

An audit of the complications of intercostal chest drain insertion in a high volume trauma service in South Africa

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ABSTRACT

INTRODUCTION Intercostal chest drain (ICD) insertion is a commonly performed procedure in trauma and may be associated with significant morbidity.

METHODS This was a retrospective review of ICD complications in a major trauma service in South Africa over a four-year period from January 2010 to December 2013.

RESULTS A total of 1,050 ICDs were inserted in 1,006 patients, of which 91% were male. The median patient age was 24 years (interquartile range [IQR]: 20–29 years). There were 962 patients with unilateral ICDs and 44 with bilateral ICDs. Seventy-five per cent (758/1,006) sustained penetrating trauma and the remaining 25% (248/1006) sustained blunt trauma. Indications for ICD insertion were: haemopneumothorax ($n=338$), haemothorax ($n=314$), simple pneumothorax ($n=265$), tension pneumothorax ($n=79$) and open pneumothorax ($n=54$).

Overall, 203 ICDs (19%) were associated with complications: 18% (36/203) were kinked, 18% (36/203) were inserted subcutaneously, 13% (27/203) were too shallow and in 7% (14/203) there was inadequate fixation resulting in dislodgement. Four patients (2%) sustained visceral injuries and two sustained vascular injuries. Forty-one per cent (83/203) were inserted outside the 'triangle of safety' but without visceral or vascular injuries. One patient had the ICD inserted on the wrong side. Junior doctors inserted 798 ICDs (76%) while senior doctors inserted 252 (24%). Junior doctors had a significantly higher complication rate (24%) compared with senior doctors (5%) ($p<0.001$). There was no mortality as a direct result of ICD insertion.

CONCLUSIONS ICD insertion is associated with a high rate of complications. These complications are significantly higher when junior doctors perform the procedure. A multifaceted quality improvement programme is needed to improve the situation.

KEYWORDS

Pneumothorax – Penetrating injuries – Chest drain

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Intercostal chest drain (ICD) insertion is an essential skill in the management of trauma patients. However, the procedure is associated with a complication rate that may be as high as 30%.^{1–5} Numerous case reports have documented individual cases of fatal complications such as ventricular perforation⁴ and pulmonary artery injury following ICD insertion.⁵ In light of this, the correct safe technique of insertion is one of the core skill sets that is heavily emphasised in the *Advanced Trauma Life Support*® (ATLS®) course.⁶ The objective of this study was to review the immediate complications associated with ICD insertion in a high volume trauma service.

Methods

This was a retrospective study undertaken at the Pietermaritzburg Metropolitan Trauma Service (PMTS) in South

Africa. A retrospective review of a prospectively maintained regional trauma registry was conducted over a four-year period from January 2010 to December 2013. Ethics approval for carrying out this study and maintaining this registry was granted by the Biomedical Research Ethics Committee of the University of KwaZulu-Natal (reference number: BE 207/09). The PMTS provides definitive trauma care to the city of Pietermaritzburg and the western part of the KwaZulu-Natal province. It also serves as the trauma referral service for 19 other district hospitals, with a total catchment population of over 5 million people. A high volume of penetrating thoracic trauma is managed by the PMTS and the volume of blunt trauma is also substantial.

Data from the trauma registry were extracted into an Excel® spreadsheet (Microsoft, Redmond, WA, US) for processing. The basic patient demographics, mechanism of injury,

indications for ICD, operator level of training, immediate complications and outcome of all patients were reviewed. Only patients who presented directly to our trauma service without an ICD in situ were included. Patients who had a tension pneumothorax and who had undergone needle decompression in the prehospital setting were also included. Patients who required ICD insertion in the operating theatre were excluded.

Complications were classified according to the following groups: drains that were too shallow (with drain hole visible externally), subcutaneous placement (extrathoracic site, including placement into breast tissues), inadequate fixation (resulting in drain dislodgement), kinked drain (non-functional despite intrathoracic placement) and any associated visceral injury (eg gastric perforation) or vascular injury (eg intercostal artery). Any drains inserted on the wrong side or placed outside the defined anatomical 'triangle of safety' were also classified under complications. The standard triangle of safety was defined conventionally by the lateral border of the pectoralis major, the medial border of the latissimus dorsi and the fifth intercostal space.⁷

ICD sizes were all standardised in our unit (minimum of 32Fr). Cases of ICD blockage by blood clot or self-removal by inebriated patients were not included as complications. The ICDs were placed by doctors of various levels of experience in our trauma unit. We defined junior doctors as those at postgraduate year (PGY) 1 or 2 after qualifying while senior doctors were those at PGY 3 or above.

