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Outcomes of an initiative to improve inpatient safety of small bore thoracostomy tube insertion

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Key words
complication, intercostal thoracostomy tube, thoracic ultrasound, pneumothorax, quality improvement.

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Abstract

Background: Intercostal chest catheter (ICC) insertion is a common hospital procedure with attendant risks including life-threatening complications such as pneumothorax and visceral damage.
Aim: To investigate the effect of a quality improvement (QI) initiative on complications associated with inpatient thoracostomy tube insertion.
Methods: Following an audit of ICC complications in inpatients over a 2-year period we implemented a comprehensive QI programme. This involved formal training in and mandatory use of thoracic ultrasound, standardisation of the procedure and documentation, a dedicated procedure room with nurses trained in assisting ICC insertion and senior supervision for medical staff. An audit over 2 years post-implementation of the QI protocol was compared with pre-implementation results.
Results: A total of 103 cases were reviewed pre-implementation and 105 cases were reviewed post-implementation of the QI programme. All procedures following the QI initiative were image guided compared to 23.3% of cases pre-implementation. The rate of developing a pneumothorax requiring intervention post-implementation was less than pre-implementation (1.9% vs 5.8% ($P = 0.023$). Post-implementation, there were no instances of dry taps, viscera perforation, clinically significant bleeding or wrong side ICC insertion and documentation improved.
Conclusion: QI initiative applied to thoracostomy tube insertion in hospital inpatients can reduce complications and improve procedure documentation.

Introduction

Pleural effusions are common in hospitalised patients constituting a large load of inpatient admissions and consultations. Thoracentesis and intercostal chest catheter (ICC) insertion are frequently performed to diagnose and manage pleural effusions. These procedures can be associated with life-threatening complications such as pneumothorax, re-expansion pulmonary oedema, organ injury and haemorrhage. These complications increase procedure morbidity and mortality, prolong length of stay and increase costs.[1–9] The New South Wales (NSW) Clinical Excellence commission identified 185 reported incidents of pleural procedures in NSW from January 2010 to October 2011. Although the severity of each incident varied, two thirds were attributed to suboptimal clinical management. In recognition of the risks associated with ICC insertion, local guidelines have been developed[10] but unfortunately ICC complications persist.

Proceduralists from the Mayo Clinic (Rochester, USA) have shown that the complications of ICC insertion can be reduced in the outpatient setting following introduction of a multimodality intervention.[11] Based on their experience, we devised a pleural procedure protocol applied to inpatients.

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Conflict of interest: None.

Methods

This project was performed in Liverpool Hospital, a major metropolitan tertiary hospital in Sydney, Australia, and consisted of three phases.

Phase I: pre-implementation

Files of hospital inpatients coded for ICCs inserted during the period 2009–2010 were audited for complications associated with small bore ICC insertion, use of image

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guidance and documentation of the procedure.[6] ICCs inserted for traumatic chest injuries and large bore ICCs were excluded. As the project pre-dated the introduction of electronic patient records, hard copy patient folders were collected from the medical records department and reviewed page by page focusing from the time of the procedure until drain removal. Chest X-rays were reviewed on the hospital picture archiving and communication system server.

Phase II: quality improvement initiative

Implementation of a comprehensive quality improvement (QI) initiative involving: (i) limiting the number of procedural respiratory physicians; (ii) thoracic ultrasound (US) training and mandatory use of US guidance for all ICC procedures; (iii) the establishment of a pleural procedure room; (iv) training of nursing staff in assisting thoracostomy tube insertion; (v) ensuring direct supervision for junior medical officers and advanced trainees inserting thoracostomy tubes; and (vi) standardisation of procedure and proforma documentation in the patient notes at the time of procedure (Fig. 1). Patients referred for ICC insertion were taken to a procedure room, where chest radiographs were reviewed and thoracic US imaging performed to select the safest site for ICC insertion.

