

Traumatic Diaphragmatic Rupture – A Clinical Experience Over Two Decades

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ABSTRACT

Introduction: Traumatic diaphragmatic rupture was once only reported in post mortem findings. But due to better advanced trauma and life support services and increased survival of the trauma patients, these are now diagnosed with increasing frequency. The purpose of this study was to present our experience with its different mechanisms of rupture and its management. The aim of this retrospective study was to evaluate manifestations of effects of diaphragmatic rupture after thoraco-abdominal trauma, and to discuss their epidemiology, diagnosis, nature and treatment with an aim to impart comprehensive timely management to reduce morbidity and mortality.

Material and methods: It is the report of combined experience of the authors on 18 patients with traumatic diaphragmatic rupture with (TDR) or without traumatic diaphragmatic hernia (TDH) treated in two Medical College Hospitals in Kolkata, from 1998 to 2019, and a retrospective analysis was performed. 9 patients who presented with severe injury with features of internal injury were operated early and 9 with non severe injury were operated later.

Results: Out of 18 patients, 14 had history of blunt trauma and 4 had history of penetrating trauma. 4 patients with penetrating together with 5 with blunt injury were included in the severe group and had undergone early surgery due to suspected internal injuries. Out of these 9 patients, 5 patients having TDR and 1 having TDH died due to hemorrhage and / or sepsis with a mortality of 33.33. TDH was diagnosed by imaging studies in 9 patients in non severe group while 1 was diagnosed intra operatively in the severe group.

Conclusions: Though priority of a blunt or a penetrating trauma patient involves resuscitation and early surgery when indicated, careful understanding of mechanism of injury can guide the emergency surgeon to suspect and examine the diaphragm for any TDR to prevent further complication. In addition to X rays computer tomographic study when available becomes helpful in preoperative planning of surgery for closure of TDR or TDH.

Keywords: Traumatic Diaphragmatic Rupture, Traumatic Diaphragmatic Hernia, Thoracotomy, Laparotomy,

traumatic diaphragmatic hernia (TDH). Sharp penetrating injuries in abdomen or chest such as bullets or knife or sharp objects like metal rods, glass fragments, can also cause TDR. Incidence of TDRs ranges between 0.8 and 15%¹ according to level of urbanization in the geographic location of primary trauma. Radiological imaging are often not diagnostic of small TDRs if they do not cause TDH. TDRs are sometimes diagnosed during emergency laparotomy or thoracotomy by examination of diaphragm whereas TDH need imaging studies. The surgical management is the only treatment for TDRs and TDH. The risk factors for mortality and morbidity depends on associated collateral injuries sustained during trauma. The aim of this retrospective study was to evaluate manifestations of effects of diaphragmatic rupture after thoraco-abdominal trauma, and to discuss their epidemiology, diagnosis, nature and treatment with an aim to impart comprehensive timely management to reduce morbidity and mortality.

MATERIAL AND METHODS

This was a retrospective review of 18 patients documented and treated by us over two decades for TDR, with or without TDH, who were treated by us in Medical College Hospital, Kolkata, and Calcutta National Medical College, Kolkata, from April 1998 to November, 2019. A retrospective analysis was performed in relation to the outcome of these patients. The demographic profile of the patients, side of TDR, history of mechanism of injury, imaging studies performed, type of operation, emergency or non emergency, mortality and survivability were noted with detailed inputs against the patients assigned with serial numbers (Table-1).

There were 15 males and 3 females and age ranged from 18 to 62 years, with a median age of 34.5 years. The patients were categorized as severe when there was evidence of penetrating wound or in cases of blunt traumas, evidence of internal gut or solid organ injuries. It was found that 9 patients had to be operated early in the severe group after resuscitation

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INTRODUCTION

Traumatic diaphragmatic rupture (TDR) is not a very uncommon injury, mostly caused in pedestrians by sudden impact with speeding motor vehicles. Injuries in vehicle occupants like seat belt or steering wheel compression on frontal collision is also not uncommon. Sudden compression by fallen walls, trees, poles etc during natural disasters, or stampede, fall from a height during normal walks of life are some other mechanisms of TDR. Large TDRs can result into

which included 4 with penetrating and 5 with blunt trauma injuries between 4 to 10 hours which also depended on the time of arrival after the trauma. The other 9, in the non severe group, who were resuscitated and stabilized, were operated mostly after 24 hours. In 1 old case of TDH, it was 2 years after blunt trauma, when TDH was symptomatic (Sl. No. 18).

