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TRAUMA SURGERY

An audit of tracheobronchial tree injuries at Inkosi Albert Luthuli Central Hospital, Durban, KwaZulu-Natal

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Background: Tracheobronchial tree injuries (TBTI) represent a type of trauma that is rare among all trauma patients, with a paucity of literature available in Africa. These may result from blunt or penetrating trauma to the neck and thorax (chest). The purpose of this study was to document the spectrum of injury and the experience with surgical and non-surgical management and outcome of TBTI in the KwaZulu-Natal setting.
Methods: This was a single-centre retrospective analysis of all patients with TBTI referred to Inkosi Albert Luthuli Central Hospital (IALCH) over 21 years. Data collection extended from 1 January 2003 to 31 December 2023.
Results: Penetrating trauma was the most common cause of injury, with a total of 32 patients (86%), while blunt injuries were seen in five patients (14%). Anatomically, there were 20 cervical tracheal injuries, eight thoracic tracheal injuries, six bronchial injuries and three multiple site injuries. A total of 27 (73%) patients underwent surgery, while 10 (27%) patients were managed conservatively. Overall mortality was seen in four patients and one patient survived with long-term disease sequelae. The overall median duration hospital stay was 6 days (IQR 4–10).
Conclusion: TBTI remains a rare injury. Sepsis was one of the main causes of death in both surgical and conservative management. Conservative management in selected cases is just as effective as definitive surgical management. Overall, there was good outcome with TBTI in this centre.
Keywords: tracheobronchial tree trauma, airway trauma, thoracic trauma, neck trauma, tracheobronchial tree injuries

Introduction

Tracheobronchial tree injuries (TBTIs) are potentially life threatening, yet uncommon injuries, resulting from blunt or penetrating trauma to the neck and thorax.[1,2,3] TBTI can involve cervical or thoracic tracheal injuries and bronchial injuries. Both neck and thorax are at risk. The trachea from the C6 level extends to the carina, branching to right and left main bronchi, collectively known as the tracheobronchial tree.[4]

TBTI incidence is estimated between 0.5–2% of all trauma patients, however, the true incidence of TBTI remains unknown as the majority of these patients die prior to hospital arrival, depending on the mechanism of injury, the severity of injury and the neighbouring anatomical structures involved. This is evidenced by the limited data that is available for this group of patients.[5-7]

Cervical tracheal injuries predominate with penetrating neck injury compared to thoracic trachea and bronchus when comparing between penetrating cervical and penetrating thoracic trauma and excluding blunt chest trauma.[1,8,9] There are also more documented survivors with penetrating neck trauma compared to blunt thoracic trauma.[5,7,8,10] TBTI is known as a potentially lethal injury pattern with a high mortality rate as up to 80% of blunt trauma patients with a TBTI will die prior to arriving at the hospital or go undocumented.[2,5,8,11,12] Tracheobronchial tree trauma remains rare with minimal reports from South Africa. The aim of this audit was to document the local experience of TBTI in a high-trauma province of South Africa with a single referral centre.

Methods

This was a single-centre retrospective quantitative, observational analytical study, involving both the cardiothoracic surgery unit and trauma unit at Inkosi Albert Luthuli Central Hospital (IALCH). All patients arriving alive with TBTI referred to IALCH from 1 January 2003 to 31 December 2023 were included. Patient demographics, mechanism and severity of injury, wound location, presentation time, clinical features, initial evaluation, associated injuries, diagnosis, management, and outcome were recorded and retrieved from an electronic patient record with ethics approved Class Approval status (BCA207/09).

Statistical analysis was performed with SPSS (IBM, Armonk NY) with descriptive data reported as percentages and comparisons as means with standard deviations or medians and interquartile ranges as relevant. No logistic regression was performed.

Definitive surgical management is surgical repair of the TBTI. Conservative management is any treatment other than definitive surgical repair, but may include temporary tracheostomy. Satisfactory results post-surgery were

defined as those patients who healed without sequela of comorbid airway compromise after either definitive surgical repair, or conservative management. Sequelae include patients bedeviled by long term complications including tracheobronchial strictures or restricted lung volume. Positive follow-up is defined as those who returned for their first clinic visit and those not returning as lost to follow-up.

Ethical approval was obtained from the University of KwaZulu-Natal Biomedical Reasearch Ethics Committee (BREC/00005697/2023).

