



DIAGNOSIS AND SURGICAL TREATMENT OF TRAUMATIC DIAPHRAGM RUPTURES

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ABSTRACT

The results of surgical treatment of 62 patients with diaphragmatic ruptures were studied. It is shown that in the structure of the causes of closed diaphragm injuries, highly kinetic types of injuries predominate. Diaphragmatic ruptures are characterized by a high frequency of multiple and combined injuries of various organs, among which fractures of the ribs and other bones of the skeleton prevail. X-ray sign of diaphragm rupture (viscerothorax) is detected in less than a half of the victims. CT scan of the chest and abdomen, emergency thoracoscopy and laparoscopy contributes to the timely diagnosis of diaphragm injuries. The use of endovideosurgical technique at the stages of surgical treatment in patients with closed diaphragm injuries in 83.9% of cases reduces the number of wide surgical approaches, which favorably affects the course of the postoperative period and the outcome of the disease.

KEYWORDS: closed injury, diaphragmatic rupture, diagnosis, surgical treatment.

INTRODUCTION

The treatment of patients with diaphragm injuries in case of the closed chest and abdominal trauma continues to be an unresolved problem in emergency surgery both in peacetime and in wartime. This is determined not only by the severity of the injury, which causes a simultaneous violation of the chest and abdominal cavities but also by the high frequency of diagnostic and treatment errors, a significant number of complications, and high mortality.^[1,3,5] The difficulty of timely diagnosis of this pathology is due to the polysymptomatic nature of the clinical picture depending on the caused damage to various organs, the severity of the condition of the victims, the absence of specific signs of diaphragm injury, combined damage to the organs of the chest and abdominal cavities, and violation of their tightness.^[2,4]

AIM OF STUDY

To clarify the main criteria for choosing surgical treatment tactics and the order of thoracic and abdominal stages of intervention for diaphragmatic ruptures in patients with blunt trauma.

MATERIAL AND METHODS

The results of surgical treatment of 62 patients with diaphragmatic ruptures, who were treated at Republican Research Center of Emergency Medicine (RRCM), Tashkent, Uzbekistan in the period from 2003 to 2017, were studied. There were 50 men (80.6%), and 12 women (19.4%). The age of the patients ranged from 19 to 67 years (mean age 40.4±12.5 years). Only 4 (6.5%) victims were elderly, all the rest were young (39; 62.9%) and middle (19; 30.6%) aged.

At admission, along with resuscitation measures, an instrumental examination was carried out. Mandatory diagnostic methods in this category of patients are multipositional radiography and ultrasonography of the chest and abdomen, which were performed on almost all victims.

When X-ray and ultrasound signs of prolapse of a hollow organ into the pleural cavity were detected, the examination was supplemented with gastroscopy (2 cases) and contrast esophagogastrography (2 cases), which made it possible to verify the diagnosis.

In recent years we have been actively using the capabilities of CT scan for closed injuries of the chest and abdomen, as a protocol method for initial examination in patients with polytrauma and concomitant trauma. In this category of victims, the main indications for CT are traumatic brain injury with clinical and sonographic signs of brain dislocation and vertebral injuries with clinical signs of spinal cord compression. In such cases, after hemodynamic stabilization, we use CT scan protocol for the whole body examination: the brain, vertebral column, chest, abdominal cavity, and pelvis.

RESULTS AND DISCUSSION

Diaphragmatic ruptures in most cases are accompanied or are the result of ribs fracture on the side of the lesion. Thus, in our observations, out of 62 victims with a closed injury of the chest and/or abdomen, 45 (72.6%) patients were diagnosed with a fracture of the ribs on the side of the lesion (Fig. 1). At the same time, only 9 (14.5%)