Investigations included X-ray of chest in all patients. CT scan of chest and abdomen was done in 10 patients and MRI was done only in a single case (Sl.No 3).

Operation

In severe group, laparotomy was done in 5 patients of blunt trauma while in 4 patients of penetrating trauma in the severe group, thoracotomy or thoracoabdominal exploration was done. In the 9 patients in the non severe group, the approach for repair of TDH was thoracotomy or thoraco abdominal exploration.

TDR was repaired in two layers with # 1-0 polypropylene sutures. Such tears 2 to 5 cm in length, were noted in the left side in 5 patients and right in 2 with acute penetrating trauma. TDH was present in TDRs larger than 9 cm in 9 patients non severe group and 1 in severe group. TDH was diagnosed through a 3 cm TDR in only 1 in non severe group with a history of old trauma (Sl. No.18). Herniated viscera included stomach and adjacent small and large gut through TDH in both sides while in 1 case it was additionally liver on the right side.

Some relevant case histories

In a patient of chest injury in a young man (Sl. No.2), TDH was diagnosed after resuscitation and performing a CT scan in an outside hospital after trauma before referral. He was hit from front on his left side of the chest by a moving vehicle from behind. But no evidence of intra-abdominal grievous injury was present. After exploration through left anterolateral thoracotomy, TDH was repaired with polypropylene mesh (Figure-1).

In one patient of blunt trauma due to hit and run by a speeding vehicle (Sl. No.5), Laparotomy was done for uncontrollable intra abdominal bleeding. Pelvic fracture was the source of hemorrhage and an incidental 4 cm TDR was found in left cupola of diaphragm without TDH. It was closed but the patient expired later due to hemorrhage.

In one case of TDH, a patient was admitted with features of shock and a history of partial run over injury (Sl. No.3) by a driver reversing back a light empty truck. After it's wheels ran over half of the right side of abdomen of the person knocked down, it instantly moved away forward on being alerted. X ray of chest showed lower 6th and 7th rib fractures with X ray suggestive of pneumothorax. Chest drain showed blood mixed bilious discharge. MRI after 48 hours showed right sided TDH (Figure-2) It was explored almost 72 hours after the trauma. Exploration revealed a single loop of jejunum herniated with right lobe of liver into right hemithorax. There was a perforation in the junal loop without contamination of the abdominal cavity. The rupture in jejunum was repaired with resection

and anastomosis and TDH was closed with polypropylene mesh.

In one case, a young girl (Sl No. 17), developed TDH due to run over by an empty bullock drawn cart. It's wheels had car tyres (which are being used more instead of the traditional wooden and iron wheels) which ran from right to left. After resuscitation, an X ray chest showed fracture of lower ribs with evidence of right sided opacity with hemothorax (7th, 8th and 9th). Chest drain was put and hemothorax was drained. There was no other intra abdominal injury. A CT performed later showed evidence of right TDH (Figure No.3) which was repaired with mesh.

In one patient (Sl. No.18) who had a history of a thoraco abdominal trauma by fall from a height 2 years back, and treated conservatively, presented recently with an obstructed TDH with omentum without any sac. There was a 3 cm antero medial tear located near the sterno costal attachment of right half of diaphragm. Repair was also done with mesh. In a unique case of penetrating injury, a flying piece of glass missile, broken off from a window show case (Sl No.11), during depression created within a shop during a cyclonic storm, pierced through the right chest of a young man causing hemothorax. Persistent bleeding needed urgent thoracotomy through right 7th space (wound of entry) which showed a bleeding intercostal artery injury which was controlled. The diaphragm over the bare area of liver was found to have developed 2 cm TDR and liver was injured. It was sutured through the diaphragmatic tear with # 1-0 polyglactin suture and TDR wound was closed with # 1-0 polypropylene suture. In the case of a stab injury by knife (Sl No.4), from the back of left chest, a rent was found to be present in the left dome of diaphragm (7 cm). The herniating fundus of the stomach after examination was reduced into the abdomen and the left TDH wound was repaired in two layers. But later within a few hours, evidence of peritonitis was noted. Rexploration through laparotomy revealed an injury to the back of the stomach lower down the body, which was missed during an earlier examination. It was repaired and the patient made uneventful recovery.

In a case of bullet injury sustained from a pipe gun (a type of improvised country made short range hand gun in India), (Sl No 7) which traversed through the right side of chest, and diaphragm was lodged in the right lobe of liver. Exploration through a right thoraco abdominal approach revealed minimal lung injury. The bullet was extracted and the small 2cm TDR was closed. But the patient suffered from a long continued biliary discharge and wound infection which healed after a month.

