

Traumatic Diaphragmatic Injuries at Medicolegal Autopsy: A 1-Year Prospective Study

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Abstract

Introduction: Traumatic diaphragmatic injuries (TDIs) are relatively rare. The forensic literature pertaining to TDIs consists mainly of case studies, suggesting little attention to these injuries during autopsies and research.

Materials and methods: This prospective study was conducted at the Ga-Rankuwa Forensic Pathology Services mortuary over a 1-year period. We included all cases who had a full medicolegal autopsy, as prescribed by the relevant South African legislation (Inquest Act 58 of 1959). All diaphragms were examined by a forensic medical practitioner performing the autopsy.

Results: Nine hundred ninety-nine cases were analyzed; of these, 71 cases with TDIs were identified. The incidence of TDI was, therefore, determined to be 7.11%. A total of 60.56% involved the right hemidiaphragm, 19.72% the left hemidiaphragm, and 19.72% were present bilaterally. A total of 85.92% were present in men and 14.08% in women. Blunt force trauma comprised 33.80%, and penetrative trauma 61.97%. Most were associated with severe injuries. A total of 12.68% had organ herniation through the defects present.

Conclusions: Our study revealed that TDIs were more common than initially reported. The right side was more often involved in our study than in other studies. Diaphragmatic injuries were observed in 21.46% of all penetrative trauma cases received in a year.

Key Words: traumatic diaphragmatic hernia, TDI, autopsy, medicolegal, diaphragmatic herniation, blunt trauma, penetrating trauma

There is a paucity of forensic pathological literature focusing on traumatic diaphragmatic injuries (TDIs), and most of the literature emanates from the surgical discipline. The majority of the literature on traumatic diaphragmatic injuries consists of retrospective studies involving surgical departments managing these cases. No forensic literature in which a full postmortem series was conducted could be found. Because of this sparsity, the true incidence of traumatic diaphragmatic injuries may be even higher than that reported in the literature.

According to the literature, traumatic diaphragmatic injuries are relatively rare,¹ often missed during the initial assessment,² and are frequently associated with other severe injuries.³ Notably, the reported incidence increases once the injury is actively sought after through laparotomy.⁴ As traumatic diaphragmatic injuries are often associated with critical injuries and are often fatal, they may not have been included in the previously mentioned studies.¹ Thus, a prospective postmortem descriptive study is needed, to accurately determine the true incidence of these cases.

It has been shown that traumatic diaphragmatic injuries present with severe complications and increased mortality and morbidity if missed during the initial assessment.⁵ Medical practitioners performing autopsies often miss these injuries because they do not actively seek them.

The purpose of this study was to increase awareness of these injuries and raise the index of suspicion of doctors treating these injuries clinically, especially in areas with similar socioeconomic systems.

MATERIAL AND METHODS

The study was conducted at the Ga-Rankuwa Forensic Pathology Services, a mortuary that conducts postmortem examinations as part of the medicolegal examination of other than natural deaths. Approximately 1200 medicolegal autopsies per annum are conducted at this facility. All cases who presented to the mortuary over a 1-year period were selected.

All possible and probable diaphragmatic injuries were included in this study. All cases were selected to exclude selection bias and to ensure that there were no anomalous cases of diaphragmatic injuries, such as congenital diaphragmatic abnormalities, iatrogenic injuries, and spontaneous injuries. Traumatic diaphragmatic injuries were defined as any contusion, laceration, gunshot, incised, or other injury caused by physical trauma to the diaphragm.

After all the data were collected, cases of nonviable fetuses, COVID-positive cases, charred, decomposed, skeletonized bodies, and forms that were not handed back to the researcher were excluded. This was done because nonviable fetuses and COVID-positive cases are often not completely eviscerated, and decomposition can cause artefactual diaphragmatic injuries. Only macroscopic injuries were described and paralysis was not considered a positive finding.

Over a 1-year period, the diaphragms of all cases who presented to our mortuary for medicolegal autopsy were examined by a medical practitioner who performed the autopsy. A data collection tool was developed, which required the medical practitioner to capture the demographics (age and sex), whether a TDI is present or not, type of injury (contusion, laceration, gunshot, and other), etiology (blunt, penetrative, or other), location of the injury (left, right, or bilateral), and associated injuries and complications. This form was inserted into each file before autopsy. The medical practitioners then removed the form before autopsy and filled it in while performing the postmortem.

After removal of the sternum, the medical practitioner examined the thoracic and abdominal surface of the diaphragm (Figs. 1, 2). For better visualization, the chest block was then retracted and the thoracic surface of the diaphragm was re-examined (Fig. 3) before the eviscerator proceeded to remove the chest block (by cutting into the diaphragm).

Relevant findings were captured by a medical practitioner using a data collection form. Statistical data processing and analysis were conducted using Microsoft Excel.

