



# The spectrum of visceral injuries secondary to misplaced intercostal chest drains: Experience from a high volume trauma service in South Africa



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## ABSTRACT

**Introduction:** Iatrogenic visceral injuries (IVI) secondary to the insertion of an intercostal chest drain (ICD) are well documented, but are usually confined to case reports and small series.

**Materials and methods:** We reviewed our experience with 53 consecutive patients over a insertion seven year period who sustained an IVI secondary to an ICD and describe the spectrum of injuries and clinical outcome in a high volume trauma service in South Africa.

**Results:** A total of 53 ICDs were inserted in 53 patients, 83% (44/53) of which were on the left side, and 17% (9/53) on the right side. 92% (49/53) of the patients were males and the mean age for all patients was 24 ( $\pm 8$ ) years. 85% of the patients were referred from rural hospitals, the remaining 15% were treated initially at our institution. A trocar was used in 75% (40/53) of patients and in 9% (5/53), a trocar was not used, 58 organ injuries occurred in 53 patients. 92% (49/53) of patients sustained a single organ injury and 4 sustained multiple injuries. The three most common injuries were: diaphragm (36%, 21/53), gastric (22%, 13/53), and pulmonary (12%, 7/53). Other injuries were: 6 (10%) spleen, 4 (7%) liver, 2 (3%) colon and 1 (2%) kidney. Three (5%) sustained an injury to the intercostal artery and one (2%) sustained a pulmonary artery injury. 39 patients (74%) required operative interventions which included laparoscopy: 20 (51%), laparotomy: 8 (21%), thoracotomy: 8 (21%), VAT: 3 (8%). A total of 28 patients (53%) developed further complications: 13 wound sepsis, 7 pneumonia, 6 empyema, 2 ARDS, and 15% (8/53) required intensive care admission. The mean length of hospital stay was 7 ( $\pm 4$ ) days.

**Conclusions:** IVI is associated with significant morbidity, with diaphragmatic, gastric and pulmonary injuries being the most common. The majority were inserted in the rural hospitals and were associated with use of a trocar, Level of evidence: III, Study type: Retrospective study.

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## Introduction

Intercostal chest drain (ICD) insertion is a common procedure in the management of thoracic trauma [1]. The reported overall iatrogenic complication rate varies [2,3], but can be as high as thirty per cent [2–6]. Although most of these complications are related to the malpositioning of ICDs and are usually self-limiting, significant iatrogenic visceral injury (IVI) can occur [7]. The literature on the topic of IVI is usually confined to case reports [8], which describe a series of injuries that range from minor pulmonary lacerations [9], to serious potentially fatal injuries

such as pulmonary artery rupture [10] and ventricular perforation [11]. There are no large studies that focus on the problem of IVI secondary to ICD insertion, and the pattern of these visceral injuries is largely unknown. This study reviews the experience of a high volume trauma service in South Africa with the problem of IVI secondary to ICD insertion. It reviews the spectrum of IVI encountered, the management and outcome of these injuries and attempts to identify potentially modifiable risk factors.

## Materials and methods

This was a retrospective study undertaken in the Pietermaritzburg Metropolitan Trauma Service (PMTS), Pietermaritzburg, South Africa. A retrospective review of a prospectively maintained regional trauma registry kept by the PMTS was performed for a 7-year period from January 2007 to December 2013. Ethics approval

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for this study and the maintenance of the trauma registry was granted by the Biomedical Research Ethics Committee (BREC) of the University of KwaZulu Natal (UKZN) and is renewed annually (Reference number: BE 207/09). The PMTS provides definitive trauma care that covers the western part of the KwaZulu Natal Province, with a total catchment population of over 3 million people. It provides coverage for the city of Pietermaritzburg, as well as serving as the trauma referral service for 19 other rural district hospitals and numerous primary healthcare clinics.

All patients managed by the PMTS who had sustained an IVI secondary to the insertion of an ICD were reviewed. The hospital records for each patient were retrieved for further relevant information. All patients who had an ICD inserted at our trauma unit, or any patients who were referred from any rural hospitals with an ICD in situ as a result of trauma were eligible. The definition of IVI encompassed all injuries caused by the process of ICD insertion. The PMTS holds a weekly structured morbidity and mortality meeting, when every patient admitted to the service is discussed in detail. In cases referred from the rural district hospitals with an IVI from an ICD, efforts are made to contact the referring staff for debriefing. Regular visits are also made to each referring hospital as a part of a structured trauma education outreach programme.