patients had a fracture of only one rib, and the remaining 36 (58.1%) patients had multiple rib fractures. It should be noted that regardless of the presence or absence of rib fractures, as well as the number of broken ribs, closed diaphragmatic ruptures are characteristic of highly kinetic types of injury - in 59 (95.2%) patients, the injury was due to an road accident or fall injury, and the rest 3 (4.8%) victims had a criminal injury (beating). In all 17 (27.4%) cases of diaphragmatic rupture without rib fracture, combined and polytrauma were diagnosed. Thus, in the pathogenesis of closed-chest injuries, two main factors are of decisive importance: 1) the impact of a high-energy injury with a sharp increase in intra-abdominal pressure; 2) direct damage to the organ by the sharp ends of rib fragments. In case of rupture according to the first scenario, the thinnest part of the diaphragm, its tendon part, is more often damaged, and in case of damage by the sharp ends of the ribs, its muscular part.

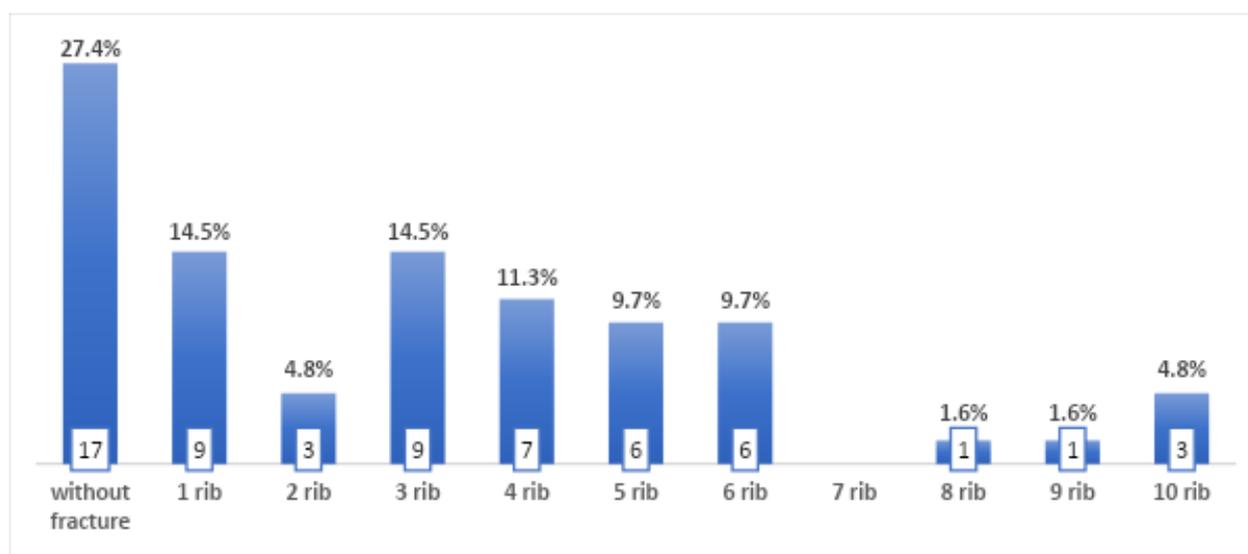


Figure 1: Patients' distribution with closed chest injury depending on the number of broken ribs on the side of the diaphragm rupture.

Thus, in our observations, 35 (56.5%) patients were diagnosed with a rupture of the tendon part of the diaphragm, including 28 (45.2%) victims - within the tendon itself, and 7 (11.3%) - with the transition to the muscular part (Table 1). The ratio of the frequency of ruptures of the left and right domes of the diaphragm is

≈2:1 (41 (66.1%) versus 21 (33.9%) cases). A certain lower susceptibility of the right dome of the diaphragm to ruptures is explained by the protective role of the liver, which covers the entire right half of the diaphragm from below.