Statistical analysis

Data were analysed using Stata[®] 13.0 (StataCorp, College Station, TX, US). The difference in complication rates for the junior and senior doctors was assessed using the Pearson chi-squared (χ^2) test for independence. A *p*-value of <0.05 was considered statistically significant.

Results

Over the 4-year study period, 1,050 ICDs were inserted in 1,006 patients, of which 91% were male (918/1,006). The median patient age was 24 years (interquartile range [IQR]: 20–29 years).

Injury mechanisms

Of the 1,006 patients, 75% (758/1,006) sustained penetrating trauma while the remaining 25% (248/1,006) sustained blunt trauma. Of the 758 patients with penetrating trauma, 75% (572/758) had stab injuries and 25% (186/758) had gunshot injuries. Of the 248 patients who sustained blunt trauma, 55% (136/248) were from road traffic accidents (RTAs), 39% (97/248) were from assaults and 6% (15/248) were from falls. Table 1 summarises the mechanism of injury in all 1,006 patients.

Indications for intercostal chest drains

A total of 1,050 ICDs were inserted in 1,006 patients: 962 patients had unilateral ICDs and 44 had bilateral ICDs. Sixty-one per cent (637/1,050) of all ICDs were inserted on the left side and the remaining 39% (413/1,050) on the

Table 1 Mechanisms of injury

Penetrating (n=758)	
Stab wounds	572 (75%)
Gunshot wounds	186 (25%)
Blunt (n=248)	
Road traffic accident	136 (55%)
Assault	97 (39%)
Fall	15 (6%)

Table 2 Indications for intercostal chest drain (n=1,050)

Indication	n
Haemopneumothorax	338 (32%)
Haemothorax	314 (30%)
Simple pneumothorax	265 (25%)
Tension pneumothorax	79 (8%)
Open pneumothorax	54 (5%)

right. The indications for insertion of these 1,050 ICDs are summarised in Table 2.

Overview of complications

The 1,050 ICDs were associated with a total of 203 complications (19%): 18% (36/203) of ICDs were kinked, 18% (36/203) were inserted subcutaneously, 13% (27/203) were too shallow and in 7% of cases (14/203), inadequate fixation resulted in ICD dislodgement.

Figure 1 shows a kinked ICD in a 24-year-old patient who sustained a pneumothorax following stab injuries to his right chest. Figure 2 shows an ICD inserted subcutaneously through the back muscles in a 50-year-old man who sustained a haemopneumothorax following an RTA. Figure 3 shows an ICD that was too shallow (with the drain hole visible) in a 35-year-old man who had a pneumothorax from stab injuries.

Four patients (2%) sustained iatrogenic visceral injuries as a direct result of ICD insertion. Three of these patients had a diaphragmatic perforation, which required subsequent laparoscopic repair. The fourth patient had an intrathoracic gastric herniation following an RTA. This was not recognised on the initial chest radiography. He sustained a gastric perforation following ICD insertion and subsequently underwent a laparotomy (Fig 4). All four of these ICDs were inserted by junior doctors. Two patients (1%) sustained iatrogenic visceral injuries to the intercostal vessels during blunt dissection, which resulted in a persistent haemothorax. They subsequently underwent video assisted thoracoscopy and cauterisation of the bleeding vessel. Both of these ICDs were inserted by senior doctors. All six patients with visceral or vascular injuries survived and were discharged home.

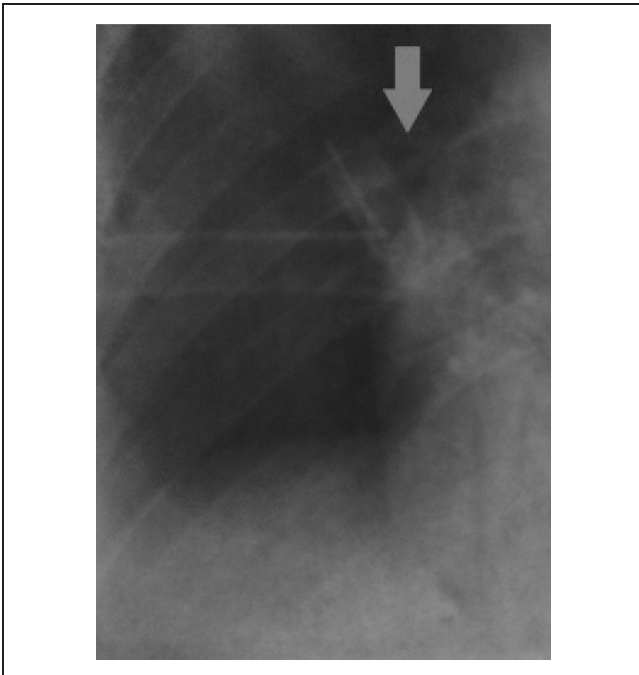


Figure 1 A kinked intercostal chest drain (arrow)