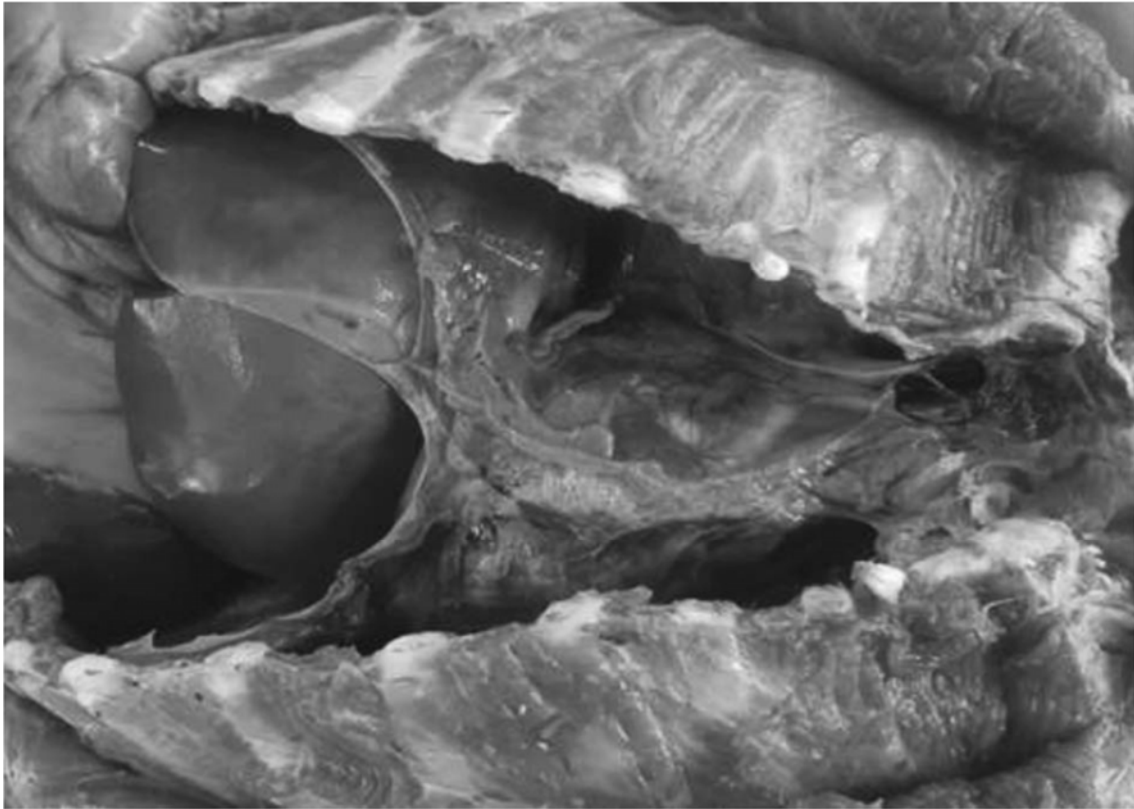


FIGURE 1. Visual inspection of diaphragm after removal of the sternum.

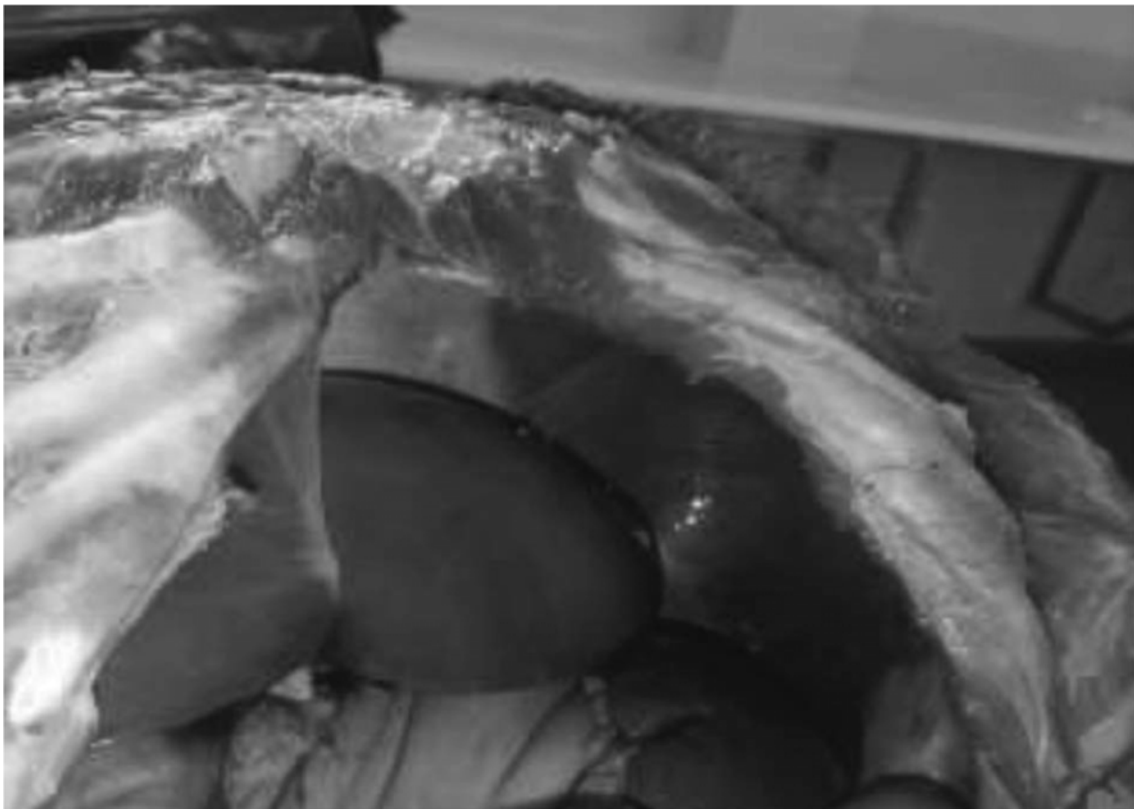


FIGURE 2. Visual examination of abdominal surface of the diaphragm.