Table 1: Localization of diaphragmatic ruptures, abs. (%)

Localization	Right	Left	Total
Muscular part	10	17	27 (43,5%)
Tendon part	9	19	28 (45,2%)
Muscular and tendon part	2	5	7 (11,3%)
Total	21 (33,9%)	41 (66,1%)	62

Since diaphragmatic ruptures are almost always associated with high-energy injuries, this category of victims is characterized by a high frequency of combined damage to adjacent cavities organs, which complicates the process of early diagnosis of all existing injuries and

the choice of treatment tactics. In our observations, only one woman out of 62 victims had an isolated rupture of the diaphragm as a casuistry, and in all other cases, a combined injury was noted, among which fractures of the ribs - 48 (77.4%) patients, and other bones of the

skeleton - 35 (56.5%), as well as traumatic brain injury (TBI) - 34 (54.8%). It is interesting to note that organs adjacent to the diaphragm are damaged with approximately the same frequency: liver injuries were detected in 18 (29.0%) patients, spleen injuries in 17 (27.4%), lung injuries in 15 (24.2%) and kidneys - also in 15 (24.2%). Often - in 9 (14.5%) cases - an injury of

the hollow organs of the abdominal cavity was diagnosed: in 5 - an injury of the small intestine, in 3 - of the stomach, and in 1 case - of the large intestine. Damage to the urinary tract (urethra and bladder) was diagnosed in 7 (12.1%) patients; as a rule, these injuries developed in traumas with pelvic fractures (Table 2).

Table 2: The frequency of combined damage to various organs in patients with diaphragmatic ruptures.

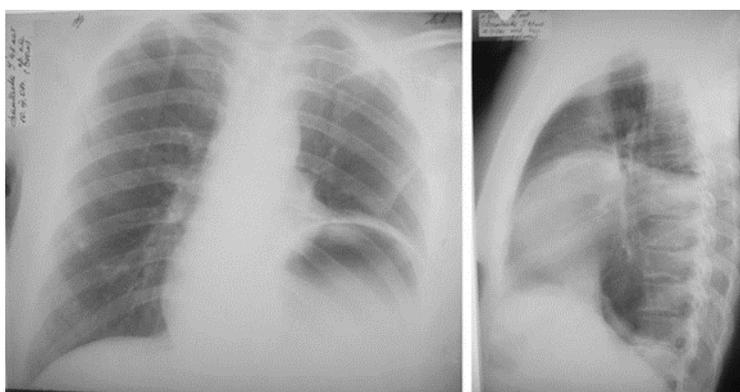
The nature of the combined damage	Number of patients	
	abs.	%
Rib fractures	48	77,4
Fractures of other skeleton bones	35	56,5
Traumatic brain injury (TBI)	34	54,8
Liver injury	18	29,0
Spleen injury	17	27,4
Lung injury	15	24,2
Kidney injury	15	24,2
Rupture of hollow organs:	9	14,5
● small intestine	5	8,1
● stomach	3	4,8
● colon	1	1,6
Urethral rupture	4	6,9
Bladder rupture	3	5,2

A direct radiological sign of diaphragm rupture - prolapse of the abdominal organs into the pleural cavity (viscerothorax) - occurred only in 28 (45.2%) victims, and all of them had left-sided damage (Fig. 2, 3). The rest of the patients had other signs of chest trauma that did not directly indicate the presence of diaphragm

damage, including rib fractures in 48 (77.4%), hemothorax, hemopneumothorax, and pneumothorax in 32 (51.6%) patients, lung contusion - in 12 (19.4%) patients and subcutaneous emphysema in 25 (40.3%) patients.



a



b

Figure 2: Rupture of the diaphragm on the left: a) loops of intestines containing gas can be traced in the left pleural cavity; b) there is a prolapse of the stomach into the left pleural cavity.

As direct ultrasound signs of diaphragm damage, we include the visualization of its defect and the detection of echo signs of the abdominal organs in the pleural cavity to those in patients with closed injuries of the chest and abdomen, which was observed only in 5 (8.1%) and 8 (12.9%) patients, respectively. Indirect ultrasound symptoms of diaphragm rupture are high standing of the diaphragm detected in 7 (11.3%) patients, the presence of free fluid in the pleural - 39 (62.9%) and abdominal - 26 (41.9%) cavities, mediastinal displacement - 4 (6.5%).