Results

There was a total of 37 patients who presented to our setting with TBTI. Out of these patients 36 were males and one was a female. The median age was 27 (IQR 20–33.5) years.

Graph 1 demonstrates the annual number of cases per year, from 2003 to 2023. Most cases were seen in 2008 and 2016. There was a sustained drop in cases at the beginning of the COVID-19 pandemic, lockdown and ban on sales of alcohol in year 2020, however the following 2 years after lockdown we noted two to three cases. This does not include all TBTI in the KwaZulu-Natal province, as this data reflects only cases referred to our centre, whereas cases managed at regional hospitals by general surgical units are not always referred to the central facility.

Injury sites were classified as neck, chest or both. Within the penetrating trauma group, the neck was more involved with 20 (62%) patients, while chest was 5 (16%) and both 7 (22%) (Table I).

Penetrating trauma was the dominant cause of injury, with a total of 32 patients (86%). Only five (14%) presented with blunt trauma, of which one (20%) was a neck injury, while the other four (80%) were in the chest. For penetrating trauma, mechanism was either gunshot wound (GSW) or stab wound (by any penetrating sharp object). Stabs wounds outnumbered GSW in a ratio of 2:1. TBTI were classified into cervical or thoracic tracheal injury, bronchial injuries and multiple injury. These findings and aetiology are demonstrated in Figure 1. Intrathoracic bronchial injury was predominantly due to blunt trauma compared to penetrating with a 2:1 ratio. There were no multiple site injuries from blunt trauma.

The most common presenting clinical features regardless of the mechanism of injury are shown in Table II. Subcutaneous emphysema and pneumothorax were the most common clinical findings. Initial investigations included plain chest radiograph, with additionally CT scan with contrast studies, most of these done at base hospital, or at initial presentation. For those with suspected oesophageal injuries, a water-soluble swallow was performed either at the referring hospital or at IALCH.

Eleven patients required definitive airway management by intubation. Out of these eleven patients, nine patients were intubated at the referring hospital and two were intubated at

Graph 1: Number of cases per year

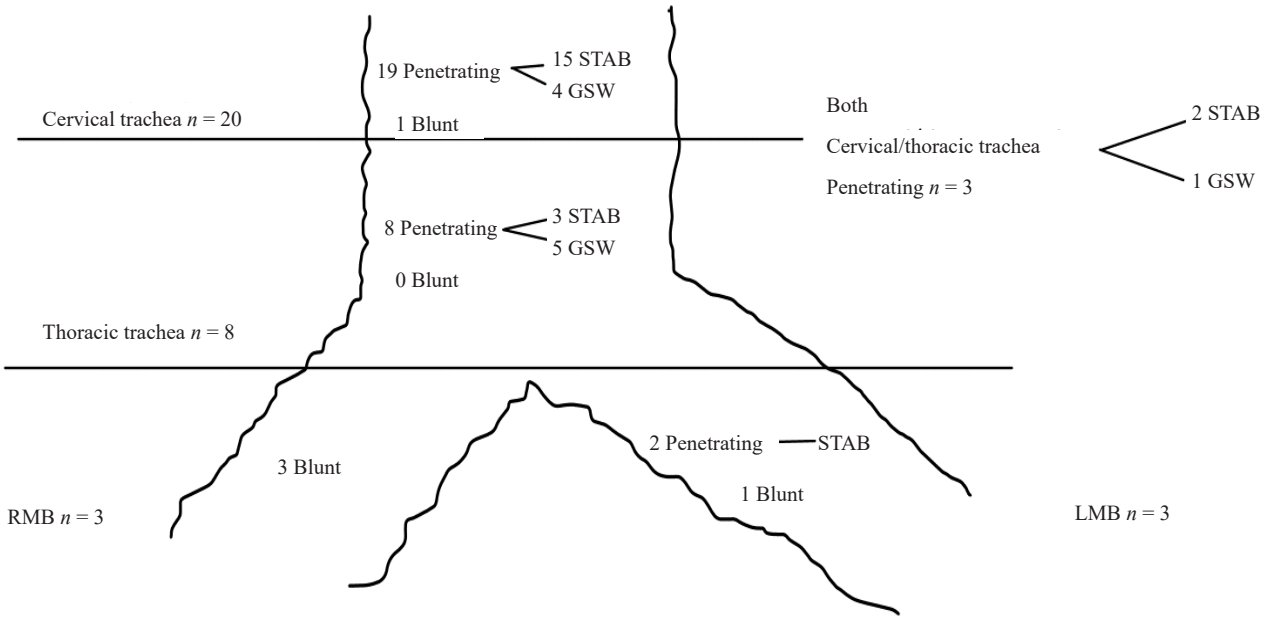

Figure 1: Aetiology, injury spread and anatomic locations
GSW - gunshot wound

Table I: Mechanism of injury and injury spectrum

Mechanism of injury	*n* (%)
Penetrating	32 (86%)
Neck	20 (62%)
Chest	6 (16%)
Both	7 (22%)
Blunt	5 (14%)
Neck	1 (20%)
Chest	4 (80%)
Both	0