Basic demographic data include age, gender, and whether patients were referred from a rural district hospital. The mechanism of trauma, the thoracic pathology and the indication for ICD were recorded. Specific details of all investigations performed (e.g. Computed Tomography (CT) scans), and the need for operative interventions were included. The operative findings and clinical outcome were reviewed. All relevant data were extracted onto a Microsoft EXCEL<sup>®</sup> spread sheet for processing and analysis.

## Results

### Demographics

During the seven-year study period, a total of 53 patients who had sustained an IVI as a direct result of ICD insertion were identified. There were forty-nine (92%) males and four (8%) females, with a mean age of 24 ( $\pm 8$ ) years. Eighty-five per cent (45/53) of all patients were referred from rural district hospitals, with ICDs already in situ. The remaining fifteen per cent (8/53) had an ICD inserted under our auspices: five by junior doctors, three by senior doctors. During the same period, a total of 1054 ICDs were inserted at the PMTS. This gives an incidence of IVI at our institution of 0.8% (8/1054).

There were a total of 53 ICDs inserted in 53 patients, 83% (44/53) of which were on the left side, and 17% (9/53) on the right side. A trocar was used in 75% (40/53) of ICDs. In 9% (5/53), a trocar was not used, and in the remaining 15% (8/53), there was no information available.

### Mechanism

Of the 53 patients included in the study, 77% (41/53) sustained penetrating trauma, and 23% (12/53) sustained blunt trauma. All of the 41 patients who had penetrating trauma sustained stab injuries. Of the 12 patients who had blunt trauma, 10 were from road traffic accidents (RTAs) and 2 were victims of assault.

### Initial pathology

The initial suspected pathology requiring ICDs were, in order of decreasing frequency: Simple pneumothorax: 72% (38/53), Hemopneumothorax: 15% (8/53), Haemothorax: 11% (6/53),

**Table 1**

Initial pathologies requiring ICD.

Pathology	N = 53	%
Simple Pneumothorax	38	72%
Hemopneumothorax	8	15%
Haemothorax	6	11%
Tension Pneumothorax	1	2%

**Table 2**

Frequency of specific organ injury.

Organ	N = 58
Diaphragm	21
Stomach	13
Lung lobe	7
Spleen	6
Liver	4
Intercostal artery	3
Colon	2
Pulmonary artery	1
Kidney	1

Tension pneumothorax: 2% (1/53). A total of 92% of (49/53) of all patients had a chest radiograph (CXR) prior to ICD insertion. The remaining 8% (4/53) had an ICD inserted based on clinical suspicion alone. Table 1 summarises the initial pathologies requiring ICDs.

### Overview of the spectrum of organ injury

A total of 58 organ injuries occurred in 53 patients. A total of 92 per cent (49/53) of all patients sustained a single organ injury and 4 patients sustained multiple organ (two organs) injuries. The most common injury was diaphragmatic perforation (36%, 21/53). The second most common injury was gastric perforation (22%, 13/53), followed by pulmonary parenchymal laceration (12%, 7/53). There were 6 (10%) splenic injuries, 4 (7%) liver injuries, 2 (3%) colonic perforations and 1 (2%) renal laceration. Three (5%) patients sustained an injury to the intercostal artery that ultimately required operative intervention, and one (2%) patient sustained a pulmonary artery injury. Table 2 summarises the 58 organ injuries.

### Operative interventions

A total of 74 per cent (39/53) of all patients ultimately required one or more operative interventions to manage the IVI. Twenty of the 39 (51%) patients underwent laparoscopy, 8 (21%) underwent laparotomy, 8 (21%) underwent thoracotomy and 3 (8%) underwent video assisted thoracoscopy (VAT) and cauterisation of the injured intercostal artery.