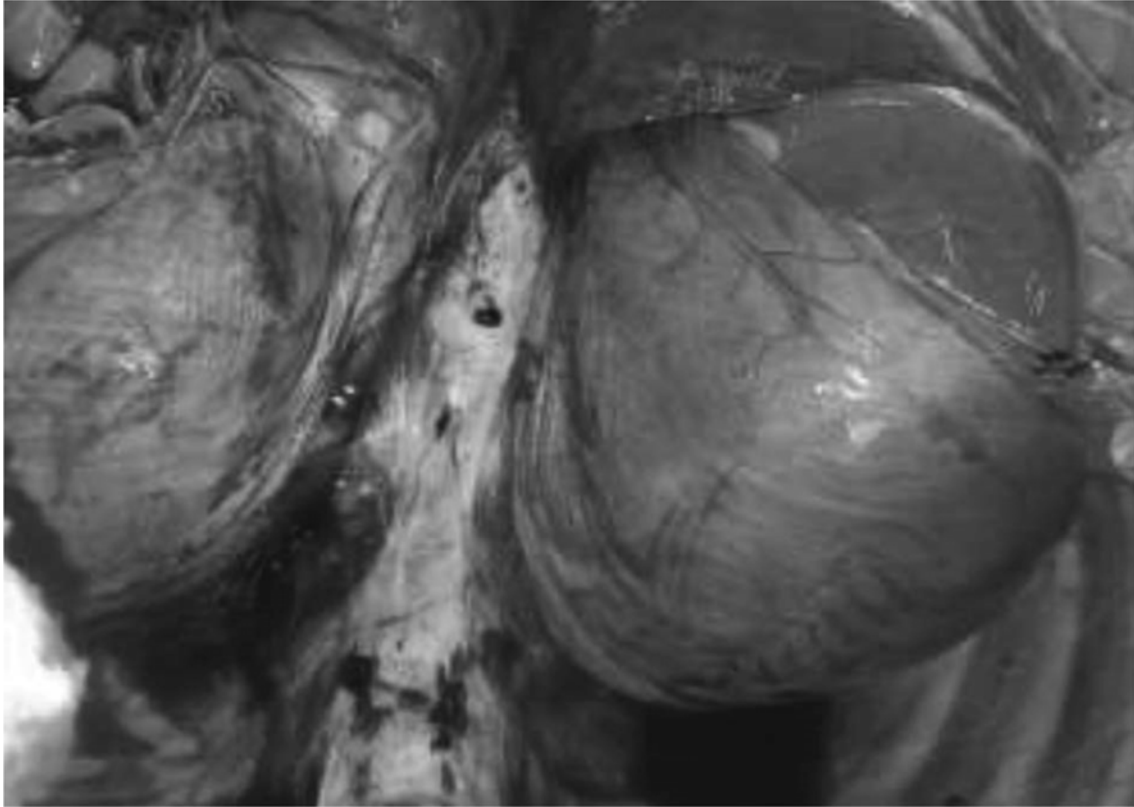


FIGURE 3. Examination of the thoracic surface of the diaphragm after retraction of the chest block, but before removal.

RESULTS

From January 1, 2021, to December 31, 2021, 1225 autopsies were performed at the Ga-Rankuwa Forensic Pathology Services. They were performed as prescribed by the relevant South African legislation (Inquest Act 58 of 1959) as part of the medicolegal investigation of other than natural deaths.

Of all cases (N = 1225), 1155 data collection forms were returned. Nonviable fetuses, COVID-positive cases, charred, decomposed, and skeletonized bodies were removed at this stage because the diaphragm was either not present or not directly observable. That left 999 cases. The youngest case was 3 days old and the oldest 91 years, with an average age of 35 years. A total of 78.18% of the cases were male (781) and 21.82% females (218) as illustrated in Figure 4. The male-to-female ratio was 3.5:1 with 781 males and 218 females. Of these 999 cases, 71 were found that acquired traumatic diaphragmatic injuries. This is an incidence of 7.11% of all the autopsies performed (where the diaphragm was observed and present) in a 1-year period.

Of the 71 cases with observed traumatic diaphragmatic injuries, the youngest and oldest were 3 and 69 years, respectively, with an average age of 37.7 years. Men experienced traumatic diaphragmatic injuries at a disproportionate rate compared with women. A total of 85.92% cases (61) involved men and 14.08% cases (10) involved women with a male-to-female ratio of 6.1:1. This is significant if taken into account that the male-to-female ratio of all the cases in this study was 3.5:1 (Fig. 4).

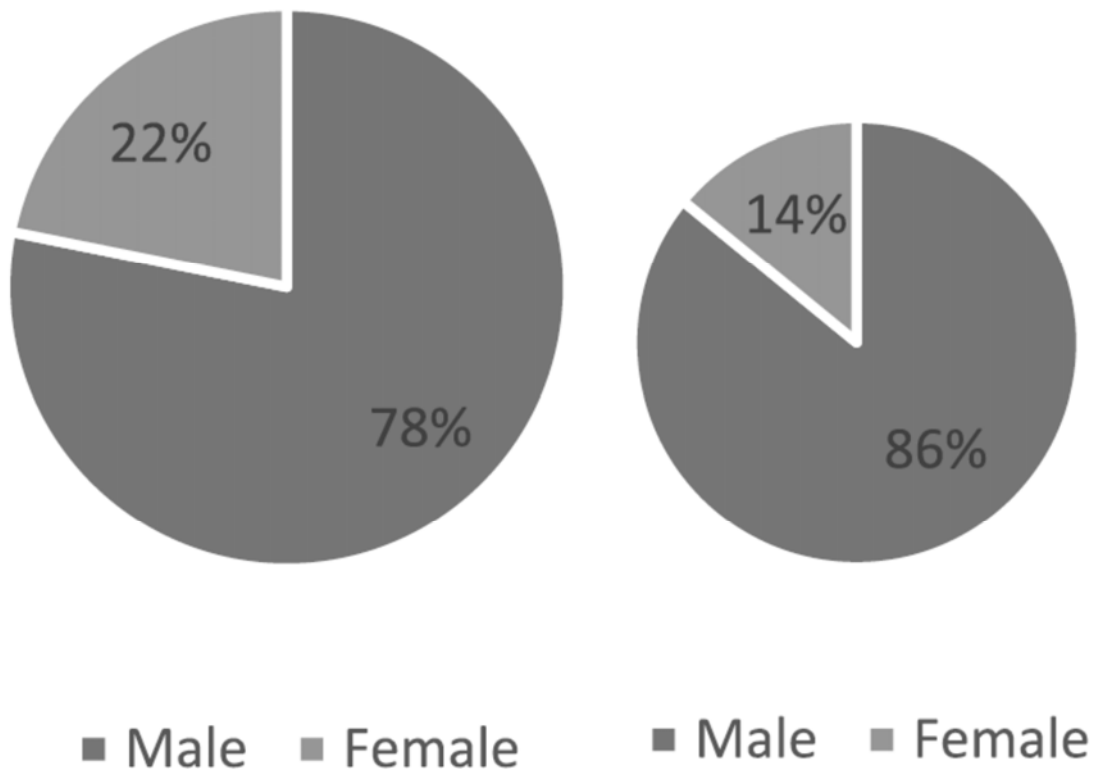


FIGURE 4. Sex as seen in all cases (n = 999) and in cases with diaphragmatic injuries (n = 71).

