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Chest tube drainage of pleural effusions—an audit of current practice and complications at Hutt Hospital

Erica Epstein, Sisira Jayathissa, Stephen Dee

Abstract

Aims The aims of the study were to review small-bore chest tube insertion practices for drainage of pleural fluid at Hutt Valley District Health Board (HVDHB), to assess complications, and compare the findings with international data.

Methods Retrospective analysis of clinical records was completed on all chest tube insertions for drainage of pleural fluid at HVDHB from December 2008 to November 2009. Descriptive statistics were used to present demographics and tube-associated complications. Comparison was made to available similar international data.

Results Small-bore tubes comprised 59/65 (91%) chest tube insertions and 23/25 (92%) complications. Available comparative data was limited. Ultrasound was used in 36% of insertions. Nearly half of chest drains placed for empyema required subsequent cardiothoracic surgical intervention.

Conclusions Chest drain complication rates at HVDHB were comparable to those seen internationally. Referral rates to cardiothoracic surgery for empyema were within described ranges. The importance of procedural training for junior medical staff, optimising safety of drain insertions with ultrasound guidance, and clear clinical governance for chest tube insertions are important in minimising harm from this procedure. Specialist societies need to take a leadership in providing guidance on chest drain insertions to secondary and tertiary hospitals in Australia and New Zealand.

Chest drains are used to manage a range of pleural diseases including empyema, malignant effusion, pneumothorax and trauma.[1] The optimal location for drain insertion as described by the British Thoracic Society (BTS) is the 'Safe Triangle'. This is an area bordered anteriorly by the lateral border of pectoralis major, posteriorly by the lateral border of latissimus dorsi, with an apex in the base of the axilla and a base on the line of the fifth intercostal space[1]; minimising the risk to the internal mammary artery, muscle, breast tissue and organs.[2]

Potential complications of chest drain insertion include puncture of major organs such as the heart, lungs, liver or spleen, bowel as well as bleeding due to arterial or other major vascular structure perforation. Other important complications include pleural infection, inter-costal neuralgia, re-expansion pulmonary oedema, pneumothorax and subcutaneous emphysema.[3]

Chest drain insertion is a common procedure carried out in general wards by relatively junior medical staff,[3] with limited knowledge of anatomy and physiology. Several studies since 2005 have documented the lack of adequate training and confidence in chest drain procedures for junior doctors.[4–6]

International interest in small-bore chest drain complications has intensified following a British National Patient Safety Association (NPSA) Rapid Response Report in 2008 addressing chest drain related patient safety incidents. Twelve deaths and 15 cases of serious harm between January 2005 and March 2008 were described.[3]

Recommendations for the National Health Service included emphasis on clinical governance, technical training, and particular endorsement was given for the use of ultrasound guidance for chest drain insertion. The BTS also reviewed their Pleural Disease Guidelines (originally published in 2003 and since updated in 2010) and a pilot audit of 50 Trusts across the UK was completed in July 2009 to review progress.

The audit revealed improved approaches to chest drain insertion safety such as improved access to bedside ultrasound, timing of insertions (less 'out of hours'), and earlier specialist involvement. Consent practices were found to be inadequate and local auditing was encouraged. In addition, further national auditing was planned for 2010.[7] The BTS has since published on their website an audit tool to review chest drain insertions in the NHS.[8]

Prior to 2009, there was relatively little published information on complications related to small-bore catheter use for pleural effusion. A large number of studies cited complications of large-bore drains using blunt-dissection insertion techniques for trauma patients and treatment of pneumothorax, but these studies are not directly applicable to medical patients. An unpublished meta-analysis of complications associated with Seldinger chest drain insertion (serial dilation over a guide wire), involving a review of 12 studies from 1987 to 2008 with a total of 1381 patients[9–19] presented at the Royal College of Physicians (London) update in respiratory medicine for general physicians in 2008, has been used for comparison of complication data in this audit.

The BTS recently updated it's Pleural Diseases Guidelines, and within this evaluated both large-bore and small-bore chest drain complications separately.[1] Studies reviewed differ in insertion indications, definitions of complications, tube size, expertise of operators and rates of image guidance. We were not able to identify published studies looking at complications of small-bore chest tubes in Australia or New Zealand.

HVDHB is a secondary level care New Zealand hospital, serving a population of 140,000 with 54 general medical inpatient beds. It has no specialist respiratory inpatient service and all medical patients requiring chest drains are managed by the general medical service.