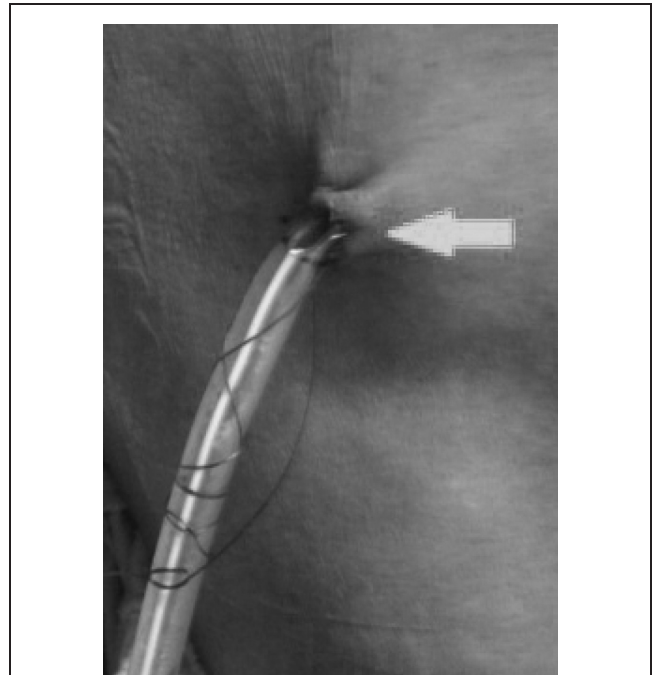


Figure 3 An intercostal chest drain with the drain hole visible (arrow)

Forty-one per cent (83/203) of the ICDs with complications were inserted outside the triangle of safety but without visceral or vascular injuries. One patient had the ICD inserted on the incorrect side. There were no mortalities as a direct result of ICD insertion in this study. Table 3 summarises all complications seen.

Complications by grade of staff

Of the 1,050 ICDs inserted, junior doctors inserted 798 (76%) while senior doctors inserted 252 (24%). The

complication rate for ICDs inserted by junior doctors was 24% (190 complications) while for senior doctors it was 5% (13 complications) ($\chi^2=42.7, p<0.001$).

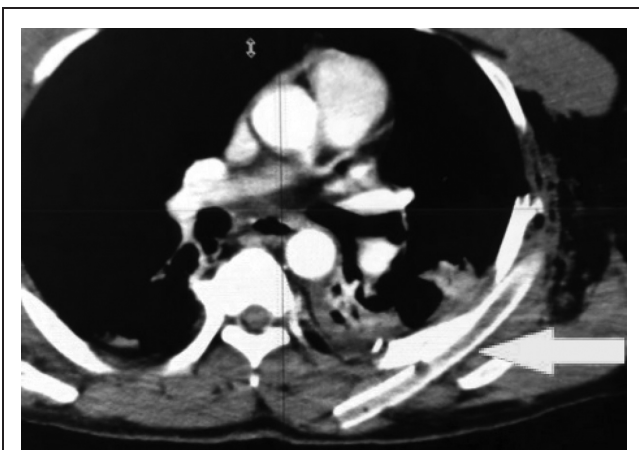


Figure 2 Subcutaneous placement (arrow)

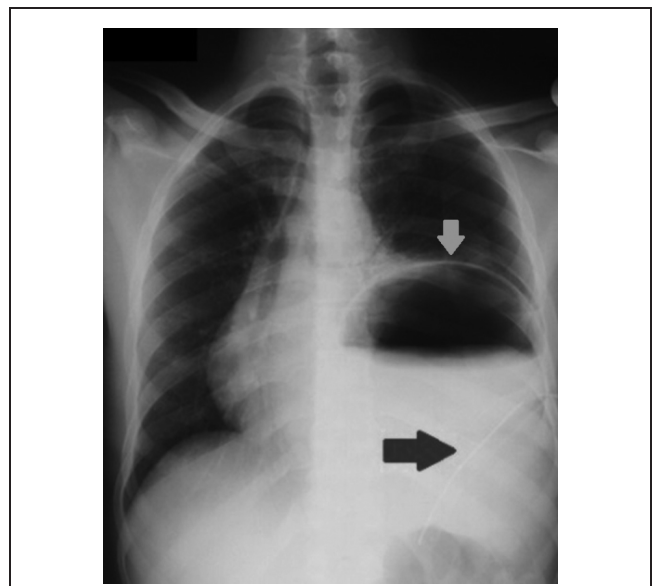


Figure 4 Iatrogenic gastric injury from an intercostal chest drain (ICD). (Lower arrow shows the ICD; upper arrow shows gastric herniation into the chest.)