Of all the cases who met the inclusion criteria (999), 30.03% (300) experienced blunt force injuries (motor vehicle accidents, assaults, falls from height, and crush injuries), 5.21% (52) experienced sharp force injuries (all of which were stabbing), and 15.32% (153) gunshot injuries were recorded. The cases where traumatic diaphragmatic injuries were noted consisted of 59.15% (42) gunshot injuries, 33.80% (24) blunt force injuries (all of which were due to motor vehicle accidents), 2.82% (2) sharp force injuries (stabblings), 1.41% (1) iatrogenic (caused by intercostal drain), and 2.82% (2) burns. The injuries seen included 15.49% (11) lacerations (Fig. 5), 2.82% (2) incised wounds (Fig. 6), 54.93% (39) gunshot wounds (Fig. 7), 26.76% (17) contusions (Fig. 8), and 2.82% (2) cases where heat altered the diaphragm.

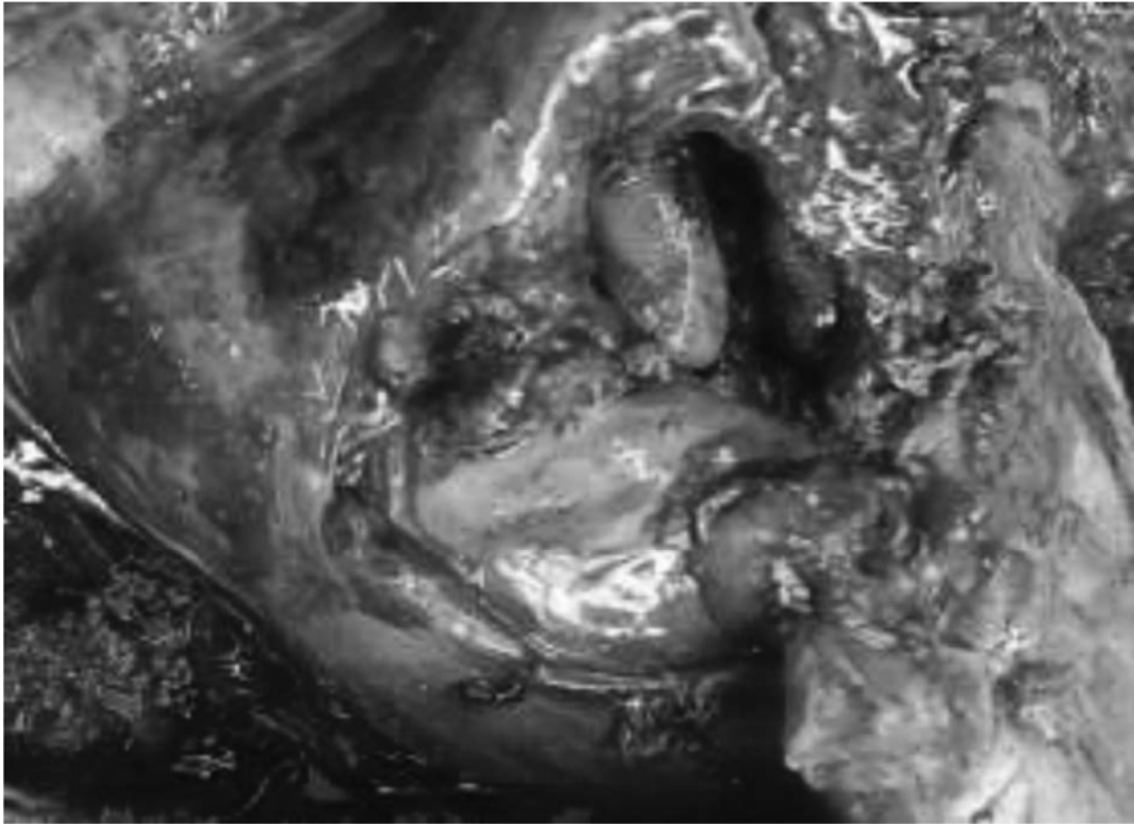


FIGURE 5. Laceration of the right hemidiaphragm seen after a motor vehicle accident and associated with multiple blunt force injuries.



FIGURE 6. Sharp force injury to the left hemidiaphragm sustained after a stab wound to the chest.

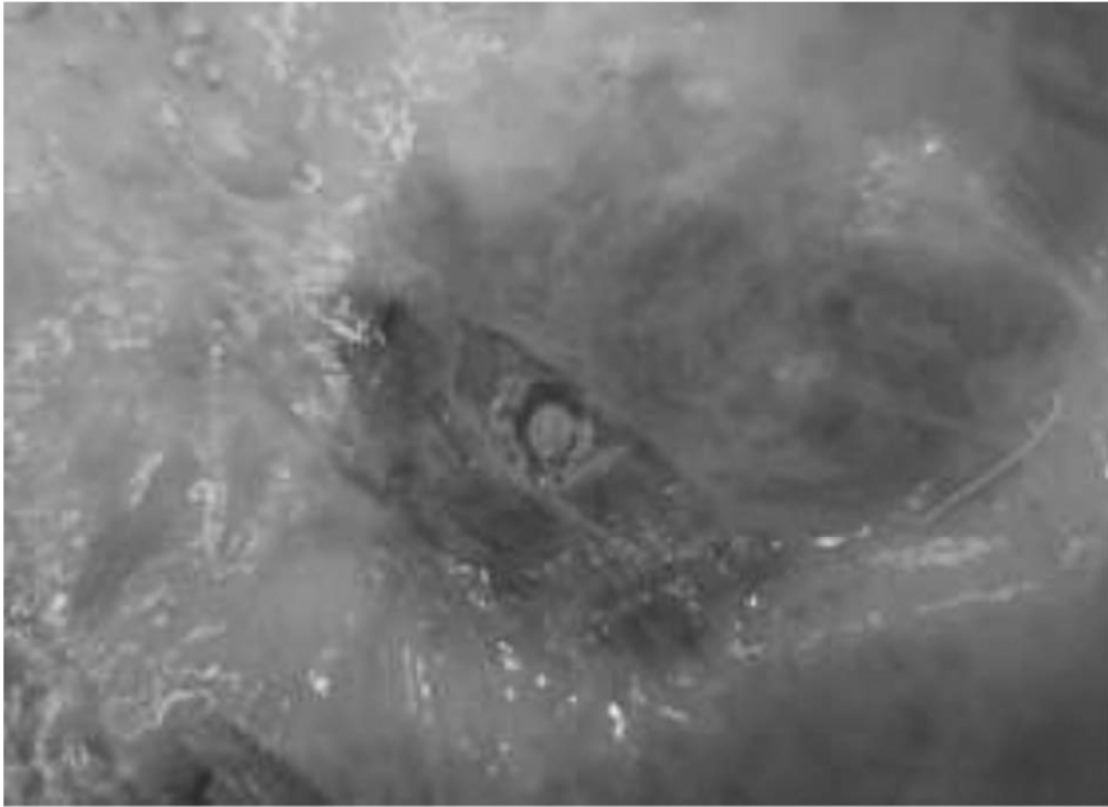


FIGURE 7. Gunshot wound.