Phase III: post-implementation

A prospective audit for the 2 years (2013–2015) following implementation of the QI protocol was conducted using the same methodology as the pre-implementation audit. Complications recorded during phases I and III of the study included radiological evidence of a pneumothorax, pneumothorax requiring intervention, clinically significant bleeding (bleeding requiring further intervention, e.g. blood transfusion, surgical or radiological intervention), thoracostomy tube malposition, dry taps, ICC dislodgement and ICC blockage. Complications were compared. During the post-QI phase (phase III), we audited additional complications, including ICC related pain, vasovagal episodes, referral for surgery, procedure documentation, chest X-rays within the first 48 h and unplanned procedure termination.

Data analysis was performed using Chi-squared statistics with significance 0.05 for comparing variables and relative risk (SPSS – student statistical package version 24; 2017). The study was approved by the Sydney South West Area Health Service Human Research Ethics Committee (SSWAHS-HREC reference DA 17/21).

Results

Characteristics of the study populations are presented in Table 1.

Phase I: pre-implementation

A total of 103 ICC insertions was identified and the files reviewed. Image guidance was used in 23.3% of ICC insertions. Computed tomography was utilised in 12% of cases. Thoracic US was used in the remaining 12%. In another 4% of cases, a US marking was performed in the Radiology Department, with subsequent transfer to the ward for the procedure.[6] No image guidance was used in 72% of cases. Complications are presented in Table 2 and included pneumothorax (all of which required intervention) (6%), catheter displacement (tube fell out) (3%), catheter blockage (7%) and chest wall infection (1%). In one case, a thoracentesis needle was attempted on the wrong side, resulting in a dry tap, but the procedure was abandoned prior to the ICC being inserted and no pneumothorax was observed.

Phase III: post-implementation

A total of 105 files was reviewed. Real-time thoracic US guidance for selection of a safe site for ICC insertion was used in all cases. In 13 patients, the procedure was terminated following the thoracic US examination without a procedure being attempted. In 10 of these, the pleural effusion appeared too small, and in three patients, no fluid was detected despite a suggestive chest X-ray appearance. Twelve patients underwent thoracentesis alone, as ICC insertion was re-assessed following US imaging as not being clinically necessary. In all patients, the fluid was reached in the first attempt.

Although there were more males than females (Table 1) in this population, there was no association between complications and gender ($P = 0.076$). Vasovagal syndrome was documented in one male in the pre-implementation audit and in three women in the post-implementation audit.

Pneumothorax

Pneumothorax was more frequently noted on chest X-ray following the QI initiative than during the pre-implementation audit (13/105 vs 6/103). However, the majority of these were very small and required no intervention. The risk of developing a pneumothorax requiring intervention post-implementation was less than pre-implementation (2.0% vs 9.3%; $P = 0.023$).

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CHECK LIST FOR CHEST TUBE INSERTION AND OPERATION REPORT

DATE_______________ **Time:** ________ **After hours Y/N**

Indication____________________ **Diagnostic** □ **Therapeutic** □

Pre Procedure:

PATIENT	**ENVIRONMENT**	**EQUIPMENT**	**OPERATOR(S)**
Consent □	Procedure room □	Vitals recording □	Name/ Position
Time out □	Others □	Sat%___ HR____	________________
No coagulopathy □	Resus trolley □	BP____	_______________
Cont Sat monitor □	________________		

Position

Sitting □ Supine □ | Tube type___________RN present □

Others □ | Tube size___________

CXR viewed	**US marking**
Sml: Blunting CP angle □	□ Min: Fluid within CP angle
Mod: Diaphragm Not visible □	□ Small: within a single rib space
Larg: >50% Hemithorax □	□ Mod: between 1 and 2 rib spaces
Total white out □	□ Large: bigger than 2 rib spaces

Procedure:

Premedication □ Anaesthetics: local________ IV Sedation ________

Methods: Seldinger □ Others: Specify____________

Post Procedure:

Analgesia ___________ □ CXR requested Draining □Y □N

Complications: Nil □ Yes:_______________________________________

____

Pain score (VAS)_____________ Patient satisfaction score____________

Figure 1 Sticker placed in the patient notes at the time of the procedure.

