Complications after Thoracocentesis and Chest Drain Insertion: A Single Centre Study from the North East of England

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Abstract: Introduction: There are no prospective studies looking at complications of pleural procedures. Previous British Thoracic Society Pleural audits and retrospective case series inform current practice. Incidence of any complication is between 1–15%. We sought to add to the existing literature and inform local practice with regards to intercostal drains and thoracocenteses. Methods: Local Caldicott approval was sought for a review of all inpatient adult pleural procedures coded as ‘T122 drainage of pleural cavity’ and ‘T124 insertion of tube drain into pleural cavity’. Those undergoing thoracocentesis (all with a Rocket 6 Fg catheter) and intercostal drain insertion (ICD, all with Rocket 12 Fg drain) were identified. Continuous variables are presented as mean (± range) and categorical variables as percentages where appropriate. Results: 1159 procedures were identified. A total of 199 and 960 were done for pneumothorax and effusions respectively. Mean age was 68.1 years (18–97). There were 280 thoracocenteses and 879 ICDs. Bleeding occurred in 6 (0.5%), all ICDs (clotting and platelets were within normal range; one patient was on aspirin and one on aspirin and clopidogrel). All settled except for one who had intercostal artery rupture needing cardiothoracic intervention (no anti-coagulation). Nine pneumothoraces occurred (0.78%) in seven ICDs and two aspirations). There were three definite pleural space infections (0.3%) with three ICDs. Fall out rates for ICDs were 35 (3%). Nine were not sutured, and out of those, seven inserted in the Accident and Emergency department, out of hours. All others ’came out’ due to patient factors (previous quoted rates up to 14%). Surgical emphysema occurred in 43 (41 ICDs), 3.7%. Eight were due to fall outs and three required surgical intervention. There was no re-expansion pulmonary oedema nor direct deaths. Conclusions: Complication rates of ICD and thoracocenteses are low. Checklists might help to remind operators of the need for suturing. Limitations of this study are its retrospective nature and reliance on correct hospital coding. We are currently contributing to a prospective observational study on pleural complications.

Keywords: pleural effusion; pneumothorax; intercostal drain; thoracocentesis

1. Introduction

The incidence of pleural disease is rising and is estimated to be 3000 per million patients in the United Kingdom (UK) alone [1]. The presence of air (pneumothorax) or fluid (pleural effusion) in the pleural space or the development of benign, malignant or infective processes often necessitates intervention to relieve symptoms. Drainage is routinely performed with small bore aspiration kits (usually 6 or 8 French gauge (Fg)) or insertion of a 12 Fg Seldinger intercostal drain (ICD) [2,3]. These are common procedures. The 2010 British Thoracic Society (BTS) pleural procedures audit estimated than an acute
hospital would carry out the placement of seven drains per month on average [4], thus approximating 15,000 drains yearly in the UK.

Thoracocentesis and ICD insertion are invasive procedures, and the risk of complications has historically been high [5]. Widespread thoracic ultrasound use has reduced the incidence of complications [6] which can include incorrect placement, drain displacement, bleeding, infection, failure to place the drain, pneumothorax, surgical emphysema, re-expansion pulmonary oedema and death. BTS guidance now further mandates pre-procedure invasive checklists [7].

Northumbria Healthcare NHS Foundation Trust provides a large regional pleural service, serving a local population of approximately 600,000. Given the lack of data on complications of thoracocentesis and ICD, we sought to inform local practice.

2. Methods

A search of all inpatient records for coding references T12.4: Insertion of tube drain into pleural cavity and T12.2: Drainage of Pleural cavity was performed between April 2015 and June 2020. This retrospective study was classed as a service evaluation and had local Caldicott approval from Northumbria Healthcare NHS Trust (reference C3426). Each thoracentesis and ICD event were analysed by collection of patient demographics, indications and any immediate or late (within 30 days) complications. Patients less than 18 years of age were excluded as we are an adult pleural service. Indwelling tunnelled catheters and large bore drains were also excluded from the analysis as those procedures are part of separate service evaluations and have already been published.

Local policy mandates strict asepsis for procedures, use of thoracic ultrasound for effusions and post procedure chest X-rays (CXRs) after every ICD insertion. CXRs after thoracenteses are at the discretion of the physician. All available radiology was checked for complications, most notably pneumothorax. All were independently checked by the local pleural disease lead and pleural fellow to ascertain absence of a pneumothorax ex-vacuo.

Descriptive statistical methodology was applied. Continuous variables are presented as mean (±range) and categorical variables as percentages where appropriate.