the scene of injury. Orotracheal intubation was performed in nine patients and two were intubated via the wound in the neck. Only three patients with blunt trauma required intubation.

All patients who underwent tracheal repair first underwent bronchoscopy to assess the airway, clear the airway and to locate the tracheal injury. This also included some of those patients who were managed conservatively after noting very small lacerations less than 1 cm in diameter with a potential to close without repair with correlation at neck/chest imaging.

A total of 27 (73%) patients underwent surgery, 14 were operated via the cervical approach, 11 underwent right posterolateral thoracotomy and two underwent left posterolateral thoracotomy. Ten patients (27%) were managed conservatively, meaning no definitive surgical repair was performed on them with criteria for conservative management including those with a less than 1 cm defect with no significant air-leak, those who improved clinically and radiologically without intervention, those who later converted to tracheostomy with clinical improvement, and those who were deemed not suitable for any surgical repair due to poor prognosis from other organ system involvement.

The most common surgical approach was through the cervical incision. This included horizontal cervical collar incision as the most common, vertical neck incision and neck exploration through the wound. The majority of these patients underwent primary repair using interrupted suture with vicryl 3.0. Some patients presented with large neck wounds, where tracheal injury exposure and wound exploration and extension was undertaken through the wound with the small wound (opposing "exit" wound) being repaired first from inside the trachea via the larger wound and the bigger wound last repaired from outside, via the original wound. One patient sustained both tracheal and oesophageal lacerations secondary to gunshot wound; this patient's defects were repaired using PDS 3.0 interrupted suture in the trachea and continuous suture in the oesophagus with sternocleidomastoid muscle interposition between the trachea and oesophagus repairs. This patient later developed sepsis and died.

Out of the 11 patients who underwent a right posterolateral thoracotomy, one of the patients sustained both tracheal and oesophageal injuries, presenting with pre-existing mediastinitis and died from sepsis despite intervention. Intraoperatively for this particular case, the pleura was entered via the 4th intercoastal space (ICS), an intercostal muscle (ICM) pedicle was harvested, azygos vein divided, and mediastinal pleura opened for drainage from the thoracic inlet to the diaphragm. Trachea and oesophagus were mobilised and freed, copious lavage of the mediastinum and pleural space and repair of the trachea with vicryl 3.0 interrupted sutures, tension free and the intercostal muscle pedicle interposed between the repaired tracheal and oesophageal defects.

One patient presented 15 days after right main bronchus (RMB) blunt trauma from a pedestrian vehicle collision. Bronchoscopy demonstrated narrowing of the RMB at the carina with granulation tissue, and laceration in the RMB with granulation tissue. A right posterolateral thoracotomy with ICM harvesting to repair the 2 cm laceration performed using end-to-end anastomosis of the RMB buttressed with ICM using interrupted vicryl 3.0 suture. Another patient had a large RMB blunt trauma laceration extending to the right upper lobe orifice, post-debridement of the RMB, end-to-end anastomosis was not possible, a pericardial patch was harvested to close the defect in the RMB followed by closure of the mediastinal pleura, with an uncomplicated recovery, and at follow-up at 6 months. An additional case with delayed referral had a missed oesophagus injury and left main bronchus (LMB) injury secondary to stab chest complicated by extensive mediastinitis and sepsis involving 40% of the LMB but died intraoperatively due to septic shock.