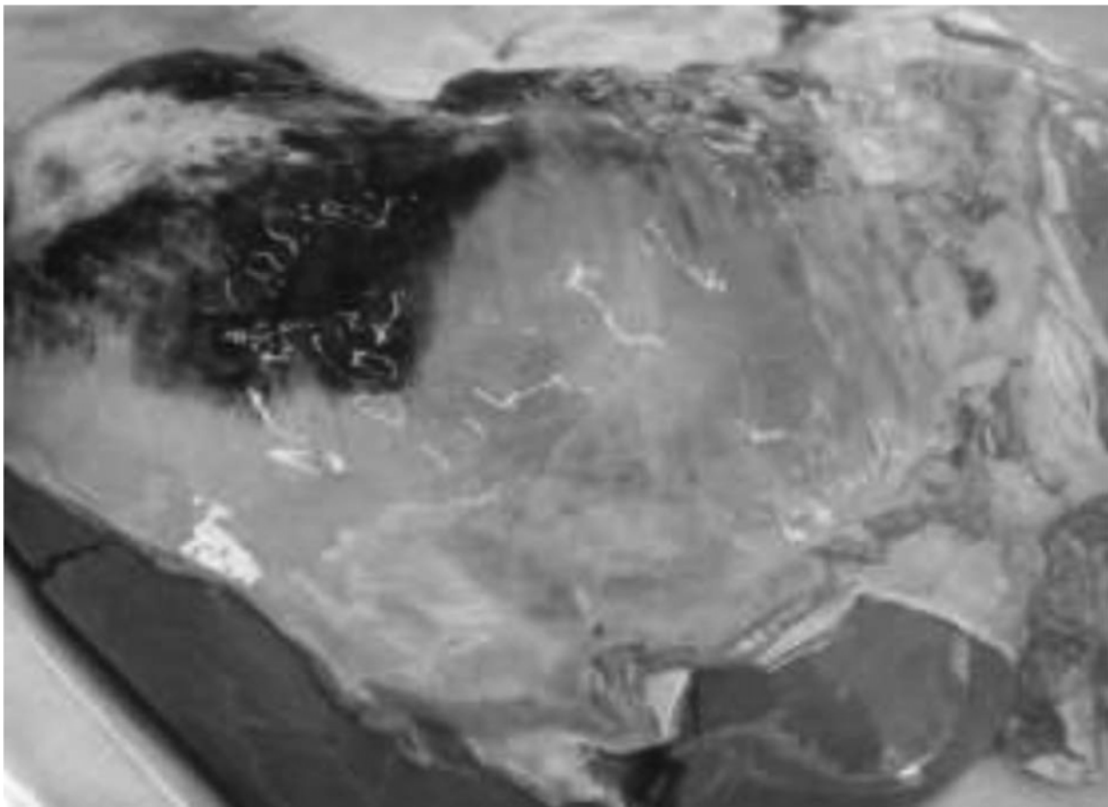


FIGURE 8. Contusion to the right hemidiaphragm sustained after a motor vehicle accident.

Traumatic diaphragmatic injuries were recorded in 8% of all the blunt force trauma cases seen, and 21.46% of all penetrative trauma cases seen. Of the 71 cases, 61.97% of cases were due to penetrative trauma, 33.80% were due to blunt trauma, and 4.2% had other etiologies (Figs. 9, 10).

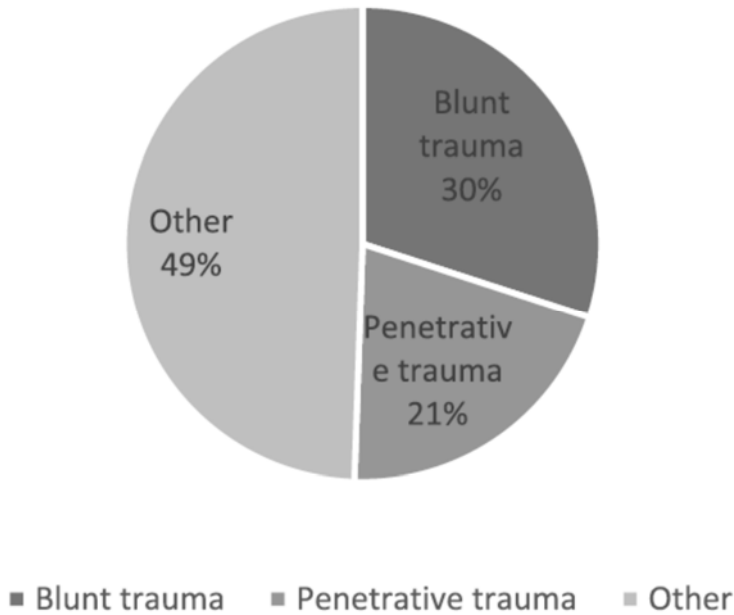


FIGURE 9. Etiology as seen in all cases (n = 999).