3. Results

A total of 1304 records were identified. A total of 145 were excluded due to incorrect coding, being incidences of large bore chest drains and/or tunnelled catheters and patients being less than 18 years of age.

1159 records were analysed. The mean age was 68.1 years (range 18–97 years), and 66.7% (n = 773) of the patients were male.

A total of 199 (17.2%) procedures were done for pneumothorax and 960 (82.8%) for pleural effusions. There were 288 thoracocenteses performed in total (all for pleural effusion) and 879 ICDs in total (672, 58% for pleural effusion and 207, 42% for pneumothorax). A total of 752 of the procedures done for pleural effusions were for malignant or presumed malignant diagnoses, 102 were for non-malignant diagnoses such as heart failure and renal failure, and 106 for infective causes. All procedures for a pleural effusion had real time or pre-procedure thoracic ultrasound use.

Overall complication rate was 8% (93 incidents out of 1159 procedures).

There was no incidence of organ puncture or re-expansion pulmonary oedema.

Bleeding was defined as a local hematoma or intra-pleural bleed. Bleeding occurred after 6 procedures (0.5%). All were ICDs. For these 6 unique patients, platelet counts, prothrombin times and activated partial thromboplastin times were all within normal range (140–400 × 109 per litre, 12.0–15.0 s and 24.0–35.0 s, respectively). One patient was on aspirin and one was on combination aspirin and clopidogrel (this was a pneumothorax that required urgent draining). Five out of the six bleeds (80%) were local hematomas which spontaneously settled. One patient had an intercostal artery rupture needing cardiothoracic intervention. There was no associated mortality. This particular patient was on no anti-
coagulation and had an ICD inserted for a malignant pleural effusion via the ‘safe triangle’ approach under ultrasound guidance, in daytime hours, by an experienced consultant.

Of the 960 procedures done for pleural effusion, 702 post-procedural X-rays were done. A total of 102 post procedural X-rays (92 ICD insertions and 10 thoracocenteses) showed air in the pleural space.

Of those 10 thoracocenteses, pneumothorax ex vacuo and non-expandable lung with no pleural apposition were deemed to be present in 8 as the X-rays showed no pleural apposition of lung, and all patients underwent eventual indwelling pleural catheter placement. Subsequent X-rays post catheter placement confirmed persistence of pneumothorax ex vacuo with no pleural apposition in all. Diagnoses were malignant pleural mesothelioma in 7 and pleural adenocarcinoma in 3. In 2 thoracocentesis patients, post procedural X-rays showed clear large hydro-pneumothoraces and those patients had ICDs inserted. Those ICDs bubbled on placement for an average of 2.5 days (range 1–4) and full lung re-expansion occurred. The patients were subsequently pleurodesed.

As mentioned above, post procedural X-rays in 92 ICDs showed air in the pleural space. All medical notes were reviewed, and air bubbling was noticed in 7, for an average of 3.2 days (range 2–9). They were all ICDs inserted for large pleural effusions and the air leaks were attributable to a shearing of the pleural surfaces rather than lung puncture. Full lung-expansion eventually occurred in all. Diagnoses were 5 malignant pleural effusions (breast, ovarian and prostate), 1 parapneumonic effusion and 1 empyema. Seven patients in the ICD group were thus deemed to have true pneumothoraces.

Out of the remaining 85 patients which had ICDs, 56 proceeded to have an indwelling pleural catheter inserted for confirmed and/or presumed malignant effusion and non-expandable lung. Post-procedural X-rays confirmed no pleural apposition. The rest of this group, 29 patients, did not require further procedures due to rapid clinical deterioration: all were presumed malignant diagnoses.

Thus, the rate of pneumothorax is 9 (1.2%) for all thoracenteses and ICD insertion.

There were no instances of infection within 30 days with thoracocenteses. In effusions requiring ICDs that were not already infected (854), there were 3 pleural space infections (0.35%) within 30 days. Two had ICDs for malignant effusions but were not pleurodesed.

The rate of pneumothorax is 9 (1.2%) for all thoracenteses and ICD insertion.