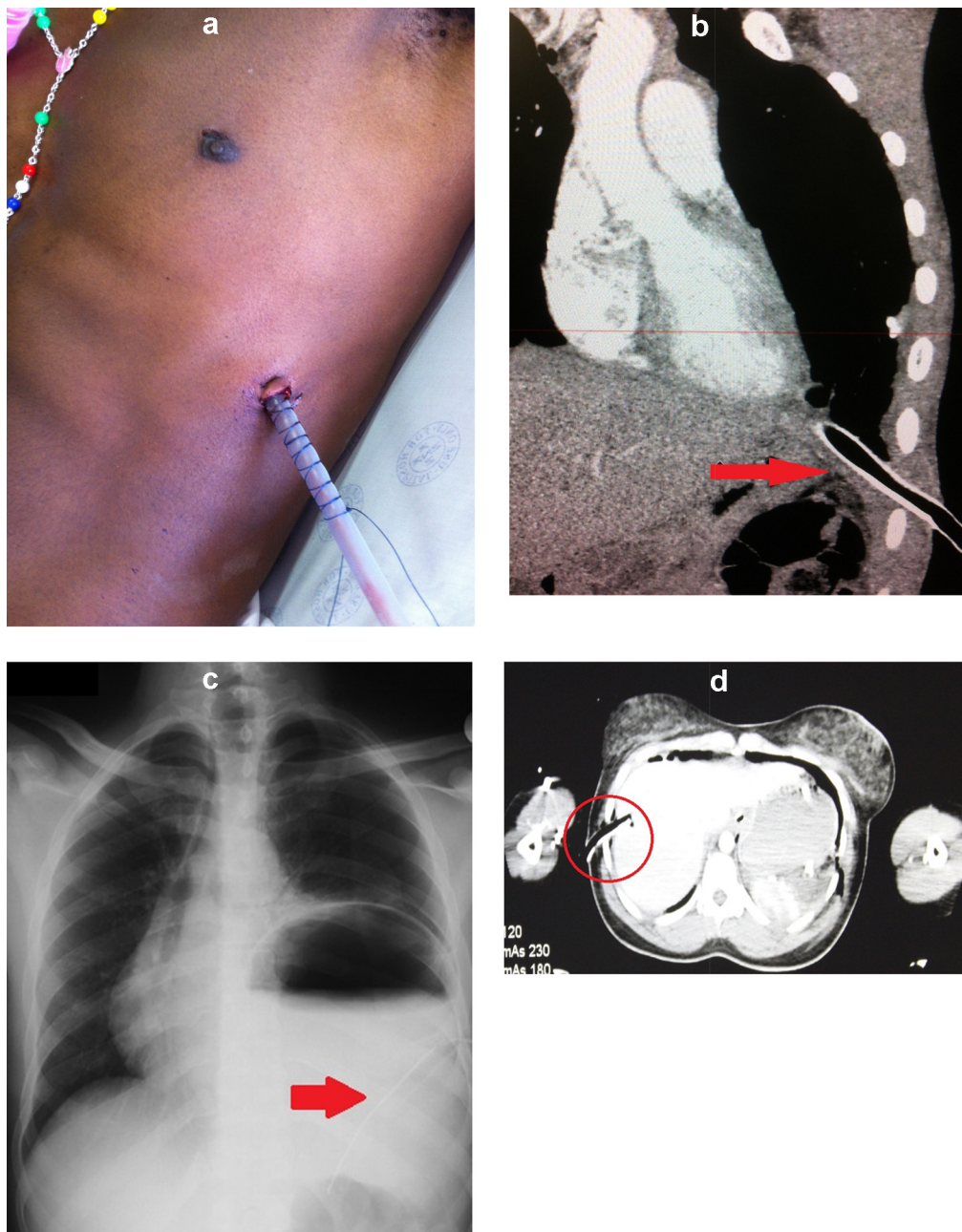
### Specific organ injury

#### Pulmonary injury

Of the seven patients who sustained a pulmonary laceration, all had drains inserted on the right side. Five were stabbed and two were involved in RTAs. All had CT confirmation of the ICD inserted directly into the lung parenchyma. These were all managed conservatively and none required operative intervention.

#### Diaphragmatic injury

Twenty-one iatrogenic diaphragmatic injuries were identified, all of which were on the left side. It was thought to be unlikely in



**Fig. 1.** (a) Misplaced ICD. (b) Sagittal view on CT showing diaphragmatic cannulation. (c) Gastric cannulation from ICD. (d) Liver injury.

each of these cases that the injury was caused by the original trauma based on clinical review of the original mechanism and site of the injury. These patients all had ICDs inserted in the seventh intercostal space or lower. These injuries were all confirmed at laparoscopy during which they were repaired. Fig. 1a shows a misplaced ICD in a 26-year-old man. CT (Fig. 1b) showed injury to the left hemi-diaphragm, which was subsequently confirmed on laparoscopy.