Pleural procedures at Hutt Valley District Health Board (HVDHB) were reviewed in late 2008 following an incident of inadvertent perforation of the myocardium with a small-bore chest drain placed for pleural effusion.[20] This has been reported to the Ministry of Health as a sentinel event.

Actions taken included the review and rewriting of procedural protocols and the introduction of a compulsory training session provided by an outpatient based respiratory physician for those inserting chest drains, as well as the availability of digital images in the procedure room, a move towards routine image guided chest drains, and the undertaking of this audit.

The primary objectives of the audit were to review HVDHB chest drain practices including use of ultrasound in drain insertion, to assess the complications, and to compare findings with national and international data. The secondary objective was to address anecdotal report of a high incidence of medically managed patients with small-bore chest tubes for empyema requiring cardiothoracic surgery.

Methods

We conducted a computer search using ICD10 codes for pleural effusion, tuberculous pleurisy, pyothorax, chylous effusion, haemothorax, unspecified pleural condition, and diagnostic and therapeutic thoracentesis for a 12-month period from December 2008 to November 2009 inclusive. This search identified 140 records. Pleural fluid drainage using techniques other than chest drain insertion, and chest drains placed for pneumothorax were excluded, resulting in 65 chest drain insertions.

We obtained data from hospital electronic records and paper-based clinical notes retrospectively. Diagnostic categories were simple parapneumonic effusion, empyema, malignant effusion, heart failure related effusion, exudates not otherwise specified and other/unknown. Laboratory data was also reviewed to clarify the diagnosis. Empyema was defined according to BTS guidelines.

We recorded drain types according to the following categories: Unknown, French gauge 6–30, or pigtail catheter. Small-bore tubes were defined as <24 French gauge. We documented the location and success of placement with or without ultrasound guidance as well as number of drain insertion attempts, number of drains inserted per patient, days of drain site use, and drain flushing practices. Complications including pneumothorax, malpositioning, vascular injury, injury to diaphragm, liver, spleen or lung, and death, were recorded.

We noted referrals to a respiratory physician or cardiothoracic service and the timing of review and transfer. Transfer outcomes were assessed by accessing electronic records from the receiving hospital.

The BTS Pleural Diseases 2003 guidelines[2,21,22] available at the time of study, and 2008 NPSA Rapid Response Report served as the basis for guidance of best practice for this audit, as there were no guidelines published by the Thoracic Society of Australia and New Zealand.

Data were entered into a Microsoft Excel spreadsheet. Descriptive statistics were used to present demographics and complications associated with chest drain insertions. Complications were compared with the data from the unpublished meta-analysis and Pilot Audit from the NPSA.

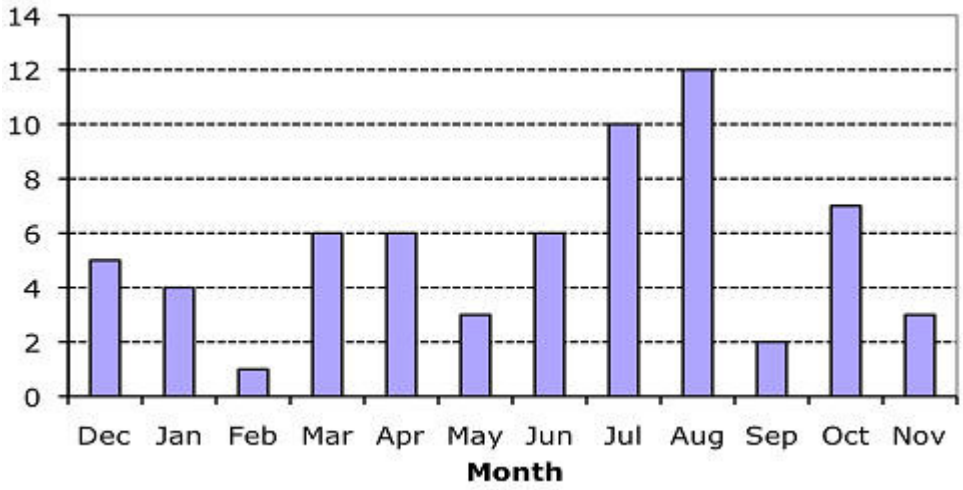
According to National Health And Disability Ethics Committee Guidelines, this study is considered as an audit primarily carried out for quality improvement activity by the employees of the HVDHB and hence did not require formal ethical approval.

Results

Forty-nine patients receiving chest tube insertion for intrapleural fluid were identified in the 12-month period. Thirty-five patients received one tube only, 12 received two tubes, and 2 patients had three tubes placed, with a total of 65 insertions. Two sets of paper-based clinical records were unavailable for review, though electronic records were accessed in all cases.