Table II: Clinical signs and symptoms on presentation of TBI

	Overall, *n* = 37(%)	Cervical trachea	Thoracic trachea	Cervical & thoracic trachea	Bronchus
Subcutaneous emphysema	34 (92%)	19	7	3	5
Pneumothorax	22 (59%)	7	7	2	6
SOB	13 (36%)	4	4	3	2
Worsening SOB	12 (33%)	4	2	-	4
Haemoptysis	10 (28%)	5	3	2	-
Pneumomediastinum	10 (28%)	4	2	-	4
Neck swelling	10 (28%)	10	-	-	-
Cough	10 (27%)	4	2	1	3
Blowing/sucking wound	9 (25%)	9	-	-	-
Dysphagia	6 (17%)	0	4	1	1
Stridor	4 (11%)	2	1	1	-
Hoarseness of voice	4 (11%)	2	2	-	-
Hematemesis	2 (5%)	-	1	-	1

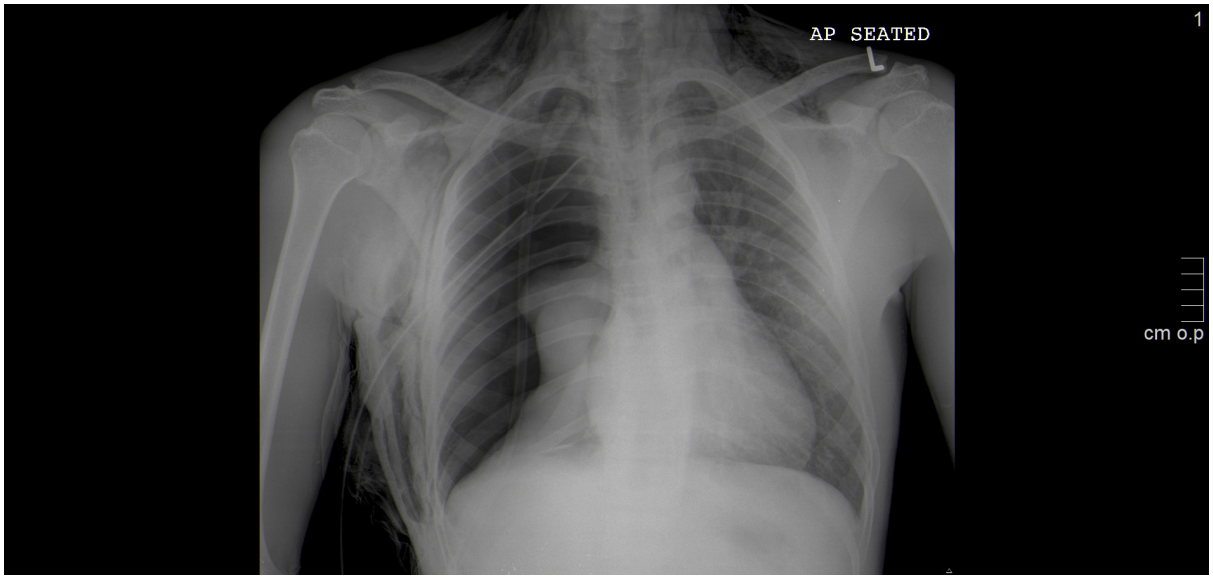

Figure 2: Collapsed right lung with ICD in the right pleural space ("Fallen Lung sign")

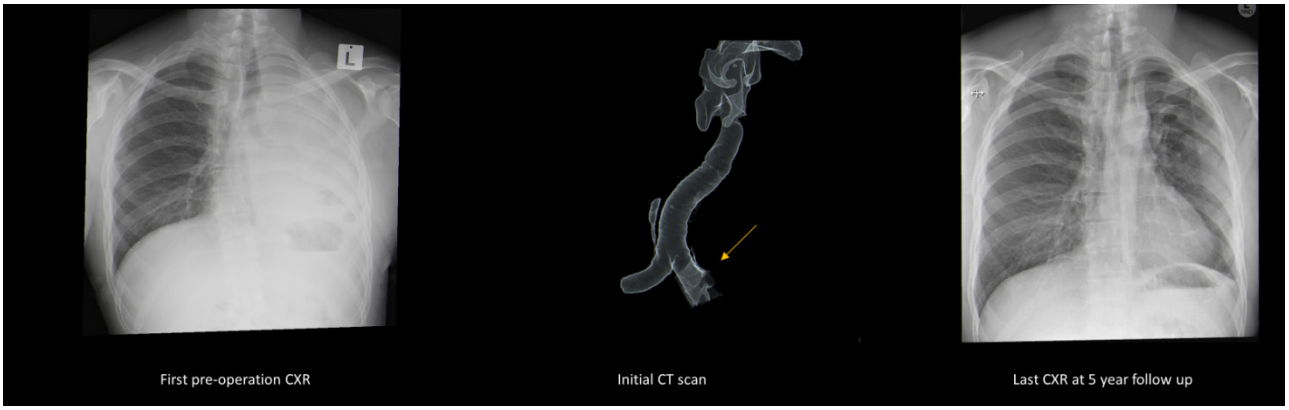

Figure 3: Initial CXR & TBTI reconstruction and latest CXR (at 5year follow-up)