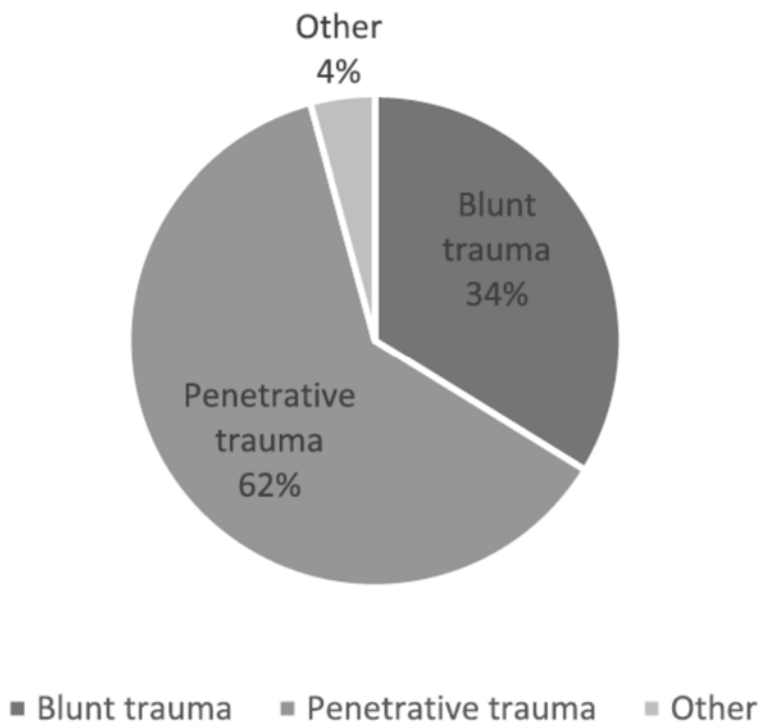


FIGURE 10. Etiology in cases with TDI (n = 71).

The cause of death was recorded in the cases with TDI as illustrated in Figure 11 hereinafter. As reported previously, penetrative injuries were the most common cause of death comprising 59.15% of all deaths with TDI. Of these, 23.94% (17) were multiple gunshot wounds, 9.86% (7) were thoracoabdominal gunshot wounds, 18.31% (13) were gunshot wounds to the chest, and 7.04% (5) were due to gunshot wounds to the abdomen. A total of 33.80% were due to blunt force injuries. Of these, all were due to motor vehicle accidents. A total of 22.54% (16) were unspecified as to the position of the deceased, 4.23% (3) were the drivers, and 7.04% (5) were pedestrians. A total of 2.82% (2) were due to sharp force injuries (stab wounds) to the chest. No stabs to the abdomen had any TDI. A total of 2.82% (2) were due to burns and 1.41% (1) was due to natural causes where an iatrogenic injury to the diaphragm was present.

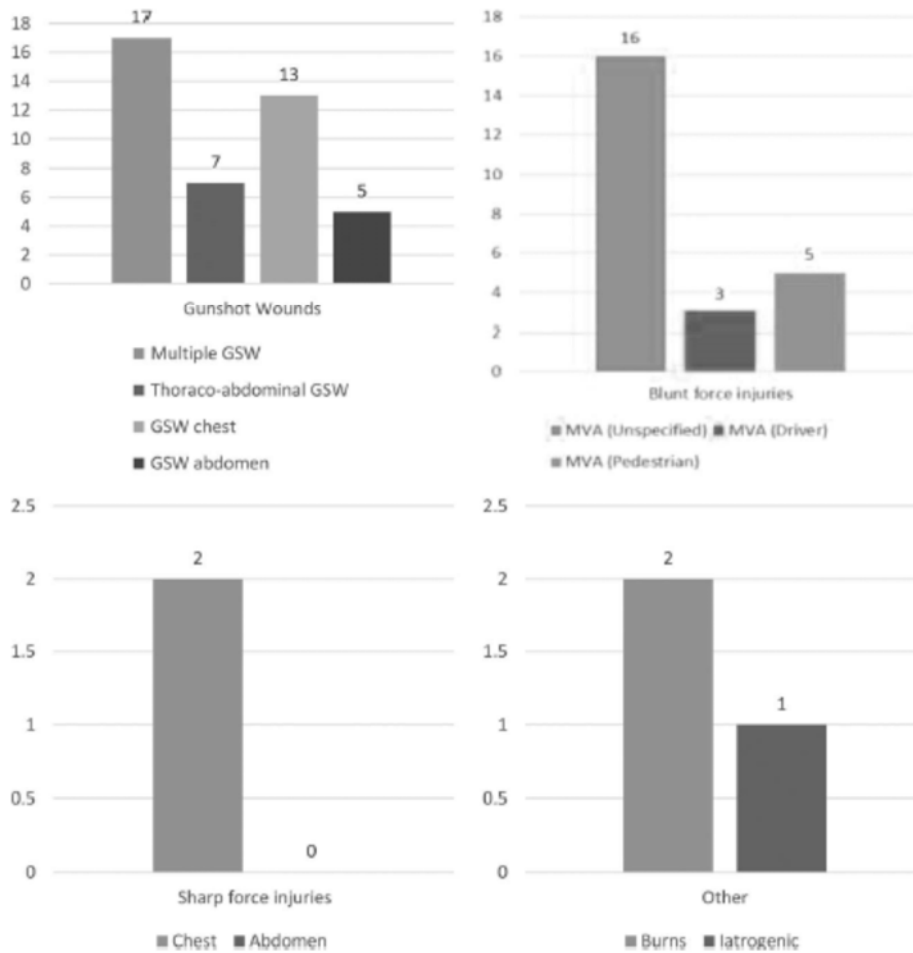


FIGURE 11. Prevalence of cause of death in cases with TDI.

A total of 60.56% of diaphragmatic injuries were seen on the right side, 19.72% were present on the left, and 19.72% of the cases had bilateral involvement as seen in Figure 12 hereinafter.