Age range at admission was 23 to 89, median age 68 years; 69% were male. More chest tube insertions were carried out during the winter months 37/65 (56.9%) (Figure 1.)

Figure 1. Number of chest drains per month (Dec 2008–Nov 2009)



Median length of stay for patients with chest tubes was 10 days, with a range of one to 45 days. 52/65 (80%) chest drains were inserted by the general medical service, 6/65 (9%) by surgical or intensive care services, 5/65 (8%) by the Cardiology Service and 2/65 (3%) Older Persons Rehabilitation Service. These comprised six large-bore drains (9%), 37 small and 22 of undocumented size.

The undocumented drain sizes are very likely to have been small-bore tubes, as medical services managed all events with undocumented tube size and large-bore drains have not been stocked or utilised by medical teams at HVDHB. Therefore for the purpose of this study all undetermined tube sizes have been considered as small-bore, giving a total of 59/65 (91%).

Diagnosis, number of insertions and number of patients are shown in Table 1.

Table 1. Chest drain insertion numbers according to diagnostic categories

Diagnosis	Number of insertions	Percentage of total insertions	Number of patients
Simple parapneumonic	8	12.3	7
Empyema	27	41.5	16
Malignancy	6	9.2	5
Heart failure related	5	7.6	5
Exudate not otherwise specified	10	16.3	7
Unknown	4	6.1	4
Transudate of unknown cause	1	1.5	1
Dressler's syndrome	1	1.5	1
Tuberculosis-associated effusion	1	1.5	1
Intraoperative diaphragm perforation requiring chest drain	1	1.5	1
Intrapleural total parenteral nutrition drainage	1	1.5	1
Total	**65**	**100%**	**49**

Of patients requiring two or more drains, 8/14 (57%) had a diagnosis of empyema. Real time ultrasound or marking the site for best insertion was carried out in 21/59 (36%) of chest drain procedures. No information was available on ultrasound use in six cases. No patients had Doppler analysis for detection and avoidance of vascular structures.

Table 2. The distribution of drain site location. Site location was not documented in 47.7% of insertions

Location	Number (N=65)	Percentage (%)
Not documented	31	47.7
Image guidance into locule	6	9.2
Left 'Safe Triangle'	5	7.7
Right 'Safe Triangle'	8	12.3
Posterior	15	23

From HVDHB data, 25 complications within the listed categories were identified from 65 chest tube insertions. 23/25 (92%) complications occurred in those with small-bore, (including five probable small-bore tubes—i.e. 23 complications of 59 small chest-drain insertions), and 2 large-bore drains had complications (of 6 inserted). There were no deaths. Comparative complications between our cohort and available studies are summarised in Table 3.

Table 3. HVDHB complication rate compared to Seldinger chest drain meta-analysis[9–19] data and NPSA Pilot Pleural Procedures audit

Complication	HVHDHB complication number and percentage occurrence	Meta-analysis patient number with non-weighted average frequency	NPSA Pilot pleural procedures audit 2009
Total events	65 (100%)	1381(100%)	68 (100%)
Pneumothorax	14 (21.5) †	*	*
Malpositioning	1(1.5) ‡	671 (1.2)	*
Lung injury	1(1.5) §	*	0
Vascular injury	1(1.5) ¶	*	0
Symptomatic re-expansion pulmonary oedema	1(1.5)	320 (0.9)	1(1.5)
Vasovagal reaction	1(1.5)	42 (1.9)	*
Drain site skin infection	1(1.5)	178 (0.4)	*
Subsequent empyema	0	1701(1.8)	2(2.9)
Drain blockage or accidental removal	5(7)	456 (14)	6(5)
Total complication events	25(38.5)	*	*

† 1/14 pneumothoraces required transfer for cardiothoracic surgery; ‡ Chest tube placed above an effusion requiring reinsertion; § Occurred during CT-guided drain placement for loculated empyema, resulting in persistent pneumothorax, extensive surgical emphysema and respiratory failure. Cardiothoracic surgery and lengthy intensive care stay followed. ¶ Myocardial perforation requiring cardiothoracic surgery. The patient made a good clinical recovery; * Information not available.

Of 27 empyema-associated insertions, 26 comprised small-bore tubes (including 10 probable small-bore). In one event a large-bore drain was used. Ten patients with empyema required transfer for cardiothoracic surgery, comprising 13/27 (48%) of the empyema category drain insertions.

Audit data showed regular drain flushing in 40% of small-bore tubes, but rare use of suction. Regular flushing was not documented in one of five small-bore drain blockages.