Two patients underwent a left posterolateral thoracotomy for LMB injury, one after penetrating and the other after blunt trauma. The penetrating case intraoperatively had LMB laceration and lung laceration repaired with prolene 4.0 and prolene 3.0 respectively. The second patient with LMB disruption following a motor vehicle collision presented 3 weeks post-injury. An empyema thoracis was treated with intercostal drainage and antibiotics. Initial bronchoscope demonstrated granulation tissue in the LMB, without the ability to advance the scope due to obstruction by granulation tissue. This protected the subtended lung from infection. After 6-weeks empyema control he underwent left bronchial end-to-end repair. Preoperative bronchoscopy demonstrated a blind ending pouching LMB 4 cm from the main carina. A left posterolateral thoracotomy with resection of the blind endings of the bronchus and end-to-end anastomosis buttressed with intercostal muscle pedicle using vicryl 3.0 suture was performed. Annual follow-up remains ongoing, due to sequelae of a small left lung. A follow-up ventilation perfusion (V/Q) scan for quantitative lung assessment showed a slightly low left lung perfusion and ventilation requiring no further intervention. This patient's chest imaging is demonstrated in Figures 2 and 3.

In those patients with sepsis, including empyema or delayed presentation, intravenous antibiotic therapy was commonly used, with targeted drug treatment as directed by cultures. Evacuation of pus was either by a chest tube or corrugated/portovac drains in the neck postoperatively. A muscle pedicle was tacked between the oesophageal and airway repairs, and also those airway injuries complicated with sepsis. This helped with protecting the repaired site, providing additional blood flow, a physical barrier between the oesophagus and airways and possibly prevented suture break down and bronchopleural fistulae. The mediastinal pleura was left open from the thoracic inlet to the diaphragm in those patients who had mediastinitis.

Post-thoracotomy, apical and basal drains are placed for complete evacuation of any residual pleural collections. Placement of a nasogastric tube aids in identifying the oesophagus intraoperatively, and postoperatively patients are kept nil per mouth and fed via the nasogastric tube to allow oesophageal healing. In patients who had associated oesophageal injury, a water-soluble swallow was performed at 10–12 days to check for any residual leaks. If there were persistent leaks, nasogastric feeding was continued until the leak sealed. There were no patients who were treated with stents.

There were five patients who had associated oesophageal injuries, two of these patients died from sepsis, while three did well postoperatively.

Most patients were extubated in the operating theatre post-tracheal repair, with the intention of prevention of pressure injury risk to the repaired tissue. A few remain intubated and

admitted to ICU following tracheal repair, where extubation is aimed to occur after 72 hours.

Ten patients were managed conservatively. One of these presented intubated through the wound, clinically and radiologically he improved and was converted to a tracheostomy. The tracheostomy was removed during the index admission, and he was discharged well. One COVID-19 patient required intubation and isolation before TBTI repair, yet clinically improved, and was discharged home after isolation. The remaining patients at bronchoscopy were found to have small lacerations which were less than 1 cm in diameter with no significant air-leak and subsequently improved clinically and radiologically.

The total hospital postoperative length of stay ranged from 1 up to 49 days with a median of 6 days (IQR 4–10). Aetiology is shown in Figure 1. Thirty-two patients had good outcomes on discharge based on clinical improvement and chest imaging. One patient complicated with sequelae of small left lung and is still being followed-up on an annual basis six years post LMB repair. There were four mortalities, two due to sepsis and mediastinitis related to oesophageal injury and two due to concomitant traumatic brain injuries.

Follow-up post discharge is approximately six months. There were 16 patients who were lost to follow-up.

Discussion

This retrospective data analysis covered 21 years with an average of 1.8 (SD 1,61) cases per year. During the FIFA Soccer World Cup in 2010, with heightened security and a positive community spirit, there were no cases reported.[13,14] During the Covid-19 pandemic shut down in 2020 no cases were reported, in keeping with the overall trauma reduction during the lockdown period.[15,16] Most injuries were in young males, with penetrating and cervical tracheal injuries predominating.