In another case of bullet injury by a revolver (Sl. No. 1), there were colonic perforations and pancreatic injury. Distal pancreatectomy, colon repair and colostomy were done along with repair of left sided 2 cm TDH. This patient expired after 7 days due to sepsis.

Diaphragm was repaired with # 1 polypropylene mattress sutures in two layers in all cases and mesh enforcement was utilized in 3 patients (Figure No. 2). Analysis was performed in Table Nos. 2 and 3.

Sl No	Age	Sex	Location and mechanism of injury	Nature Of trauma Blunt Or Penetrating,	TDR or TDH with and associated injuries	Investigations	Approach Th/Lap/ThAbd	operation Severe (S)/ Non severe (N)	Size of TDR (approx)	Cause of death	Died/Sur
1	38	M	Left (Revolver bullet)	Penetrating (left chest and abdomen)	TDR, Liver pancreas and colon injury	CXR	Th Abd	6 Hrs, S	2 cm,	Sepsis	Died
2	32	M	Left (MV hit)	Blunt, (chest, medium impact)	TDH with stomach, Rib#	CXR, CT	Th	1 Day, N	12cm		Sur
3	25	M	Right (MV partial run over)	Blunt, (partial run over by truck over abdomen)medium impact	@ TDH with Rt Liver, jejunal rupture, Rib #	CXR, MRI	Th Abd	3 Days, N	20cm		Sur
4	34	M	Left (Stab injury by knife)	Penetrating (left lower chest)	TDH, Stomach injury	CXR,	Th and late Lap	7 hours, S	7 cm		Sur
5	56	M	Left (MV hit)	Blunt, (abdomen and Pelvis,)	TDR, Pelvic #,	CXR	Lap	3Hours, S	4cm	pel hge	Died
6	44	M	Left (MV hit)	Blunt, (chest, medium impact)	TDH, Limb #, Spine #	CXR, CT	Th	1 Day, L	12cm		Sur
7	37	M	Right, pistol bullet	Penetrating (from lower chest to right lobe of liver)	TDR, Liver injury,	CXR	Th Abd	7 hours, S	2 cm		Sur
8	28	M	Left MV (steering wheel)	Blunt, (abdomen, steering wheel compression)	TDH with stomach, Rib #	CXR, CT	Th	1 Day, N	11cm		Sur
9	29	M	Left, (wall collapse)	Blunt, (fall of mud wall over chest and abdomen)	TDR, Rib# and intestinal perforation	CXR, CT	Lap	8 Hours, S	5 cm	Sepsis	Died
10	54	F	Left, (MV hit)	Blunt, (chest, high impact)	TDR, Rib #, multiple ileal perforations	CXR	Lap	4 Hours, S	5cm	Sepsis	Died
11	21	M	Right (missile injury)	Penetrating sharp injury by Glass fragments	TDR, Liver penetrating inj	CXR	Th	7 Hours, S	2 cm		Sur
12	37	M	Left, (MV hit)	Blunt, chest medium impact	TDH, Rib #	CXR, CT	Th	1Day, N	10cm		Sur
13	23	M	Left, (MV hit)	Blunt, chest, high impact	TDH, Liver, kidney, intestinal inj,	CXR, CT	Lap	8 hours, S	9 cm	Sepsis	Died
14	47	M	Left, (MV)	Blunt, chest high impact	TDH, Rib#, stomach Int inj	CXR, CT	Lap	8Hours, S	12 cm	Sepsis	Died
15	32	M	Left, (MV hit)	Blunt, (chest, medium impact)	TDH, stomach herniation,	CXR, CT	Th	1 Day, N	12cm		Sur
16	53	M	Left, (MV hit)	Blunt, (chest, medium impact)	TDH, stomach herniation,	CXR, CT	Th	1 Day, N	12cm		Sur
17	18	F	Right, (Bullock cart run over)	Blunt, compression injury to abdomen	@ TDH, with stomach herniation, Ri	CXR, CT	Th Abd	2 Days, N	12cm		Sur
18	54	F	Right (fall from a ht)	Blunt, chest, medium intensity localized trauma)	@ TDH, with herniation of omentum	CXR, CT	Th and Lap	2 years, L	2cm		Sur