Table 3 Complications (*n*=203)

Complication	<i>n</i>
Kinked	36 (18%)
Subcutaneous placement	36 (18%)
Too shallow	27 (13%)
Dislodged	14 (7%)
Visceral injury	4 (2%)
Vascular injury	2 (1%)
Wrong side	1 (1%)
Outside safety triangle	83 (41%)

Discussion

ICD insertion is a common procedure that is an integral part of trauma management. *ATLS*[®] training has standardised the teaching of ICD insertion and the technique described is regarded currently as the gold standard in terms of safety.⁶ Despite the widespread adoption of *ATLS*[®] training and principles as part of both undergraduate and postgraduate training worldwide, there continues to be a steady stream of literature reporting an unacceptably high rate of complications^{1–5} and even mortality⁵ associated with the procedure.

Complication rates following ICD insertion are dependent on several factors, the most important of which are operator training, specialty and previous supervised experience.⁸ In the UK, the National Patient Safety Agency reported 12 deaths and 15 cases of serious harm caused by ICD insertion between 2005 and 2008.⁹ While the report was not exclusive to ICDs in the trauma setting, it demonstrates that a low level of experience with the procedure and poor supervision of junior doctors performing it are associated with complications.⁹ Griffiths and Roberts surveyed 55 junior doctors in Sheffield and found that 45% did not know the correct anatomical location for ICD insertion.¹⁰ A further

study by Elsayed *et al* showed that only 44% of junior doctors indicated that they would insert an ICD in the triangle of safety.¹¹ Furthermore, only 58% of junior doctors working in surgery had sufficient knowledge for safe insertion of ICDs.

There appears to be a general deficiency of baseline knowledge of the procedure despite the expectation that junior doctors should be competent in performing it in the emergency setting. The current trend of restructuring surgical training worldwide, with the concomitant reduction in working hours and the subsequent lack of exposure to key procedures, may have exacerbated these problems.¹² Table 4 compares the published complication rates to date.

Our overall immediate complication rate of 19% is a major concern. A total of 1,050 ICDs inserted over a 4-year period would equate to approximately 263 per year or 22 per month. In principle, this should offer ample training opportunities for junior doctors. However, the level of training and experience varies invariably between doctors and not all are currently *ATLS*[®] certified. ICD insertion in trauma is often delegated to the more junior doctors, based on the erroneous assumption that the individual doctor has been taught the procedure at some stage during his or her training. Our study has shown that junior doctors have a significantly higher complication rate than senior doctors. While educational interventions and structured training may improve the situation, evidence for a significant positive impact of these initiatives remains elusive. Even when associated with high volume exposure, educational initiatives may perhaps be insufficient.

There was a single incident of wrong side surgery in this cohort and this occurred during a mass casualty event, in which the chest radiograph from another patient was reviewed inappropriately. This error was related to cognitive and system failures that can be difficult to eliminate completely. Understanding human error and non-technical skills may help develop strategies to reduce the incidence of these avoidable complications.¹⁸ One of the most widely publicised error reducing strategies is the World Health Organization's surgical safety checklist. Since its introduction in 2008, the checklist has been adopted widely across

Table 4 Comparative data, 1999–2014

Study	Country	Period	Number of cases	Penetrating	Blunt	Complications
Present study	South Africa	4 yrs	1,050	75%	25%	19%
Martin, 2013 ¹³	US	4.5 yrs	313	13%	87%	5%
Alrahbi, 2012 ¹	Australia	1 yr	94	14%	86%	38%
Maybauer, 2012 ¹⁴	Germany	5 yrs	70	Not known	Not known	22%
Iribhogbe, 2011 ¹⁵	Nigeria	3 yrs	74	54%	46%	24%
Maritz, 2009 ¹⁶	South Africa	3 mths	273	Not known	Not known	10%
Sethuraman, 2008 ²	US	3 yrs	242	40%	43%	37%
Ball, 2005 ¹⁷	New Zealand	1 yr	76	1%	99%	22%
Bailey, 1999 ³	UK	1 yr	57	6%	90%	30%

the world, and has been shown to have a significant impact in reducing human error related morbidity and mortality.¹⁹ A multifaceted programme that addresses knowledge and technical skills together with a tick box checklist may be the key to reducing the complications associated with ICD insertion.^{20,21} Further studies on the effectiveness of such interventions are needed.

Conclusions

ICD insertion is a common procedure in trauma and it is associated with a high incidence of potentially preventable complications. Although these complications are usually self-limiting, they are associated occasionally with significant morbidity. Junior doctors had a significantly higher complication rate than senior doctors and interventions are needed to improve this situation. It is unlikely that educational initiatives alone will be sufficient and error reduction techniques such as tick box checklists must be used in conjunction with these other initiatives, if we want to improve the situation.

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