Management goals are based on two crucial steps by first responders at the scene or first hospital arrival. Firstly, airway stabilisation to achieve a definitive airway, followed by defining the extent and location of injury.[1] Clinical suspicion in correlation with mechanisms of injury is demonstrated in our results. Eleven of the patients required a definitive airway before being transferred to the referral centre with largely good outcomes. A number of reports have documented that airway injuries can be missed in the first 24–48 hours and also immediate intubation differs in each patient and depends on the degree of injuries and anatomical level of involvement, with the lower airway being more difficult to secure.[8,11,17,18]

A sentinel autopsy study of TBTI reported 37 patients who died from traumatic lesions of the trachea or bronchus.[11] Twenty-eight died from bronchial injuries, RMB being the majority, while there were nine who died from tracheal injuries.[19] This study demonstrated the difficulty in securing definitive lower airway which resulted in the majority of deaths. Kummer and associates reported on 104 patients with TBTI; definitive airway was established in a total of 71 patients, of which 32 patients had intubation at the scene/enroute to hospital, 22 at a referring hospital and 17 in the trauma room.[7] These two studies emphasised the importance of securing the definitive airway early within the initial assessment when required. Even though our four mortalities were not related to TBTI as a cause, three had definitive airway established at a referring hospital. One had blunt RMB injury complicated by severe traumatic brain injury. One had LMB injury secondary to multiple stab neck/chest and one had a GSW to the cervical trachea.

Following a history of mechanism of injury and a high degree of clinical suspicion of airway injury, locating the site of injury and related complications is undertaken with chest imaging (chest radiograph and neck-chest CT scan with contrast) and using surgeon-performed bronchoscopy. The choice of flexible bronchoscopy or rigid bronchoscope depends on experience and equipment availability.[20-22]

Local experience with these injuries demonstrated similarities with international norms. The study has made several observations, first the number of penetrating traumatic TBTI at 4.5% being more common than blunt TBTI at 0.4%, is in keeping with reported literature demonstrating fewer patients presenting with blunt TBTI due to its lethal nature.[5,7,10,11] There were no patients who presented to us with blunt thoracic tracheal injury, however there were four with blunt bronchial injury.

In South Africa, particularly in the KwaZulu-Natal (KZN) province, due to the extensive distances and remote rural areas, the patient's journey often starts in peripheral district and regional hospitals before they present to IALCH, which is the only hospital with both cardiothoracic surgery and specific trauma intensive care.[23] Some patients present directly to the trauma unit from the scene of injury. This may also contribute to delayed transfer of patients with lethal blunt TBTI. Delayed definitive surgical repair was a factor contributing to sepsis, leading to death or survival with sequelae of injury.

Similarly, cervical penetrating tracheal injuries were more common than thoracic trachea and bronchus.[5,7] The stab group was the most common mechanism of injury by any penetrating sharp object, mostly a knife. This was followed by gunshot wounds, which were more common in the thoracic trachea than cervical trachea, possibly from trans-mediastinal gunshot wounds.

Subcutaneous emphysema, common in both blunt and penetrating injuries was the dominant presenting symptom.[6] Associated oesophageal injury presented with dysphagia and hematemesis, while those with upper airway and recurrent laryngeal nerve injuries presented with stridor and hoarseness. If associated injuries to the oesophagus or major vessels are suspected, a CT scan with contrast and a water-soluble swallow are undertaken, being rapid and non-invasive.[21,24]

At IALCH, chest radiograph with or without CT scan with contrast are performed if not done already by a referring hospital. Bronchoscopy is the gold standard investigation for TBTI.[25]

The majority of international data detail the repair of these injuries with interrupted or continuous absorbable suture techniques.[2] In our setting, interrupted suture technique was most common. Complex reconstructive techniques were required in those patients with bronchial injuries, delayed presentations and also in those with a complex of trachea-oesophagus involvement, these included pericardial patch and tracheobronchial released manoeuvres.[24,26-28] Patients with a complete or partial circumferential airway involvement underwent debridement, resection with tension free end-to-end anastomosis using interrupted sutures with the knots on the outside to prevent granulation tissue formation and narrowing, with or without release

manoeuvres.[5] With combined tracheal and oesophagus injury, it is important to buttress the suture-line and the use of harvested muscle pedicle to prevent trachea-oesophageal fistula formation, particularly if there is inflammation, mediastinitis or empyema thoracis which present a risk of wound dehiscence and poor healing.[2,28] Sternocleidomastoid muscle (cervical trachea-oesophageal injury) and intercostal muscle pedicles for thoracic trachea and bronchus injuries were used.