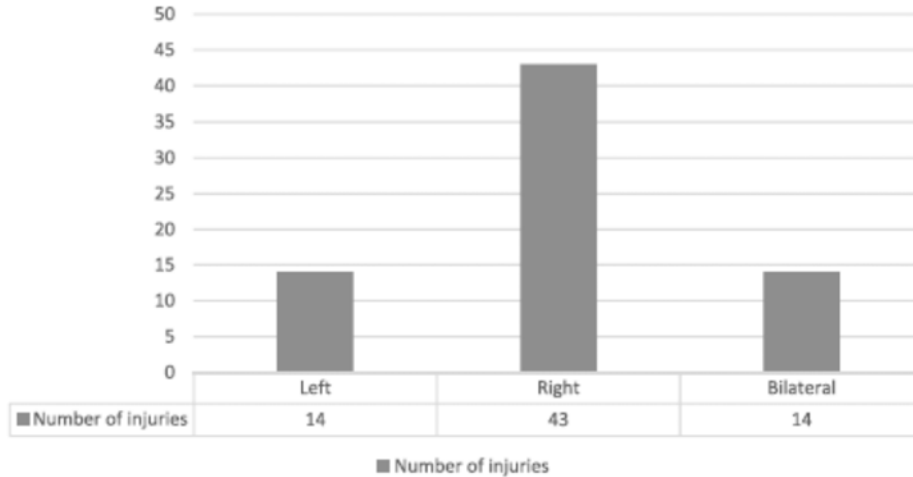


FIGURE 12. Right- versus left-sided TDI.

As expected, almost all cases had multiple severe associated injuries. A total of 81.7% of cases had associated injuries to the skin, 76.06% to the liver, 69.01% to the lungs, 33.8% to the heart, 29.58% to the sternum, 25.35% to the thoracoabdominal vessels, 23.94% to the stomach, and 32.39% to other nonspecified structures (Fig. 13).

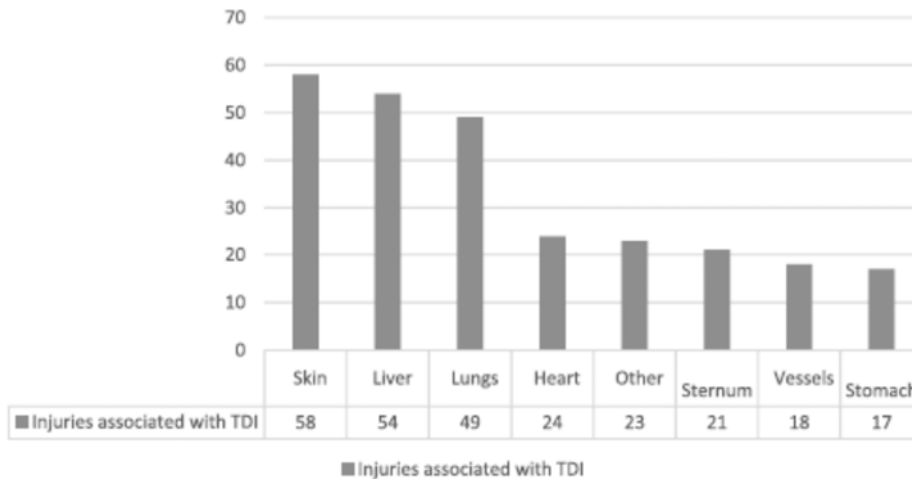


FIGURE 13. Injuries associated with TDI.

Herniation of other structures through the traumatic diaphragmatic injuries was present in 12.68% of the cases. The structures involved were the liver in 9.86% of all diaphragmatic injuries, the stomach in 4.23%, small bowel in 1.41%, large bowel in 1.41%, omentum in 2.82%, and the spleen in 1.41% as seen in Figure 14 hereinafter.

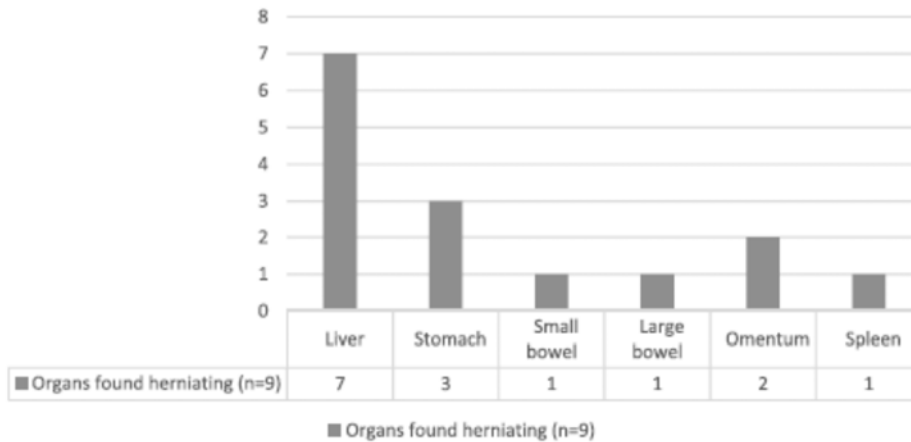


FIGURE 14. Prevalence of the organs seen herniating through TDI.

DISCUSSION

The demographics of traumatic diaphragmatic injuries are surprisingly consistent throughout most of the literature.^{3,6,7} Traumatic diaphragmatic injuries tend to affect people in the third decade of life.^{3,6} This is also similar to the average age of all the cases who were seen at our facility in a 1-year period. The studies have a mean age ranging from 31 to 37 years.^{3,7} Males are also more susceptible to this type of injury than females. The male-to-female ratio ranges from 4 to 5.7:1.^{6,8} This is consistent with our findings, where the average age was 37.7 years and the male-to-female ratio was 6:1. This is significant if you take into account that the male-to-female ratio of all the cases seen were 3.5:1. These findings may show that males in the third decade of their lives are more likely to die from other than natural deaths and engage in activities that could lead to severe injury.

Traumatic diaphragmatic injuries are reported to be relatively rare with an incidence of 1% to 7% in blunt force trauma and 10% to 15% in cases of penetrating trauma.¹ Our study found the incidence to be present in 8% of all the blunt force trauma cases seen and 21.46% of all penetrative trauma cases seen, which is higher than that seen in the current literature. However, the incidence may be as low as 0.065% in certain communities.⁵ This is most likely due to the literature that we are comparing the study with is coming from accident and emergency departments and surgical departments where the associated injuries are obviously not as fatal as the cases we saw.