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Table 1 Patient age, gender and indications for intercostal chest catheter (ICC) insertion

Study population	Pre (n = 103)	Post (n = 105)
Female/male	33/70	46/59
Mean age (range) (years)	58 (20–90)	65 (24–90)
Pneumothorax, n (%)	40 (38.8)	13 (12.4)
Pleural effusion†, n (%)	63 (61.2)	67 (63.8)
Transudate, n (%)	5 (4.9)	6 (5.7)
Exudate, n (%)	32 (31.1)	67 (63.8)
Malignancy‡, n (%)	25 (24.3)	22 (21.0)

†Based on thoracic ultrasound appearance, thoracentesis without ICC insertion or no procedure was performed. ‡All malignant pleural effusions were exudates.

Bleeding

No clinically significant bleeding occurred in either group.

Malposition and dry tap

There were no malpositioned tubes in either group. There was one dry tap in the phase I group (noted above) and none in the phase III group.

Tube dislodgment

There were three cases of chest tube dislodgement in the pre-implementation and four in the post-implementation phase ($P = 0.58$).

Thoracostomy tube blockage

Of 103 cases, there were seven cases of ICC blockage in the pre-implementation group and no cases in the post-implementation group ($P < 0.013$).

Documentation

There was limited and inconsistent documentation in nine of 103 patients in the pre-implementation audit group and only one of 105 cases noted in the post-implementation group.

There were no cases of inadvertent visceral tube placement or deaths related to the ICC procedure in either group.

Discussion

QI initiative resulted in a reduction in procedure-related complications and improved documentation associated with inpatient ICC insertion. We used a systematic approach that included training senior physicians in performing bedside thoracic US, formal training and supervision of advanced trainees in respiratory medicine in thoracic US and thoracostomy tube insertion and standardised documentation by way of a sticker placed in the notes following the procedure. Additionally, the proceduralists were familiarised with standardised equipment in a dedicated pleural procedure room and thoracic US was routinely performed.

Pneumothorax is a potential complication of thoracentesis and ICC insertion with a variable incidence.[3,5,8,9,12] Pneumothorax requiring intervention increases length of hospital stay, costs and mortality.[4,8] Interestingly, the pneumothorax rate as assessed by post procedure chest X-ray was higher post-QI implementation than with routine image guidance. However, most of those pneumothoraces were small, of no clinical significance, and required no intervention. The rate of pneumothorax requiring intervention was lower in this group. It is likely that small pneumothoraces, not requiring intervention, were a consequence of variations of intrapleural pressure[13] and related to air entering the pleural cavity during the procedure rather than due to breach of the visceral pleura. In this study, the higher rate of detected pneumothorax could be related to the fact that a chest radiograph was performed routinely in the post-QI initiative group and it was less reliably documented in the pre-QI group. This raises the question of

Table 2 Outcomes pre- and post-implementation of the quality improvement (QI) initiative

Outcomes (n)	Pre-QI initiative (103)	Post-QI initiative (105)	P-value
Image-guided procedure	24 (23.3%)†	105 (100%)	0.0001
Pneumothorax	6 (5.8%)	13 (12.4%)	0.10
Pneumothorax requiring intervention	6 (5.8%)	2 (1.9%)	0.02
Chest wall infection	1 (1%)	0	0.31
Thoracostomy tube dislodgement	3 (3%)	4 (3.8%)	0.58
Pain complaint recorded	14 (14%)	4 (3.8%)	0.01
Vasovagal syndrome	1 (1%)	4 (3.8%)	0.18
Dry tap	1 (1%)	0	0.31
Significant bleeding	0	0	No significant bleeding occurred in either group
Insufficient documentation	9 (9%)	1 (1%)	0.009

†Computed tomography-guided procedures.