The median duration of stay in the majority of our patients with TBTI post-surgical repair was 6 days (IQR 4–10) but ranged from 1 to 49 days. Some centres have reported mean hospital stay to be between 9–20 days.[28,29] Those with prolonged stay had other associated injuries such as oesophageal injuries which also required repair with time for swallow follow-up to monitor for post repair oesophageal leaks, or those who developed sepsis from mediastinitis or empyema thoracis requiring prolonged antibiotics and intercostal drain management. Sepsis was a major contributing factor to our mortalities due to delayed presentation, delayed initial management and organ system involvement other than TBTI. Those that were lost to follow-up are those who never came back for a clinic review post discharge.

Where patients reached the quaternary unit, they ended with a good outcome. The vast majority of cases required surgical repair.

Limitations

This was a single-centre retrospective study, albeit using an electronic database, and although some data may not have been captured, the system uses very comprehensive template-based recording. Private sector patients and those who died before arrival were excluded. Patients with TBTI managed at base hospitals conservatively or surgically, who were not referred to our centre were also excluded.

Conclusion

TBTIs remain rare, yet lethal injuries. Penetrating injury remains more common with cervical tracheal injuries being the most common. Subcutaneous emphysema and breathlessness should raise high levels of suspicion regarding airway injury. Critical airway assessment is imperative and securing a definitive airway is crucial to patient survival. The surgical approach depends on clinical presentation, injury location and associated injuries. Conservative management, with or without tracheostomy, may be as effective as surgical repair in selected cases. Patients with TBTI may die from other associated injuries and poorly managed sepsis, apart from TBTI.

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Conflict of interest

The authors declare no conflict of interest.

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Ethical approval

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REFERENCES

1. Karmy-Jones R, Wood DE. Traumatic injury to the trachea and bronchus. Thorac Surg Clin. 2007;17:35-46. https://doi.org/10.1016/j.thorsurg.2007.03.005.
2. Welter S. Repair of tracheobronchial injuries. Thorac Surg Clin. 2014;24(1):41-50. https://doi.org/10.1016/j.thorsurg.2013.10.006.
3. Saleh ME, Beshir H, Mohammed WH, Sanad M. Tracheobronchial injuries - tertiary centre experience. Asian Cardiovasc Thorac Ann. 2020;28(1):22-28. https://doi.org/10.1177/0218492319893822.
4. Shields TW, LociCero III J, Reed CE, et al. General Thoracic Surgery. 7th ed. Philadelphia (PA): Lippincott Williams & Wilkins; 2009. p. 1730-1757. (ISBN: 9780781779821).
5. Prokakis C, Koletsis EN, Dedeilias P, et al. Airway trauma: a review on epidemiology, mechanism of injury, diagnosis and treatment. J Cardiothorac Surg. 2014;9:117. https://doi.org/10.1186/1749-8090-9-117.
6. Riley RD, Miller PR, Meredith JW. Injury to the oesophagus, trachea and bronchus. In Trauma. 5th ed. Moore EE, Feliciano DV, Mattox KL, editors. New York: McGraw-Hill; 2004. p. 539-52. (ISBN: 0071500561, 9780071500562).
7. Kummer C, Netto FS, Rizoli S, et al. A review of traumatic airways injuries - potential implications for airway assessment and management. Injury. 2007;38:27-33. https://doi.org/10.1016/j.injury.2006.09.002.
8. Milner A. The airway in face, head and neck injury. SAJAA. 2008;14(1):52-7. https://doi.org/10.1080/22201173.2008.10872522.
9. Saad R Jr, Gonçalves R, Dorgan Neto V, et al. Tracheobronchial injuries in chest trauma: a 17-year experience. Rev Col Bras Cir. 2017;44(2):194-201. https://doi.org/10.1590/0100-69912017002014.
10. Shemmeri E, Vallières E. Blunt tracheobronchial trauma. Thorac Surg Clin. 2018;28(3):429-34. https://doi.org/10.1016/j.thorsurg.2018.04.008.
11. Bertelsen S, Howitz P. Injuries of the trachea and bronchi. Thorax. 1972;27:188-94. https://doi.org/10.1136/thx.27.2.188.
12. Schneider T, Volz K, Dienemann H, et al. Incidence and treatment modalities of tracheobronchial injuries in Germany. Interact Cardiovasc Thorac Surg. 2009;8:571-6. https://doi.org/10.1510/icvts.2008.196790.
13. Hardcastle TC, Samlal S, Naidoo R, et al. The redundant resource: a pre-planned casualty clearing station for a FIFA2010 stadium; the Durban experience. Prehosp Disaster Med. 2012;7(5):409-15. https://doi.org/10.1017/S1049023X12000453.
14. Hardcastle TC, Naidoo M, Samlal S, et al. The Moses Mabhida medical plan: medical care planning and execution at a FIFA2010 stadium; the Durban experience. Open Access Emerg Med. 2010;2:91-7. https://doi.org/10.2147/OAEM.S14899.