In order to review HVDHB clinical governance of patients with chest drains, we documented referrals to HVDHB respiratory service, regional respiratory physicians, or cardiothoracic service. Referrals occurred in 29/65 (44.6%) instances. Most (76%) were referred within 5–7 days from diagnosis, which is within the BTS guidelines. There were two delayed referrals (14 and 31 days), though unfortunately clinical records for these were not available to identify the causes of delay.

All 15 patients accepted for further treatment by the cardiothoracic unit were transferred within 6 days of referral. Nine events were referred to HVDHB respiratory physicians, of which three were reviewed on the day of referral and one 2 days following. In five events no record of review was found, though three of these five patients were transferred for cardiothoracic surgery.

Discussion

This study showed complication rates at HVDHB were comparable to international rates where available, although event numbers were small. Pneumothorax which was the most common documented complication in our audit was not included in the two comparative studies. All but one of the pneumothoraces in our study were small and did not require further intervention.

There were anecdotal reports of a high incidence of subsequent cardio thoracic surgery in medically managed patients with small-bore tubes for empyema at HVDHB. The rate of requirement for cardiothoracic surgery in patients with empyema is variable in the literature but HVDHB referral rate of 48% was within described ranges.

Although it is well recognised that patients with purulent fluid and/or loculations at presentation are more likely to require surgical drainage, there is not an appropriately powered study comparing surgical and medical treatments of empyema.[23]

A 2005 Cochrane review revealed only one small randomised trial, and suggested that firm conclusions were difficult, but video-assisted thoracoscopic surgery for large loculated empyemas was superior to chest tube drainage in terms of duration of chest tube in situ and length of hospital stay.[23] The majority of patients within our audit requiring surgery, 10/12 (83%), were those with empyema. 26/27 chest tube insertions for empyema were of small-bore category.

HVDHB utilised small-bore drains 24 French gauge or less inserted with Seldinger technique during the audit period. Now BTS describe small-bore drains as those less than 16 French gauge. Small-bore tubes are more comfortable for patients than larger

tubes, but there is no evidence that either is therapeutically superior (for diagnoses other than haemothorax), or safer.[2]

Some believe classical surgical insertion of chest tube is safer than Seldinger technique. There is limited data on the rate of adverse events for different insertion techniques. Use of the Seldinger technique is widespread but what proportion of chest drains are inserted by this method is uncertain though the NPSA quote a rate of 85–90%.[25] However, there remains a substantial body of opinion that considers large-bore tubes to be more effective for thick pus empyema based on clinical experience.[21,26,27] Some studies have shown failure rates in medical treatment for empyema of 19 to 55% (including use of intra-pleural streptokinase),[19,24] though utilised tube size varies within these studies. The 48% failure rate in this audit was within this range. Failure of medical treatment may be an expected outcome especially in those with loculated effusions at presentation.

This information raises the question whether patients presenting to HVDHB with empyema or complicated effusions would be best managed under the nearest cardiothoracic unit which is 20 km away, from the time of diagnosis.

Since our audit there have been recommendations[1] for routine use of real time image guidance for all chest drains placed for pleural fluid, and it is suggested this may become mandatory.[25] Latest BTS guidelines[1,8] state that use of ultrasound to mark a site suitable for later drain insertion is no longer recommended except in large effusions. Although real time ultrasound guidance is now recommended, BTS also state, “ultrasound may not reduce the incidence of laceration of the intercostal vessels because they are not visualised on ultrasound”. Ultrasound is available in the radiology department at HVDHB, but its rate of use for assisting chest drain placement is low (36%).

The NPSA Pilot Pleural Procedures Audit during July 2009, showed a combined rate (real time and remote) of ultrasound guidance usage of 34/68 (50%). No other published data were available to compare acceptable rates of use of ultrasound at the time of this study.

Lack of understanding of thoracic anatomy and relative assurance of ultrasound marking often applied by ultrasonographers may lead to injuries to the vital structures. Top of the diaphragm is usually at the level of the nipple and in cases of patients with lung disease the position of the diaphragm may be high. Intercostal arteries may become under the cover of ribs beyond posterior axillary line and insertions medially could potentially lacerate the intercostal arteries. Chest tube placement in mid clavicular line could cause injury to pulmonary artery.

The majority of structures one wishes to avoid are located medically hence the thoracic surgical axiom “go high, go laterally” need to be kept in mind while inserting chest drains.