For polytrauma, CT scan of the chest and abdomen was performed in 171 patients, and signs of diaphragm rupture were found in 16 (3.5%) cases. Subsequently, damage to the diaphragm was confirmed intraoperatively in 15 of them, including rupture of the left dome was detected in 11 (73.3%), the right one - in 4 (26.7%). In 1 case, the conclusion of the CT scan on the likelihood of diaphragm damage was not confirmed during diagnostic thoracoscopy.

In addition, CT scan also revealed combined pelvic fractures in 9 out of 15 patients and hemoperitoneum in 9 patients. Chest scanning revealed hemothorax in 8 and rib fractures in 7 cases. CT scan showed signs of combined TBI in 3 patients (Table 3).

In all 15 patients, on CT sections, we noted the presence of a defect in the contour of the diaphragm, which was inevitably accompanied by signs of diaphragmatic hernia of various sizes (Fig. 3).

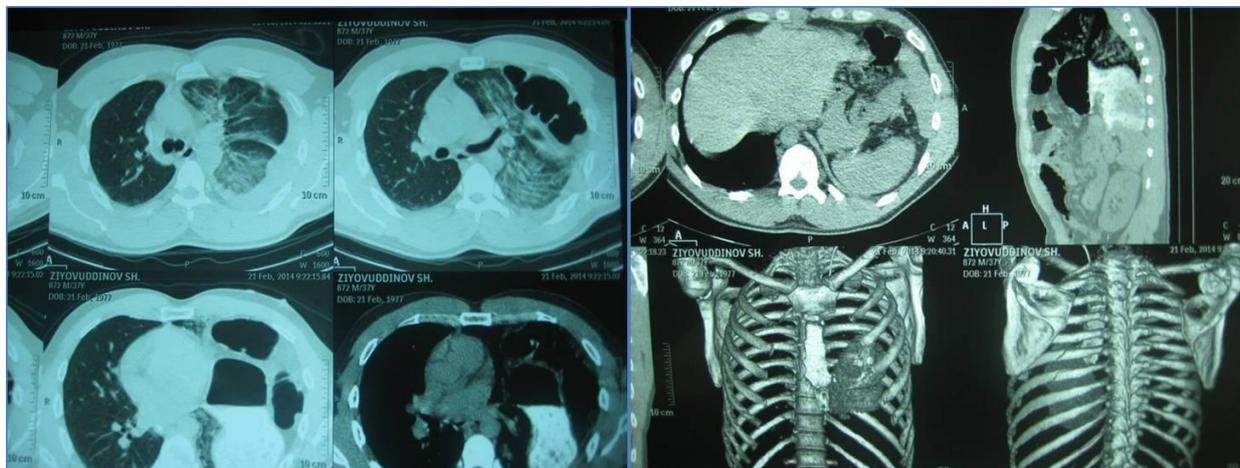


Figure 3: CT scan of the chest: signs of the abdominal organs prolapse into the left pleural cavity. Hemothorax on the left. Fracture of 6-7 ribs on the left. Mediastinal shift to the right. Contusion of the left lung.

Table 3: Combined injuries revealed by whole body CT scan in patients with diaphragmatic ruptures, total n=15.

Combined damage	Abs.	%
Pelvic fractures	9	60,0
Hemoperitoneum	9	60,0
Hemothorax	8	53,3
Rib fractures	7	46,7
Lung contusion	5	33,3
TBI	3	20,0

Obvious signs of diaphragm damage in the form of dislocation of the abdominal organs into the pleural cavity on primary radiographs and CT scan were detected only in 28 (45.2%) patients, and in the remaining 34 (54.8%) patients either there were no clinical and radiological signs of diaphragm damage or however, only its indirect signs took place, and the fact of the rupture was stated or confirmed during surgery stage: thoracoscopy - 24 cases, laparoscopy - 15 cases

and laparotomy - 3 cases (Table 4). This circumstance emphasizes the importance of expanding the indications for thoracoscopy and laparoscopy in patients with indirect signs of diaphragm damage or in victims with high-energy injuries of the chest and abdomen.