#### *Enteric injury*

Of the 13 patients who sustained an iatrogenic enteric injury, all developed drainage of gastrointestinal content from the ICD. All 13 patients sustained ICD from ICD inserted into the left chest. Twelve of the 13 sustained a gastric injury, and one patient sustained a

combined gastric and colonic injury. All 13 patients had concurrent diaphragmatic injuries. Five patients in this group were involved in RTAs and the remaining 8 were from stabs. The diaphragmatic injuries were confirmed at operation. Twelve of the 13 patients (92%) had a pre-insertion CXR that showed herniation of stomach into the thorax and were misinterpreted as pneumothorax or haemothorax. Seven of the 13 (54%) patients underwent thoracotomy and had gastric and diaphragmatic repair. The remaining six patients were subjected to a laparotomy. Fig. 1c shows the CXR of a 31-year-old man who an ICD had inserted following a stab injury to the left chest. His chest X-ray was misinterpreted as a hemopneumothorax. He was referred from a rural district hospital with the ICD draining gastric content. He underwent a laparotomy during which his herniated stomach was reduced into the abdomen and a gastric perforation was repaired and his left chest cavity was



copiously irrigated. He had an uneventful recovery. A total of six patients with an intra-thoracic gastric injury eventually developed an empyema and required a decortication.

#### *Solid organ injury*

Of the six patients who sustained an iatrogenic splenic injury three had an isolated splenic injury and three had combined splenic and diaphragmatic injuries. All 6 patients initially presented with stab injuries. In the three patients with isolated iatrogenic splenic injuries, the injuries were confirmed on CT. One of these three patients underwent a diagnostic laparoscopy and ultimately required a splenectomy. The three patients with combined splenic and diaphragmatic injury underwent laparoscopy and diaphragmatic repair. All four patients who sustained an iatrogenic liver injury were managed conservatively. Fig. 1d shows an ICD inserted into the liver in a 35 year old woman following an RTA. This was managed conservatively and the patient was discharged home. One patient who had minor renal laceration confirmed on CT had persistent haematuria, which subsided spontaneously.

#### *Vascular injury*

All the three patients who sustained an injury to an intercostal artery, remained haemodynamically stable but had persistent blood drainage. They were all subjected to video assisted thoracoscopy (VAT), which confirmed the injury and allowed for control of haemorrhage. All three recovered uneventfully. One patient sustained pulmonary artery injury and underwent an emergency left thoracotomy. This patient also survived and was discharged.

#### **Morbidity and mortality**

A total of twenty-eight patients (53%) developed further complications. Thirteen patients developed wound sepsis, seven patients developed nosocomial pneumonia, and six developed empyema following thoracotomy. Two patients developed acute respiratory distress syndrome (ARDS). A total of 15 per cent (8/53) of all patients required admission to the intensive care unit (ICU). The mean length of hospital stay was 7 ( $\pm 4$ ) days.

Two of the fifty-three patients with IVI died. One sustained a pulmonary laceration (managed conservatively) but had a background of AIDS, developed catheter related sepsis and subsequently died from multiple organ failure. One patient who had combined gastric and colonic injuries eventually died from multiple organ failure secondary to intractable sepsis. The overall mortality was four per cent (2/53).

#### **Discussion**

Insertion of an ICD is a potentially hazardous procedure and is associated with potentially significant morbidity which is often under-appreciated [6]. International literature reports a complication rate that varies from 10 to 30 per cent [2–6], and there are numerous individual case reports of iatrogenic injuries to most organs located within the trunk [8–12]. Whilst some injuries are self-limiting (e.g. minor pulmonary laceration) [9], fatal injuries from perforation of the atrium [13], ventricle [11] and pulmonary artery [10] have been reported. Although these injuries are extremely rare, most clinicians who perform ICDs will undoubtedly encounter some form of iatrogenic complication at some point. Given the massive volume of ICDs inserted in a wide variety of clinical settings, IVI are likely to be substantially underreported [14]. A previous audit from our institution showed that a total of

1054 ICDs were inserted for trauma, with an overall complication rate of 22 per cent. Following a publication from the National Patients Safety Agency (NPSA) in the United Kingdom, which reported 12 deaths and 15 cases of serious harm over a three-year period, there are increasing concerns regarding the safety of this procedure [14]. It was noted that poor training and lack of experience were responsible for the majority of the adverse outcomes [14]. Harris et al. surveyed 148 acute hospital trusts in England from 2003 to 2008 regarding adverse events related to ICD insertion [15]. There were 31 cases of misplaced drain and 7 deaths. The most common injuries encountered were liver, cardiac and splenic. However, this study only surveyed respiratory physicians, and often involved insertion of varied size drains with the Seldinger technique. This carries a different risk profile than the open blunt dissection technique used in trauma and the spectrum of pathology requiring ICD in respiratory medicine is quite different from those in trauma [16].

