural procedures[18], it is likely that the pleural procedure-related complications are underreported. However, the risks of complications from pleural procedures can be greatly reduced with appropriate clinical training, especially among trainee medical doctors.[1-5] In a meta-analysis by Gordon *et al.*, overall iatrogenic pneumothorax following thoracentesis was 6%, with 34% pneumothoraces needing chest tube insertion. Lower pneumothorax rate was observed with experienced operators (3.9% vs 8.5%, P=0.04) and with use of ultrasonography (odds ratio [OR], 0.3; 95%CI, 0.2-0.7).[19] British Thoracic Society recommends that all doctors expected to be able to insert a chest drain should be trained using a combination of didactic lecture, simulated practice and supervised practice until considered competent.[20]

Earlier studies have shown that training in pleural procedures is limited and need for further training.[9,10,21,22] It is also noted that resident doctors were uncomfortable performing common procedures and this was higher for thoracentesis than for other procedures including central line insertion, lumbar puncture or paracentesis.[23] Our study confirms this as most doctors in training in our study felt they needed more training in pleural procedures. Ninety-one percent of the initial responders expressed that they would like to have training in pleural procedure skills of all the other procedures performed routinely as doctors in training. Earlier studies have demonstrated that resident doctors (in about 87%) referred thoracentesis procedure to radiology service due to lack of confidence in performing such procedures on their own.[22] This has been replicated in other studies. [24] Referral to radiology may be the best practice if prompt interventional radiology services were available 24x7. However, even at major

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Explanation as described

hospitals in developed countries like Australia and United Kingdom, this is not the case. Regional and rural hospitals may even lack interventional radiology services. This may affect timely patient care with potential of unfavorable outcomes. Further, research on the outcomes and costs of referred and non-referred procedures suggests referral may not be the better decision.[25]

More recently, there are also a variety of different pleural procedure kits available and without proper expertise and training in using these new interventions it is more likely that we will encounter more complications. We believe our training mannequin module may help to address this issue. Simulation technology has been used to increase knowledge, provide deliberate and safe practice to help develop clinical skills.[26,27] Simulation has proven effective in developing and accessing competence in various procedures including angiography, emergency airway management, basic bronchoscopy, and advanced cardiac life support (ACLS). However, commercially available mannequin is expensive, which can be a deterrent to its use. With our model any teaching/training hospital can develop simulated training modules in a cost-effective manner incorporating the local/favored procedural kits, as presented in this study, for safety and to avoid serious complications. Incorporating image guidance using ultrasound with simulation mannequin training may further reduce pleural procedure complications.[11,12,28,29]

Simulator manikin are safer compared with performing the same procedure on real patients though cannot duplicate real time experience.[12] During this training, we implemented role play to make opportunity for the doctors in training to include the ability to communicate with the patient. Recently, there is development of a tool to access physician skill at chest tube insertion: The Chest Tube Insertion Competency Test (TUBE-iCOMPT), the validity of which has been examined in mannequins and live patients. Incorporation of such a tool into training program may further help guide and access individualized training.[30]

Our study had some limitations. Total number of participants was small and not all responded to the survey. Furthermore, our study design did not have a control group not receiving structured education on the mannequin. This may be performed in a future study with larger number of trainee doctors.

Conclusion

Traditional apprenticeship model has paved way to pleural procedure training mannequin model which is a reliable method for gaining procedural competence although it cannot completely substitute the real clinical setting. The costs involved can be a hurdle for some institutions. The simulated practice using our model before proceeding on to real patients is cost-effective way to increase the confidence and competence of doctors in training and may help to minimize procedure-related complications.

Main Message:

- Training mannequin improved pleural procedural competence
- The costs involved in acquiring simulation is a barrier.
- Our training model is cost-effective and easy to implement.

Research Questions:

- What is the differences in patient outcomes and health care costs in pleural procedures performed by radiologists compared to doctors in training?
- Is our mannequin-based teaching method superior to learning by osmosis?
- Does teaching through mannequin translates to procedural competence?