Table 4: Frequency of preoperative diagnosis of diaphragmatic ruptures, total n=62.

Result	abs.	%
Diagnosed before surgery	28	45,2
Intraoperative finding:	34	54,8
● with thoracoscopy	19	57,1
● during laparoscopy	12	35,7
● during laparotomy	3	7,1

Practically, in all patients with closed diaphragm injuries (in 61 (98.4%) patients) endovideosurgical technique was used at the stages of surgical treatment, including thoracoscopy in 60 (96.8%) and in 21 (33.9%) – laparoscopy (Table 5).

Table 5: Character of primary surgical approach in patients with diaphragmatic ruptures, total n=62.

The nature of the primary surgical approach	Number of patients		Conversion	
	Abs.	%	Abs.	%
Thoracic stage				
Thoracoscopy	60	96,8	11	18,3
● as the first stage	29	48,3	10	34,5
● after the abdominal stage	31	51,7	1	3,2
Thoracotomy (without primary thoracoscopy)	2	3,2		
● as the first stage	2	100		
● after the abdominal stage	-	-		
Abdominal stage				
Laparoscopy	21	33,9	8	38,1
● as the first stage	8	38,1	7	87,5
● after thoracic stage	13	61,9	1	7,7

Laparotomy (without primary laparoscopy)	40	64,5	
● as the first stage	23	57,5	
● after thoracic stage	17	42,5	

When choosing the sequence of intervention on the chest or in the abdominal cavity, the volume of hemothorax and hemoperitoneum was mainly taken into account. So, if signs of bleeding from the chest organs prevailed, then the intervention was started with thoracoscopy (29) or thoracotomy (2), and if hemoperitoneum prevailed and/or there were clear signs of viscerothorax (prolapse of the abdominal organs into the pleural cavity), the first stage resorted to laparoscopy (8) or laparotomy (23). In our observations, the ratio of the number of thoracic and abdominal interventions performed at the first stage was 31:31 (Table 5).

At the same time, indications for thoracoscopy were X-ray and/or CT signs of pneumothorax, small and medium hemothorax, and contraindications were the presence of signs of large hemothorax, viscerothorax, damage to the trachea and main bronchi. Indications for laparoscopy were US and CT signs of hemoperitoneum up to 400 ml, damage to the liver and spleen, contraindications - hemoperitoneum more than 400 ml, signs of damage to hollow organs, and obvious signs of viscerothorax. If the specified conditions for the use of videoendosurgical technique are met, the conversion rate after thoracoscopy does not exceed 18.3%, and after laparoscopy - 38.1%. As a rule, conversion to a wide surgical approach

occurred during endovideosurgical revision performed at the first stage in an adjacent cavity with a dominant amount of bleeding. So, if the conversion rate when performing thoracoscopy at the first stage was 34.5%, then when performing this intervention at the second stage, this figure was 3.2%. A similar ratio was observed when performing laparoscopy - 87.5% and 7.7%, respectively (Table 5).

If there are obvious clinical, radiological, and ultrasound signs of diaphragm rupture with the dislocation of the abdominal organs into the pleural cavity, we resort to primary laparotomy, performed in 23 (37.1%) patients (Tables 5 and 6), which allows us to extract the prolapsed into the pleural cavity organs and evaluate their condition for damage and viability. In 1 (1.6%) patient with an X-ray picture of subtotal darkening of the left lung field (large hemothorax?) and a fracture of the 3rd rib on the left, a wide thoracotomy was performed at the first stage, and a diaphragm rupture was detected. In this case, the surgeons failed to reposition the prolapsed organs back into the abdominal cavity, moreover, the spleen with signs of its rupture was also included in the upwardly dislocated organs, and therefore it was necessary to resort to the second wide surgical approach - laparotomy.