Surgical emphysema was noted on post procedure X-rays after 43 (3.7%) procedures of which 41 were ICD insertion. Eight were due to fall outs, and 3 required further drain insertion and subsequent surgical intervention (Table 1).
Table 1. Summary of records analysed and complication rates.

| Total Number of Records | 1304 |
|-------------------------|------|
| Excluded                | 145  |
| Incorrect coding large bore drains, tunnelled catheters, patients less than 18 years of age |
| Records Analysed        | 1159 |
| Procedures for Pneumothorax | 199/1159 (17.2%) |
| Procedures for Pleural Effusions | 960/1159 (82.8%) |
| Type of Procedure       | 288 thoracocenteses 879 intercostal drains (ICDs) |
| Overall Complication Rate | 93/1159 (8%) |
| Bleeding Incidence       | 6/1559 (0.5%) 5 local haematomas and 1 intercostal artery rupture |
| Number of Post Procedural X-rays in Procedures for Pleural Effusion | 702/960 |
| 102 (92 ICDs and 10 thoracocenteses) showed air in pleural space |
| Pneumothorax Incidence   | 9/702 (1.2%) Pneumothorax ex-vacuo/non-expandable lung observed in others |
| Infection Incidence within 30 Days with ICDs | 3/854 (0.25%) |
| 854 procedures done for effusions not already infected |
| ICD Fall out Incidence   | 35/879 (4%) 9 were not sutured, patient factors involved in 19 others and 7 had unknown causes |
| Surgical Emphysema       | 43/1159 (3.7%) 41 ICDs and 2 thoracocenteses |

4. Discussion

This is a single centre retrospective study with an overall 8% complication rate after thoracocentesis and ICD insertion.

No organ puncture is attributable to widespread thoracic ultrasound use for pleural effusion. No re-expansion pulmonary oedema is attributable to adherence to local guidance (Supplementary Materials: Annex 1) of close observation and limitation of rate of drainage.

Bleeding usually occurs due superficial vessel laceration or damage to the intercostal artery or vein. Guidance suggests avoiding a posterior approach (the intercostal neurovascular bundle loses the protection of the rib posteriorly), to approach the pleural space just superior to a rib, to have a cut off-of platelet count <50 × 10^9 per litre, and to correct coagulopathies for the international normalized (INR) ratio to be <1.5 [2,3,8]. Our study suggests that bleeding is rare, and no meaningful inference can be made from 2 patients being on anti-platelet therapy. The patient who was on dual anti-platelet therapy required an urgent ICD for his pneumothorax. More recently, direct visualization of the intercostal artery with Doppler has been suggested [9], and perhaps this might have prevented the one case of intercostal artery rupture. Local training is ongoing but challenging given the wide range of practitioners that perform pleural procedures.

Thoracentesis has widespread use as the first investigative step in the diagnosis of a pleural effusion and can be used for removal of air in a pneumothorax, but the latter practice is variable and not done locally. BTS guidance does suggest that instrumentation can be physician dependent [2,3]. Case series describe pneumothorax complicated 5% of thoracocentesis and less than 2% require a subsequent ICD [8]. In the absence of symptoms post thoracocentesis, we do not routinely perform X-rays, which is in line with expert opinion [10]. This might have underestimated the proportion of asymptomatic pneumothoraces present. Hence, we only found 2 post thoracocentesis pneumothoraces on post procedure X-rays (0.7%). Our pneumothorax rate is low and is most likely attributable to widespread use of thoracic ultrasound and limiting drainage of effusions to 1 L at a time, thus limiting significant negative intrapleural pressure and shearing.

Pleural infection secondary to an intervention has an incidence of about 1–3%. Due to high morbidity and mortality, a full sterile technique is advocated. The use of prophylactic...
antibiotics in the trauma setting is also advocated [11], but there is no evidence to suggest their role in routine ICD insertion. Locally, all ICDs are done under strict asepsis.

Fall out and/or displacement rates of ICDs are estimated to be between 9.2 and 42% and approximately 6.6% of sutured drains fall out too [12]. Asciak et al. performed a retrospective analysis of chest drain fall out rates and defined the drain tip migrating out of the pleural cavity. In 369 ICDs, 106, 28.7% were sutured. Of the sutured drains, 7 (6.6%) fell out after a mean of 3.3 days (SD 2.6) compared to 39 (14.8%; \( p = 0.04 \)) unsutured drains falling out after a mean of 2.7 days (SD 2.0; \( p = 0.8 \)). The study had significant limitations but a trend of lower fall out rates with suturing was suggested. We did not measure how many ICDs were unsutured but simply noticed that 9 out of 35 ICDs which ‘fell out’ were unsutured. As per Asciak et al. [12], those were inserted out of normal working hours and by junior staff, and this highlights training issues which are being rectified locally by rolling ICD insertion courses.

Our local pleural procedure invasive checklist is annexed (Supplementary Materials: Annex 2). Uptake is variable (local unpublished data), and suturing is mandated. This would have perhaps prevented nine of the non-sutured ICDs from not falling out, but this cannot be reliably inferred. An electronic system mandating the use of the checklist is currently being developed.