Obtaining adequate training and skill for staff to conduct real-time ultrasound- poses difficulties in a secondary hospital with limited access to respiratory physicians and a stretched radiology service. The radiology department may not be able to manage increased demand for training or performing real time ultrasound and therefore general medical specialists may need to become proficient in pleural ultrasound.

More careful planning of the timing of necessary drain insertions may also aid in achieving safer procedures with adequate supervision and ultrasound guidance, however resources and training for pleural ultrasound are important considerations.

The implementation of clinical governance for the management of patients with chest drains at HVDHB requires review, particularly in view of the limited local respiratory and cardiothoracic services. Only 45% of our patients in total were referred to respiratory specialists, including 12/16 patients with empyema.

The BTS recommends that a respiratory physician or thoracic surgeon should be involved in the care of all patients requiring chest tube placement for pleural infection given the substantial associated mortality rate. Early respiratory specialist input is beneficial not only for their expertise in managing these patients but also their relationship with the cardiothoracic service, improving communication and expediting patient transfer for surgery if necessary.

Matters that may be contributing factors to serious insertion complications are those highlighted in recent studies that reveal a lack of understanding, "training, experience and confidence in junior doctors performing pleural procedures."[4–6] These factors are generalisable to junior doctors at HVDHB. Wong et al[5] highlighted the variable confidence and experience of junior medical staff, and the need for better training.

Griffiths et al[4] drew attention to the lack of understanding of guidelines on use of the 'safe triangle' and the need for training. They surveyed 55 junior doctors, finding 45% were unable to mark a hypothetical insertion position within the 'safe triangle'. In 47.7% of cases in our audit, location position was not documented (Table 2), though due to small complication numbers it was not possible to observe a meaningful trend in relationship between complication and insertion location.

Pleural procedures are widely performed across many specialties and although in some cases different procedural techniques may be appropriate, generalisable training sessions may be economic and useful. HVDHB has now introduced a compulsory training session delivered by a respiratory physician completed at the commencement of each new medical registrar intake. A simulation model is utilised in an approach previously shown to be effective in improving confidence and skill in chest drain insertion.[5,28] Physicians at HVDHB also may need to consider regular re-training, in order to provide supervision for their junior staff. One or two physicians assuming the responsibility of inserting chest drains under US guidance could be an option for smaller hospitals to ensure that they remain proficient with small number of procedures undertaken in such hospitals.

This audit has several limitations. They include the retrospective nature of data collection, unavailability of all relevant data on medical records and small sample size limiting subgroup analysis. However, the small number of chest drains performed during a year also highlights the need for clinical vigilance. Interpretation and statistical comparison of the data is restricted due to limited number of published studies on complications and variable definition of complications of small-bore chest drains placed for pleural fluid. In addition there was a potential for misclassification as we included all chest drains inserted by physicians as small-bore drains even though we couldn't find supporting documentation in some cases, but this unlikely to

be inaccurate as medical service don not routinely perform large-bore chest drain insertions.

In the absence of published studies on small-bore chest tube insertions in Australia and New Zealand this audit makes a significant contribution to understanding of complications of chest drain insertions in a secondary hospital. It also raises questions about appropriate management of empyema, improvement of clinical governance related to chest tube insertions and the feasibility of training in real time ultrasound, which are all important in reducing the unacceptably high rate of complications associated with chest drain insertions.

Recommendations arising from this study include the need for hospital wide training and the use of ultrasound guidance to enhance the safety of the procedure, as well as the implementation of uniform clinical governance for patients with chest drains and the need for improved procedural and care documentation. Consent practices and nursing education around drain management which were not examined in detail, need further review.

In conclusion we feel complication rates associated with small-bore chest drain insertions while in keeping with the literature are still unacceptably high at our hospital, especially given some are associated with serious morbidity. Documentations of the procedure and care were suboptimal.

Further studies are required to define acceptable complication rates after implementing guidelines to improve safe chest drain insertion. Moreover, Thoracic Society of Australia and New Zealand in collaboration with Internal Medicine Society need to develop appropriate guidelines for safe chest drain insertions targeted at different types of hospitals throughout Australia and New Zealand according to the size of the hospital and variability of available specialist respiratory services.

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Author information: Erica Epstein, Aged Care Registrar, St. Vincent's Health, Melbourne, Australia; Sisira Jayathissa, General Physician, Stephen Dee, General Physician, Hutt Valley District Health Board, High Street, Lower Hutt, New Zealand

Correspondence: Sisira Jayathissa, Consultant General Physician, Hutt Valley Health, High Street, Lower Hutt, New Zealand. Email: sisira.jayathissa@huttvalleydhb.org.nz

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