15. Hardcastle TC. COVID-19 and its impact on surgery in KwaZulu-Natal, South Africa: a wholistic overview. Adv Hum Biol. 2021;11(2):141-2. https://doi.org/10.4103/aihb.aihb_13_21.
16. Hardcastle TC, Den Hollander D, Ganchi FE, Naidoo S, Shangase TN. Management issues with infection control during trauma resuscitation in the era of COVID-19 - South African experience. Bangladesh J Med Sci. 2021;20(5):72-6. https://doi.org/10.3329/bjms.v20i5.55410.
17. Bhojani RA, Rosenbaum DH, Dikmen E, et al. Contemporary assessment of laryngotracheal trauma. J Thorac Cardiovasc Surg. 2005;130:426-32. https://doi.org/10.1016/j.jtcvs.2004.12.020.
18. Kiser AC, O'Brien SM, Detterbeck FC. Blunt tracheobronchial injuries: treatment and outcomes. Ann Thorac Surg. 2001;71:2059-65. https://doi.org/10.1016/S0003-4975(00)02453-X.
19. Symbas PN, Justicz AG, Ricketts RR. Rupture of the airways from blunt trauma: treatment of complex injuries. Ann Thorac Surg. 1992;54:177-83. https://doi.org/10.1016/0003-4975(92)91177-B.
20. Grewal HS, Dangayach NS, Ahmad U, et al. Treatment of tracheobronchial injuries: a contemporary review. Chest. 2019;155(3):595-604. https://doi.org/10.1016/j.chest.2018.07.018.
21. Moser JB, Stefanidis K, Vlahos I. Imaging evaluation of tracheobronchial injuries. Radiographics. 2020;40(2):515-28. https://doi.org/10.1148/rg.2020190171.
22. Altinok T, Can A. Management of tracheobronchial injuries. Eurasian J Med. 2014;46(3):209-15. https://doi.org/10.5152/eajm.2014.42.
23. Hardcastle TC, Samuels C, Muckart DJ. An assessment of the hospital disease burden and the facilities for the in-hospital care of trauma in KwaZulu-Natal, South Africa. World J Surg. 2013;37(7):1550-61. https://doi.org/10.1007/s00268-012-1889-1.
24. Nel L, Whitfield Jones L, Hardcastle TC. Imaging the oesophagus after penetrating cervical trauma using water soluble contrast alone: simple, cost effective and accurate. Emerg Med J. 2009;26;106-8. https://doi.org/10.1136/emj.2008.063958.
25. Cakmak G, Cansun F, Saracoglu A, T Saracoglu K. Airway management in penetrating thoracic trauma. Anaesthesiol Intensive Ther. 2022;54(3):253-61. https://doi.org/10.5114/ait.2022.118332.
26. Glazer ES, Meyerson SL. Delayed presentation and treatment of tracheobronchial injuries due to blunt trauma. J Surg Educ. 2008;65(4):302-8. https://doi.org/10.1016/j.jsurg.2008.06.006.
27. Moishe L, Douglas JM. General thoracic surgery - surgical anatomy of the trachea and techniques of resection and reconstruction. 7th ed. Shields MD, et al, editors: Lippincott Williams & Wilkins; 2009. p.1863-82. (ISBN: 9780781779821).
28. Gabor S, Renner H, Pinter H, et al. Indications for surgery in tracheobronchial ruptures. Eur J Cardiothorac Surg. 2001;20:399-404. https://doi.org/10.1016/S1010-7940(01)00798-9.
29. Welter S, Essaleh W. Management of tracheobronchial injuries. J Thorac Dis. 2020;12(10):6143-51. https://doi.org/10.21037/jtd-2019-as-05.