Table-1: Summary of demographic characteristics of the study population

Sl No= Serial number, Sex= M (male) or F (Female), S (sharp) may be due to knife, missiles like glass fragments, or bullets, TDR= traumatic diaphragmatic rupture, TDH= Traumatic diaphragmatic hernia, CXR= chest X ray, SPINE # = vertebral spine fracture. MV hit = Injury to pedestrian by impact of a speeding motor vehicle, MV Steering wheel = Compression of driver against the steering wheel of MV on frontal collision, inj= injury, Bullock cart run over = run over by a bullock cart with rubber tyre, Wall collapse = fall of mud wall on house collapse, @ = right side, glass missiles = broken pieces of glass flying after break during storms, MRI = Magnetic resonance imaging, E= Early operation within 8 hours of injury, L= Late operation after 24 hours of injury, @ = right side, int inj= intestinal injury,

Variables	Total (n=18)	Survived(S) (n=12)	Died(D) (n=6)
Age, years	38± 11.01	34.66±11.34	44.66±10.11
Male gender	15/18 (83.33%)	10/16(62.50%)	6/16(37.50%)
Female	3/18(16.67%)	2/2(66.67%)	1/3 (33.33%)
Blunt trauma	14(77.78%)	9/18(50.00%)	5/18(27.78%)
		9/14 (64.28%)	5/14 (35.71%)
MV impact	9/18 (50.00%)	5/9(55.56%)	3/9(33.33%)
Impact by steering			
Wheel after MV			
Collision	1/18(5.56%)	1/18(5.56%)	0
Impact by run			
Over by mini truck	1/18(5.56%)	1/18(5.56%)	0
Impact by Fall	1/18(5.56%)	1/18(5.56%)	0
Impact by Wall			
Collapse	1/18(5.56%)	0	1/18(5.56%)
Impact by run over by			
Bullock cart	1/18(5.56%)	1	0
Penetrating trauma	4/18(22.22%)	3/4(75.00%)	1/4 (25.00%)
	3/18(16.67%)	1/18 (5.56%)	
Bullet injury	2/18(11.11%)	1/18(5.56%)	1/18(5.56%)
		1/2 (50.00%)	
Glass splinter injury	1/18(5.56%)	1/18 (5.56%)	0
	1/4 (25.00%)		
Stab injury with knife	1/18(5.56%)	1/18(5.56%)	1/18(5.56%)
		1/4 (25.00%)	1/4(25.00%)

Table-2: Analysis of baseline characteristics of blunt or penetrating trauma in 18 patients and the outcome after operation.

RESULTS

There were 3 females and 15 males. The average age was 37.28 ± 12.75 years with a median age of 34.5 years. TDH was more common in the left side. Most affected age group with diaphragmatic ruptures was found in 12-56 years. The mean sizes of the defects with TDH in 11 patients varied from 2 to 20 cm with mean 11.81 cm. Mortality was 33.33% (6 out of 18). It was 1 out of 4 (25.0%) among the TDR by penetrating injuries while it was 5 out of 14 (35.71%) cases of TDR by blunt injuries. The present collective review suggests 14 (77.78%) of the injuries were due to blunt trauma and 4 (22.22%) were due to penetrating trauma (Table 1 and 2).

In the severe group, out of the 4 patients with penetrating injury, there were 3 survivors and a single mortality while all the 5 patients with early laparotomy did not survive.

In the non severe group all the patients survived operation. Most of the survivors were followed up for 1st 1 to 2 years and did not have recurrence within that period. The follow up of the last patient (Sl. No.18) is only 2 weeks.

Causes of death among both the sharp and blunt trauma cases varied among bleeding, shock, intestinal injury and sepsis.

Mean hospital stay

The mean hospital stay was 14 days with extreme of 50 days in cases of survivors.

All the datas were processed in Microsoft XL, tabulation done, and statistical averages, standard deviations and relevant proportion were calculated. No further statistical tests could be done due to small numbers of these cases.