This single centre retrospective case series has significant limitations. We relied on hospital codes to search for patients and might not have captured all the procedures done during the prescribed time frame. We did not collect variables for the patients without complications and thus do not have control groups for any of the above subset analyses: meaningful statistical analysis is hence not feasible. Furthermore, as described above, we do not perform post-procedural X-rays routinely after thoracocentesis, and thus, pneumothorax rates after that specific procedure are probably underestimated. Bleeding rates are probably also under-estimated as the notes will have only mentioned significant bleeding events.

5. Conclusions

Complication rate for intercostal drain insertion and thoracocentesis is low. In the absence of prospective studies on pleural complications, retrospective analyses of local data sets remain crucial. A prospective observational study (IRAS 260269) [13] on pleural complications is currently underway.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/jor1020014/s1, Annex 1: pleural drainage observation chart and Annex 2: invasive procedure check lists.

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References

1. Bodtger, U.; Halifax, R.J. Epidemiology: Why is pleural disease becoming more common? In Pleural Disease (ERS Monograph); Maskell, N.A., Laursen, C.B., Lee, Y.C.G., Rahman, N.M., Eds.; European Respiratory Society: Sheffield, UK, 2020; pp. 1–12. [CrossRef]

2. Hooper, C.; Lee, Y.C.G.; Maskell, N.A. Investigation of a unilateral pleural effusion in adults—British Thoracic Society pleural disease guideline. Thorax 2010, 65 (Suppl. 2), ii4–ii17. [CrossRef] [PubMed]

3. MacDuff, A.; Arnold, A.; Harvey, J. BTS Pleural Disease Guideline Group. Management of spontaneous pneumothorax: British Thoracic Society Pleural Disease Guideline 2010. Thorax 2010, 65 (Suppl. 2), ii18–ii31. [CrossRef]

4. Hooper, C.; Maskell, N. British Thoracic Society national pleural procedures audit 2010. Thorax 2011, 66, 636–637. [CrossRef]

5. Safety Alerts Insertion of chest drains: Summary of a Safety Report from the National Patient Safety Agency. Available online: https://research-information.bris.ac.uk/en/publications/safety-alerts-insertion-of-chest-drains-summary-of-a-safety-repor (accessed on 29 March 2021).

6. Havelock, T.; Teoh, R.; Laws, D.; Gleeson, F. Pleural procedures and thoracic ultrasound: British thoracic Society pleural disease guideline 2010. Thorax 2010, 65, i61–i76. [CrossRef]

7. Stanton, A.E.; Edey, A.; Evison, M.; Forrest, I.; Hippolyte, S.; Kastelik, J.; Latham, J.; Loewenthal, L.; Nagarajan, T.; Roberts, M.; et al. British Thoracic Society Training Standards for Thoracic Ultrasound (TUS). BMJ Open Respir. Res. 2020, 7, e000552. [CrossRef] [PubMed]

8. Wrightson, J.M.; Helm, E.J.; Rahman, N.M.; Gleeson, F.V.; Davies, R.J. Pleural procedures and pleuroscopy. Respiratory 2009, 14, 796–807. [CrossRef]

9. Hassan, M.; Mercer, R.M.; Rahman, N.M. Thoracic ultrasound in the modern management of pleural disease. Eur. Respir. Rev. 2020, 29, 190136. [CrossRef] [PubMed]

10. Lenaeus, M.J.; Shepard, A.; White, A.A. Routine Chest Radiographs after Uncomplicated Thoracentesis. J. Hosp. Med. 2018, 13, 787–789. [CrossRef] [PubMed]

11. Ayoub, F.; Quirke, M.; Frith, D. Use of prophylactic antibiotic in preventing complications for blunt and penetrating chest trauma requiring chest drain insertion: A systematic review and meta-analysis. Trauma Surg. Acute Care Open 2019, 4, e000246. [CrossRef]

12. Asciak, R.; Addala, D.; Karimjee, J.; Rana, M.S.; Tsikrika, S.; Hassan, M.F.; Mercer, R.M.; Halifax, R.J.; Wrightson, J.M.; Psallidas, I.; et al. Chest Drain Fall-Out Rate According to Suturing Practices: A Retrospective Direct Comparison. Respiration 2018, 96, 48–51. [CrossRef] [PubMed]

13. Prospective Data Collection on Clinical, Radiological and Patient Reported Outcomes after Pleural Intervention. NIHR CRN Portfolio Search. Available online: https://public-odp.nihr.ac.uk/QtvAJAXZfc/opendoc.htm?document=CRNCC_Users%2FFind%20A%20Clinical%20Research%20Study.qvw&sheet=SH01&bookmark=Document\backslash$BM02&select=LB01, =StudyID=43300 (accessed on 8 May 2021).