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Table Legends

Table 1 Description of the past experience in pleural procedures and knowledge and confidence level in performing pleural procedures among doctors in training.

Table 2 Post Training Survey Questions and Response.

Diagram Legends

Diagram 1 Bar diagram demonstrating performance status in pleural procedures among the doctors in training.

Diagram 2 Bar diagram demonstrating knowledge and confidence in performing pleural procedures among doctors in training.

Figure Legends

Figure 1: Panel a The measurement and shape of the rib section copied to create the module ribs section**. Panel b** The ribs with intercostal space next to the finished skin module**. Panel c** Block module**. Panel d** Two block spaces created on the torso one posteriorly for pleural aspiration training and another anterior axillary space (Safe triangle) for chest tube insertion training, **Panel e** The water container for refill fluid.

Table 1: Past experience in pleural procedures and knowledge and confidence level in performing pleural procedures among doctors in training.

Past Experience in pleural procedures	**Rating - Experience** **Scale of 1 to 5** **1 being least and 5 being maximum**
During my training, I have encountered patients requiring pleural procedure	2.1
I have observed pleural procedure	2.0
In the last 5 years, I have observed or performed pleural procedure with or without supervision	1.2
In the last 12 months, I have observed or performed pleural procedure with or without supervision	1.4
Knowledge and confidence in pleural procedure	**Rating – Knowledge** **Scale of 1 to 5** **1 being strongly agree and 5 strongly disagree**
I have good knowledge (theoretical) of how to perform pleural procedures	2.9
I have encountered complications while performing pleural procedure	3.5
I would like to have training in pleural procedure skills	1.5
I am competent in performing plural procedure	4.0

Number of participants: 47.

Table 2: Post Training Survey Questions and Response

Post training Survey Question	**Rating** **Scale of 1 to 5** **1 being strongly agree and 5 strongly disagree**
Difficulty in attending the training session	3.8
Following training I have encountered patients requiring pleural procedure	3.7
My knowledge on plural procedure has improved following the training	2.2
I am confident that I can perform plural procedure un supervised	3.1
At my level of training. Trainee doctors should be competent in performing pleural procedure	2.4
The current training method was useful	2.1
Following training I am knowledgeable about complications and precautions of pleural procedure	2.2
I need further practice prior to performing on real patient	2.7
The training manikin was realistic comparable to real patient experience	2.3

Number of participants: 23.

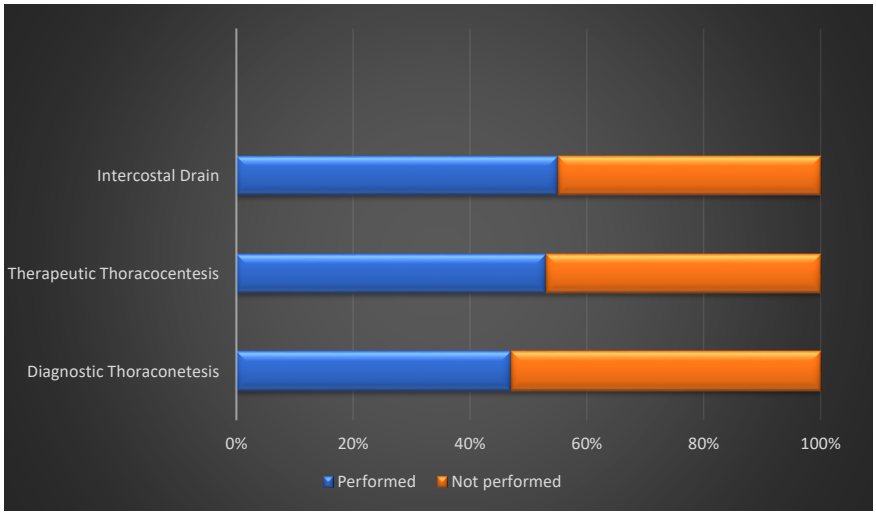

Diagram 1 Bar diagram demonstrating experience in pleural procedure among the doctors in training.

Diagram 2 Bar diagram demonstrating knowledge and confidence in performing pleural procedures increased after training.