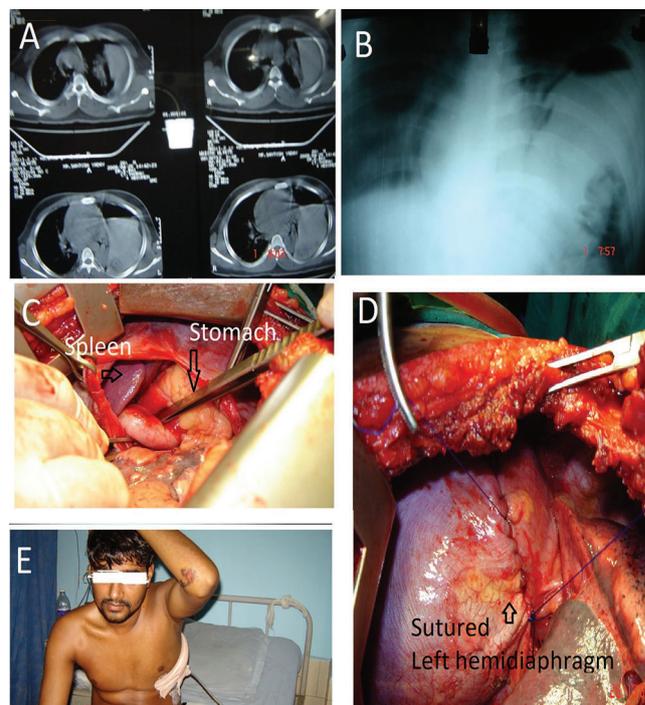


Figure-1: Preoperative imaging, operative findings and post operative photograph of the patient as described in Sl No.2 in Table 1. (A) CT; (B) Chest X- ray of herniated viscera in left hemi thorax; (C) Spleen and stomach after reduction through the ruptured diaphragm held with Babcock's forceps after exploration by left lateral thoracotomy; (D) The diaphragm being sutured in 2 layers with # 1 polypropylene, E. post operative appearance of the patient in the next day. All frames contain explanatory arrow sign for anatomic structures.

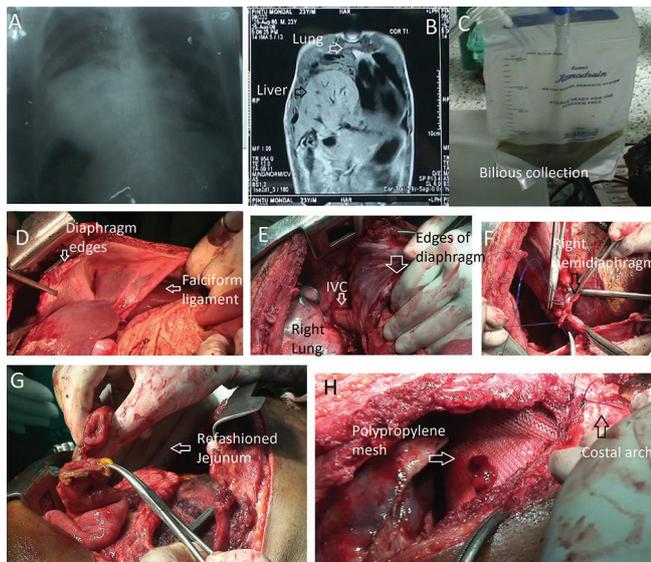


Figure-2: Preoperative imaging and operative photograph of the patient as described in SI No.3 in Table 1. (A) Chest x- ray of the patient suggestive of right sided pneumothorax; (B) MRI findings after 48 hours shows TDH of right lobe of liver in the right hemithorax with compressed right lung; (C) The chest drainage bag put earlier filled with bilious content; (D) Ruptured edge of the right side of diaphragm and the herniated liver after reduction and the falciform ligament; (E) The right lung and the upper portion of the inferior vena cava at the left side and the diaphragm and right lobe of liver held with hand on the right; (F) the torn edges of diaphragm being sutured with #1 polypropylene; (G) the portion of ruptured jejunum reduced from the right hemi thorax refashioned before anastomosis; (H) polypropylene mesh being used to cover the sutured diaphragm on the thoracic aspect while costal arch, can be seen approximated and sutured during closure. All frames contain explanatory arrow sign for images and anatomic structures. (reproduced from Dasbaksi et al¹⁶).

DISCUSSION

History

Diaphragmatic hernia was first described in 1541 by Sennertus in an autopsy finding.² Ambroise Pare in 1579 described TDH again as an autopsy finding after a gunshot wound sustained 8 months back in a French artillery captain³ who died due to strangulation in a portion of herniated intra thoracic colon.⁴ In 1853 the first antemortem diagnosis of traumatic rupture of diaphragm was made by Bowditch and the first successful diaphragmatic repair was reported by Riolfi in 1886 in a patient with omental herniation.⁴ The blunt injury causes raised intra abdominal pressure applied to the abdomen or flanks and according to Pascal's law, is distributed equally in all directions through the fluid abdominal contents. The left dome of the diaphragm is not buffered by solid viscera as on right and ruptures due to transmitted pressure.⁴ There are a few reported cases involving the right diaphragmatic dome.^{5,6-11} The right dome tear is often fatal because the force required to rupture the right dome is massive and cause extensive collateral damage to other intra abdominal organs, spine, pelvis and great vessels with high pre hospital mortality.^{9,12} In the past, incidence of TDR was reported as rare or infrequent.^{4,13} Extensive use of CT scan increased the