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the need for chest radiograph as a routine post procedure – possibly, it could be performed when there is clinical suspicion of pneumothorax.[14] Trapped lung is another cause of post-ICC pneumothorax that is not directly related to the procedure and would be unlikely to be altered by US guidance.

The use a pre-procedure checklist (Fig. 1), standardised protocol and record keeping facilitated handover between respiratory trainees and patient monitoring and this is in agreement with previous studies.[11,15]

Thoracic US prior to the procedure was probably the most important part of the QI protocol. Indeed, 13 of 105 patients in our cohort avoided an unnecessary procedure, which may have prevented unintentional 'dry taps'. The incidence of these has been reported at 7.4%,[16] and carries potential morbidity associated with viscus perforation, including the lung. There is ample evidence favouring bedside thoracic US prior to ICC insertion or thoracentesis[17,18] and thoracic US is strongly recommended in recent NSW guidelines.[10] However, limitations persist in the widespread uptake of thoracic US, and operator training, skill and experience in thoracic US are important factors. Indeed a survey of Australian respiratory physicians in 2016 noted that only 21% of respondents were demonstrably competent in thoracic US, despite 90% having access to a US unit. Australian experience suggests the use of ward-based thoracic US is safe and accurate when appropriate training and supervision is provided.[19] Several freely available 'how to' articles have been written aiming to upskill non-radiologists in the use of bedside thoracic US[20] and evidence suggests that when thoracic US is performed by a skilled physician, the outcomes of thoracentesis and ICC tube insertion are similar to those performed by radiologists.[21]

Tube dislodgement occurred similarly in both groups and is a potential target for further QI. It is probably related to inadequate fixation technique and post-insertion ICC management. Tube blockage was more often seen in the pre-implementation group for reasons that are unclear. Routine flushing was not part of our ICC management protocol.

Conclusion

This project demonstrates that in inpatients, a systematic approach for thoracostomy tube insertion can reduce the risk of pneumothorax requiring intervention and improve the procedure safety profile and documentation. This outcome was achieved by training respiratory physicians and advanced trainees using a standardised protocol, mandating bedside US guidance, and the direct supervision of skilled consultants. It demonstrates similar findings to those obtained in an outpatient setting[11] and to a recent Australian inpatient pre- and post-hospital wide ICC QI initiative by Edwards *et al.*[22] corroborating the feasibility of such interventions in the local setting.

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Recent trends in cyclic vomiting syndrome-associated hospitalisations with liberalisation of cannabis use in the state of Colorado

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cannabis, cyclic vomiting syndrome, Colorado, hospitalisation, legalisation.

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Abstract

Background: Currently, 33 states in the United States along with the District of Columbia have legalised cannabis in some forms. There is a paucity of data on the impact of legalisation of cannabis use on hospitalisations due to cyclic vomiting syndrome (CVS).
Aim: To study the trends in CVS-related hospitalisations and cannabis use in CVS in relation to legalisation of recreational cannabis use in Colorado.
Methods: All hospital admissions in Colorado between 2010 and 2014 with the diagnosis of CVS were identified using the Colorado State Inpatient Database. Five-year trends in CVS-related hospitalisations along with the cannabis use were analysed. Multivariate logistic regression analysis was performed to determine predictors of cannabis use in CVS.
Results: There was a significant increase in CVS-related hospitalisations by 46% from 806 in 2010 to 1180 in 2014 when CVS was included as all-listed diagnoses ($P <$ 0.001). The overall prevalence of cannabis use in CVS (13% with CVS as primary diagnosis and 17% with CVS as all-listed diagnoses) was much higher than non-CVS-related hospitalisations (1.7%) ($P < 0.001$ for both comparisons). Cannabis use increased dramatically in both CVS and non-CVS-related hospitalisations following legalisation of cannabis for recreational use in 2012.
Conclusion: Our study shows a significant increase in CVS-related hospitalisations concomitant with an increase in cannabis use with its liberalisation in Colorado. Future studies on the relationship between cannabis use and hyperemesis are warranted, especially with its ongoing legalisation in the United States.

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