The diaphragm, the stomach and the pulmonary parenchyma were the three most commonly injured structures. The majority of pulmonary lacerations can be successfully treated non-operatively. Cardiac injury was not seen in our study. Most trauma patients are young with minimal comorbidities such as cardiomegaly, which may place these patients at higher risk for iatrogenic cardiac injury [13]. The other possibility is that patients who did sustain a significant cardiac injury in a district hospital would have died prior to transfer to our service. Iatrogenic diaphragmatic injury can occur when an ICD is inserted below the triangle of safety. Gastric injury usually occurs in the setting of acute diaphragmatic herniation. This may occur secondary to either blunt or penetrating trauma and is notoriously difficult to diagnose as plain chest radiograph (CXR) may be confusing [17]. In twelve of the 13 patients in this study who sustained a gastric perforation secondary to an ICD, the plain CXR was misinterpreted, contributing to an IVI.

IVI secondary to ICD is relatively uncommon and many of these injuries will be referred directly to a specific specialty (e.g. cardiothoracic surgery), or managed by general surgeons who may not have substantial trauma experience. Our unique setting as a referral service for a large rural population and a high incidence of trauma allowed us to accrue an unusually high volume of complicated cases. The vast majority (approximately 90%) of patients in this study sustained their IVI in a rural district hospital. Of the small number of iatrogenic injuries that occurred in our unit, almost all ICDs were inserted by junior doctors. Although we were unable to accurately quantify the experience level of staff involved in IVI in the rural district hospitals, it is likely that the trauma experience of these doctors is extremely heterogeneous [18].

There is an on-going commitment on both a global and national level to the trauma training of junior doctors and rural hospital staff. Despite the widespread penetration of courses such as the ATLS globally, there is evidence to suggest that junior staff have a poor understanding of safe ICD insertion techniques [19]. Griffiths et al. from the United Kingdom surveyed 55 junior doctors and noted that 45% of them did not know the correct anatomical location for ICD insertion [19]. A further study by Elsayed et al. showed that only 44% of junior doctors indicated that they would insert an ICD within the triangle of safety [20]. This corresponds to our own findings that the most common error encountered in ICD insertion is placement below the safety triangle. Despite the teaching of ATLS, there persists a high incidence of self-disclosed routine use of the trocar, which is associated with major complications [21]. Currently in our environment, the ICD sets come from the suppliers with a trocar. A simple piece of safety engineering would be to remove the trocar from the commercially available ICD sets prior to distribution. International authorities often feel that complications are related to a poor knowledge of

and limited experience with the procedure [15]. We have significant experience with the procedure, but that does not automatically translate into an improved outcome and less complications. Mandating the successful completion of ATLS course as a pre-requisite of being allowed to perform ICD insertion in the unit would be the most ideal solution but is difficult to achieve for logistical reasons. Ongoing in-house educational initiatives are now in place. Strict supervision by senior doctors who are ATLS certified is enforced. Educational initiatives by themselves however, are almost certainly insufficient and need to be supplemented by other error reduction strategies [22]. These include the use of pre-insertion tick box style checklists and mechanical lock out systems to prevent the unsupervised insertion of ICDs [23].

## Conclusions

ICD insertion can be associated with significant morbidity. This is often under appreciated. IVI is fortunately uncommon, but can occur in the setting of confusing radiology with loosely enforced protocols. The presence of a traumatic diaphragmatic hernia, the use of a trocar and insertion outside the safety triangle increase the risk for IVI. The spectrum of IVI varies widely, but pulmonary, diaphragmatic and gastric injuries were the most common injuries seen, with over half of all patients requiring operative interventions. IVI is associated with substantial preventable morbidity, prolonged hospital stay, intensive care admission and even mortality.

## Conflict of interest statement

None declared.

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