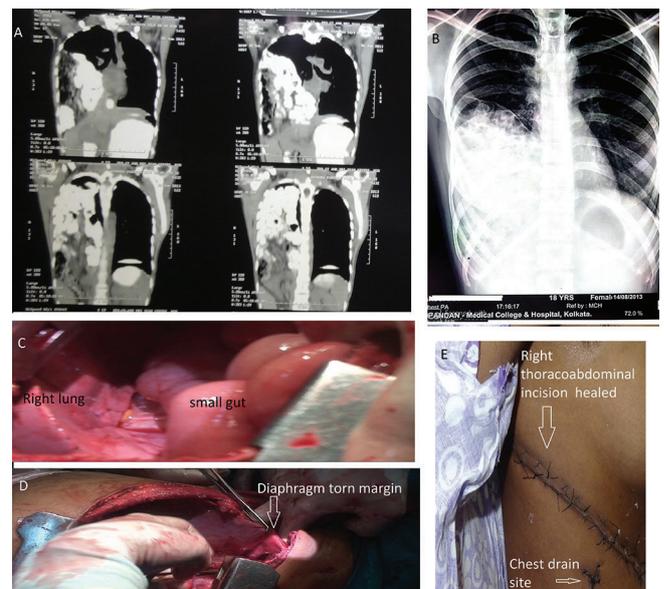


Figure-3: Preoperative imaging, operative findings and post operative photograph of the patient as described in SI No 18, in Table 1. (A) CT findings; (B) X ray appearance of TDH of gut into right hemithorax; (C) Herniated guts and lung in the thorax; (D) Edges of the ruptured right side of the diaphragm near the costal attachment being held by a tissue forceps, (E) Healed right thoracoabdominal incision and the chest drainage site. All frames contain explanatory arrow sign for anatomic structures.

pre operative diagnosis of TDR to 6%.¹⁴ But such increased diagnosis of TDR is due to inclusion of the more severely injured patients into emergency surgery, as a result of better resuscitation and improved advanced trauma life support services. Majority of the TDRs were caused by motor vehicles injuries in pedestrians. Recent report from Canada on the contrary cited a higher proportions of MV occupants to have suffered TDR due to vehicular collisions.¹⁴ This may be due scanty pedestrians encountered in Canadian roads unlike the Indian subcontinent. Run over by animal drawn carts are not uncommon in the rural Indian subcontinent but many are unreported. Such injuries are not so uncommon in the Western world¹⁵ too and we also had one such case (SI. No.17).

Mechanisms of injury of TDR due to blunt trauma: Certain incidents in our cases helped us to determine the reason for right dome rupture two of our cases, (SI. No.3 and 17). In one with partial run over injury (SI. No.3) causing Right sided TDH, was indeed a rare event and has been reported by our group¹⁶ earlier. The raised intra abdominal pressure in this case did not result in any rupture in the left dome after the right dome was ruptured. Had the truck not move away after partial run over, severe vascular injury could be a possibility had there been complete run over. Again, raised intra abdominal pressure by compression by a relatively lighter vehicle such as bullock cart run over as described (SI. No.17) resulted in right TDR and supported by others.¹³ The direction of run over from right to left could also be another reason for development of right sided TDR. Compressive forces from front as in one patient who had steering wheel compression (SI.No.8) resulted in left sided TDR with TDH.

Probably, high intra abdominal pressure (IAP) generated caused equal pressure on both sides, and the left dome being relatively unprotected, resulted in left dome rupture. Another mechanism for development of TDR in this case could be fractured lower 7th, 8th, 9th rib fragments causing tear at the lateral costal attachment of the right side of diaphragm as described by other authors.¹⁷ Mechanisms of TDR has also been explained by the fact that the contracted diaphragm during fall and direct impact, is distorted by opposing forces leading to a tear in the membrane.¹³ Such trauma could also explain the 2 cm antero medial tear located near the sterno costal attachment of right half of diaphragm in our last case (Sl. No.18) who sustained thoraco abdominal trauma 2 years back by fall from a height and presented with an obstructed hernia without any sac containing omentum only 2 weeks back. However, it was difficult to decide whether it was a Morgagni's hernia being symptomatic at a later stage of life or a truly traumatic origin as because no X ray of chest, before or soon after trauma was ever done, as she never had any symptoms for last 2 years. Incidents of relatively less severe trauma raising instantaneous raised IAP due to frontal collisions¹⁸ were also present in other cases of TDR too (Sl No. 2,6,8,12,15,16) and all survived operation. Severity and nature of compressive forces determine collateral damage and survival. Thus, severe blunt trauma like falling of walls or frontal collisions by vehicles in high speed, in certain cases resulted in TDR (Sl. Nos.5, 9,10,13,14) and resulted in severe collateral damage due to pelvic or solid organs or small and large gut injuries and death.