Traumatic diaphragmatic injuries are reported in 4% to 6% of cases who underwent either laparotomy or thoracotomy,² which is similar to our study where it was found in 7.11% of all cases, indicating that it is more prevalent when actively sought. The incidence typically ranges from 7% to 20% if only diaphragmatic injuries after penetrating left-sided thoracoabdominal trauma are considered.⁴

The true incidence of traumatic diaphragmatic injuries may be greatly underestimated, as the diagnosis is often missed or delayed during initial assessment.² This is corroborated in our study as almost all the cases with traumatic diaphragmatic injuries has severe associated injuries. Many patients with traumatic diaphragmatic injuries also do not attend hospitals as the associated injuries may be fatal.¹ The incidence of TDIs is also thought to be increasing, which could be due to more motor vehicles and subsequently more motor vehicle accidents.¹ This could also be true in our geographic area due to the large amount of gun violence we have.

Traumatic diaphragmatic injuries typically occur after blunt or penetrating thoracoabdominal traumas. The most common etiology, however, often varies geographically and generally depends on various socioeconomic factors.¹ In Singapore where gun violence is rare they found blunt trauma (with a prevalence of 76.1%) to be the most common etiology for TDIs, with only 23.9% of cases found to be due to penetrative trauma.⁹ This was similar to a Greek study that recorded an incidence of 80% of TDIs due to blunt trauma and 20% due to gunshot wounds and stab wounds.¹⁰

This is in contrast to Israeli and Canadian studies where they found penetrative injuries to be more common than blunt trauma, with an incidence of 65.51% and 63%, respectively.^{11,12} In South Africa, it was found that penetrative TDIs were the most commonly seen with an incidence of 85%.⁴ This is also true in our study we found blunt trauma contributed only 33.80% of all diaphragmatic injuries. South Africa has a huge burden of gun violence, and this is highlighted in our findings. A total of 23.94% of the cases with TDI were associated with multiple gunshot wounds, followed by thoracoabdominal gunshot wounds (9.86%), gunshot wounds to the chest (18.31%), and gunshot wounds to the abdomen (7.04%).

Blunt force injuries to the diaphragm include simple contusions and lacerations, whereas penetrating injuries include incisions and gunshot wounds.¹³ Furák and Athanassiadi¹³ included the following categories to their study to classify injuries into broad groups: acute diaphragmatic herniation, acute diaphragmatic tears, and diaphragmatic contusions.

Other causes of traumatic diaphragmatic injuries were also found to be iatrogenic in some cases, with Dupont et al¹⁴ describing a case of TDI after manual and automated external chest massage. Rupture of the diaphragm was also found to occur spontaneously during pregnancy, and there are also reports of cases of unexplained spontaneous rupture.² We found one case of contusion caused by incorrect placement of an intercostal chest drain. Iatrogenic injuries to the diaphragm are relatively rare, but in the Forensic community, it is of utmost importance to identify these injuries as it will have medicolegal significance.

The left hemidiaphragm was involved more often than the right hemidiaphragm. The involvement of the left diaphragm ranges from 55.8% to 90% of cases.^{6,7} It is postulated that the left hemidiaphragm is more vulnerable because of embryological development, which makes the left hemidiaphragm less structurally strong, and the protection that is offered to the right hemidiaphragm by the liver.¹³ This is in contrast to our findings. Right-sided injuries were much more common than left-sided injuries. This could be because the liver does not provide any protection against penetrative trauma, which is more commonly found in our study. It can also be that right-sided injuries are missed more often because of the incorrect belief that they are rarer. Another aspect to keep in mind is that the blunt force trauma needed to incur right sided lacerations could be ultimately more fatal.

Traumatic diaphragmatic injuries are indicators of critical injury, and these associated critical injuries are usually found to be the ultimate cause of death.^{5,15} The mortality rate of TDIs is found to be between 9.3% and 26.8%.^{5,7} The mortality rate increases from 30% up to as much as 60% if the diagnosis is delayed.⁵ The most commonly associated injuries are skeletal, lung, and solid organ injuries, including splenic injuries and liver injuries. Other studies have identified hollow organ injuries, including small bowel and stomach injuries. Most patients suffer multiple injuries.^{5,11} This is consistent with our findings, in which almost all cases had significant associated injuries.

Delayed diaphragmatic injuries often present with complications. These complications are usually in the form of diaphragmatic herniation with strangulation of the bowel, and patients present with constipation and difficulty in breathing.¹ The most common organs that herniate include the stomach and the large and small bowel.¹⁶ Our study showed that the most common herniated organ was the liver, followed by the stomach and omentum. Delayed traumatic diaphragmatic herniation can also be seen at autopsy, where it presents as sudden and unexpected death.¹⁶

Readers should reacquaint themselves with the anatomy of the diaphragm. Both the thoracic surface and the abdominal surface need to be actively examined for pathology and trauma. As demonstrated in this article, diaphragmatic injuries may be easily missed. The diaphragm is integral to normal respiration, and as such if it is compromised, it may ultimately be the mechanism of death in certain cases.¹⁷

The diaphragm is often underappreciated and incompletely evaluated both in clinical practice and in forensics. Complications of TDI such as organ and viscera herniation with strangulation and necrosis are another possible mechanism of death.¹⁶ This could have far-reaching medicolegal implications, if it is found to be the ultimate mechanism of death, the issue of medical negligence may be called into question.

CONCLUSIONS

This was a 1-year prospective study of all traumatic diaphragmatic injuries presenting to our medicolegal facility. A literature review revealed a dearth of forensic literature on this subject. This study serves as one of the only prospective autopsy studies of its sort in the literature at the moment. No pathological guidelines for diaphragmatic examination could be found in the forensic literature, and a proposed methodology is presented in this article.

The results of our study showed that the incidence of traumatic diaphragmatic injuries was more common than that recorded in the literature. Males experienced TDI more commonly than females. Penetrative injuries were significantly more common than blunt force injuries in our study. Unique to our study was that the right side was significantly more involved in than what is seen in the existing literature. This could possibly be attributed to our unique socioeconomic and geopolitical situation, as well as the relatively high trauma and gun violence rates seen in our region. As expected, TDIs were associated with severe associated injuries, and the most common organ that herniated through the injuries was the liver.

In conclusion, our findings emphasize the importance of actively looking for these injuries because they are more common than previously thought, and the right side should always be examined thoroughly to avoid missing them. In cases with penetrative trauma, a high index of suspicion should be maintained, as traumatic diaphragmatic injuries were found in one fifth of all cases and one fourth of all gunshot wound cases.

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