It is also intriguing to find most cases of severe blunt abdominal trauma in our series required laparotomy for intra abdominal injuries with the findings of smaller TDR (2 to 4 cm). In a recent Korean study¹⁷ it was found that the diameter of TDR was larger in the non-severe group (9.70 ± 4.10 cm) than the severe group (4.80 ± 3.60 cm) and this finding is agreeable to ours.

Alertness at the time of contact injury: Sudden thrust from the front on the torso of an alert subject, coordinated reflex contraction of the thoracic, abdominal and pelvic muscles, generates increased intra-abdominal pressure (IAP), displaces the diaphragm upwards. This muscular defense serves as protection due to reflex contraction of the muscular abdominal and thoracic wall and acts as deterrent to intra abdominal organ injuries [18 Stokes IA]. The same injury on an unaware and sleeping subject may cause intra abdominal hollow or solid viscus injury along with TDR which is exemplified in the patient in Sl No 9.¹⁸ Diagnosis of TDH is frequently not obvious and is missed in 7% to 66% of such patients with blunt injury while the actual incidence may be higher.¹⁹ Thus, for a delayed diaphragmatic rupture, it was also hypothesized that most patients with delayed diaphragmatic ruptures had no acute TDR. The diaphragmatic muscle became devitalized several days or months after the initial injury^{7,20} resulting in its later lysis.²¹ Therefore, X ray of chest is often not diagnostic initially due to slow herniation of abdominal contents through the diaphragm and requires follow up with serial X Rays^{6,22} or CTs if they are available.

Patients of TDR with penetrating injuries like bullet or knife or sharp fragments as observed in our patients were the ones who had naturally been selected by nature to reach hospital alive. Injury to pancreas, small gut and colon produced much complicated local wound, sepsis with dehiscence and added to later mortality (Sl. No.1). In the patient with stab injury (Sl. No.4) stomach injury was initially missed which was only confirmed by a 2nd look laparotomy. So, watchful monitoring is needed in post operative period. In case of the low velocity bullet injury to the liver after causing TDR (Sl. No. 7), biliary drainage continued for over a month. Watchful expectancy resulted in effective healing of the biliary fistulas and our method of management was in agreement with those of others.²³

Out of the patients who were admitted with blunt trauma in our series, 6 did not require urgent surgery other than intercostal chest drain for chest injuries due to hemothorax and /or pneumothorax and had surgery on an average 24 hours or longer for TDR or TDH. The prognosis depended on the extent of injury and duration of contamination before surgical intervention as in any other cases of trauma.

The generally accepted protocol in our series in the acute trauma setting tear was laparotomy with management of concomitant intra abdominal injuries, and TDR was a concomitant finding and our protocol is in agreement with others.^{4,13,14} Because of inclusion of patients with grievous wounds and attempt to salvage such high risk patients like pelvis and intra abdominal injuries, the mortality in our series was high (33.33%) and is in agreement with others (10%–35%).¹⁴ We found pelvic fracture, gut injuries and sepsis as risk factors and also reported by others.^{19,22}

CONCLUSION

Complications of diaphragmatic ruptures are mainly determined by injuries associated with TDR like gravity of blunt mechanical thrust imparted to internal organs with range of injuries extending from nil to rupture and /or bleeding. Likewise, penetrating injuries by bullet or knife, may also cause internal injuries depending on the organ involved in damage. As in any other cases of trauma, the principles of trauma care applies to both types of these injuries. Prognosis depends on severity of associated injuries in TDR and incarcerations or obstructions of herniated organs in TDH.

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Ethical Approval: This was a retrospective study and being it retrospective in nature, patient consent was waved off by the ethics committee of Medical College Hospitals, Kolkata700073 and also Calcutta National Medical College, Kolkata 700014

REFERENCES

1. Thiam O, Konate I, Gueye ML, Toure AO, Seck M, Cisse M, Diop B, Dirie ES, Ka O, Thiam M, Dieng M, Dia A, Tidiane C, Traumatic diaphragmatic injuries: epidemiological, diagnostic and therapeutic aspects, Springerplus. 2016; 5: 1614
2. Bosanquet D, Farboud A, Luckraz H. A review of diaphragmatic injuries. *Respir Med CME*. 2009;2:1–6.
3. Biswas S, Keddington J. Soft chest wall swelling simulating lipoma following motor vehicle accident: transdiaphragmatic intercostal hernia. A case report and review of literature. *Hernia*. 2008;12:539–43.
4. Shah R, Sabanathan S et al. Traumatic rupture of diaphragm. *Ann Thorac Surg* 1995;60:1444-9.
5. Thillois JM, Tremblay B, Cerceau E, et al. Traumatic rupture of right diaphragm. *Hernia*. 1998;2:119–21.
6. Jennifer M, Whitely JM, Cohen RC, Steinberg A. Right sided traumatic diaphragmatic hernia in a child a simple technique for diagnosis. *Pediatr Surg Int*. 1993;8:427–8.
7. Hiroyuki O, Isao I, Kazuo U, Takeshi Y, Isotoshi Y, Sadaki I. A case of right sided traumatic diaphragmatic hernia resulting in progressive respiratory failure. *J Jpn Assoc Surg Trauma*. 2006;20:356–9.
8. Yamamoto H, Taki T, Teramatsu T. Traumatic right sided diaphragmatic hernia—a case report and review of Japanese cases. *Bull Chest Dis Res Inst Kyoto Univ*. 1974;7:148–54.
9. Christophi C. Traumatic diaphragmatic hernia: analysis of 63 cases. *World J Surg*. 1983;7:277–80.
10. Bhatia S, Kaushik R, Singh R, et al. Traumatic diaphragmatic hernia. *Indian J Surg*. 2008;70:56–61.
11. Ala-Kulju K, Verkkala K, Ketonen P, Harjola PT. Traumatic rupture of the right hemidiaphragm. *Scand J Thorac Cardiovasc Surg*. 1986;20:109–14.
12. Sirbu H, Busch T, Spillner J, Schachtrupp A. Late bilateral diaphragmatic rupture: challenging diagnostic and surgical repair. *Hernia*. 2005;9:90–2.
13. Morley, J.E.: Traumatic diaphragmatic rupture. *South African Med. J* 1974;48:325.
14. Chughtai T1, Ali S, Sharkey P, Lins M, Rizoli S, Update on managing diaphragmatic rupture in blunt trauma: a review of 208 consecutive cases. *Can J Surg*. 2009;52:177-81.
15. Tremelling, Abigail M. et al. Similarities Between Large Animal-Related and Motor Vehicle Crash-Related Injuries, Wilderness & Environmental Medicine, 2017;28: 213 - 218
16. Dasbaksi K, Hazra R N, Mukherjee K, Mondol M, Nayak S, Repair of right sided Traumatic Diaphragmatic Hernia with intrathoracic herniation of liver and a segment of ruptured jejunum—a case report and review of literature, *Indian J Thorac Cardiovasc Surg* 2011; 27:39–44.
17. S. Kim et al. The clinical implications of severe low rib fracture in the management of diaphragm injury: A Case Control Study, *International Journal of Surgery* 2017;42: 178-182
18. Stokes IA, Gardner-Morse MG, Henry SM. Intra-abdominal pressure and abdominal wall muscular function: Spinal unloading mechanism. *Clin Biomech (Bristol, Avon)*. 2010;25:859–866.
19. Gao et al, Traumatic diaphragmatic rupture with combined thoracoabdominal injuries: Difference between penetrating and blunt injuries, *Chin J Traumatol*. 2015;18:21-6.
20. Zhao L, Han Z, Liu H, Zhang Z, Li S, Delayed traumatic diaphragmatic rupture: diagnosis and surgical treatment *J Thorac Dis*. 2019; 11:2774-2777.
21. Jha S, Singh, DP, Abdominal Necrotising Fasciitis Mimicking Peritonitis in a Gatka Playing Indian Male: A Case Report, *J Clin Diagn Res*. 2016;10:32–33.
22. Hofmann S, Kornmann M, Henne-Bruns D, Formentini A. Traumatic diaphragmatic ruptures: clinical presentation, diagnosis and surgical approach in adults. *GMS Interdiscip Plast Reconstr Surg DGPW*. 2012;1:
23. Armenta-Duran E, Enriquez-Domínguez L, de Dios Díaz-Rosales J D, Duarte-Erives E, Bile fistula after penetrating hepatic trauma with expectant management in the "era" of endoscopic treatment: clinical report, *Medicas UIS, Bicaromanga* 2013;26:71-73

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