Table 6: Character and stages of intervention in patients with diaphragmatic ruptures, n=62.

Nature and stages of intervention	Abs.	%
Endosurgical interventions in both adjacent cavities		
thoracoscopy + laparoscopy	9	14,5
laparoscopy + thoracoscopy	1	1,6
Total	10	16,1
Hybrid interventions (endosurgical in one and open operations in another adjacent cavity)		
thoracoscopy + laparoscopy + laparotomy	1	1,6
thoracoscopy + laparotomy	9	14,5
thoracoscopy + thoracotomy + laparoscopy	2	3,2
thoracotomy + laparoscopy	1	1,6
laparotomy + thoracoscopy	22	35,5
laparoscopy + laparotomy + thoracoscopy	7	11,3
Total	42	67,7
Open surgeries in both adjacent cavities*		
thoracoscopy + thoracotomy*	1	1,6
thoracoscopy + thoracotomy + laparotomy	7	11,3
thoracotomy + laparotomy	1	1,6
laparotomy + thoracoscopy + thoracotomy	1	1,6
Total	10	16,1

* – In the first case with the right dome of the diaphragm damage, laparotomy and laparoscopy were not performed, the surgeon limited himself to revision of the subdiaphragmatic space through the diaphragm defect (Fig. 4).

In total, open surgeries in both adjacent cavities were performed in 10 (16.1%) patients (including 1 patient, the revision of the subphrenic space on the right was performed through a defect in the diaphragm during wide thoracotomy on the right (Fig. 4)). In another 10 (16.1%)

patients, all therapeutic and diagnostic interventions in both adjacent cavities were performed using the endovideosurgical techniques, without resorting to open operations. In 42 (67.7%) patients, hybrid technology was used, when in one of the adjacent cavities all

diagnostic and therapeutic procedures were performed by the endosurgical method, and in the other cavity by the open method. Thus, in only 52 (83.9%) patients with closed diaphragm injuries, the use of endovideosurgical technique at the stages of surgical treatment made it

possible to reduce the number of wide surgical approaches, which for this category of patients are an additional injury potentially aggravating the severity of the traumatic disease.

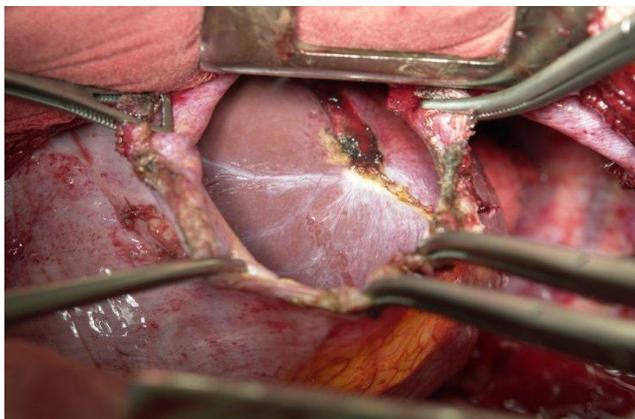


Figure 4: Revision of the subdiaphragmatic space and hemostasis of liver rupture through a defect in the diaphragm during thoracotomy.

Diagnostic thoracoscopy was used in 60 (96.8%) patients for chest injuries with signs of hemothorax, pneumothorax and diaphragmatic rupture without viscerothorax (Table 6). As is known, the sensitivity of thoracoscopy in detecting diaphragmatic ruptures reaches 100% - in our observations, it was always possible to

visualize almost all parts of the diaphragm and identify its defect (Fig. 5). Diagnostic laparoscopy (Fig. 6) was used in 21 (33.9%) patients, including in 8, the first stage and in 13, the second stage after interventions on the chest (Table 5).



Figure 5: Thoracoscopic picture of the left dome of the diaphragm rupture.

In surgery of diaphragmatic ruptures, the question of choosing the optimal surgical approach for suturing a diaphragm defect remains the most controversial. Surgeons use thoracotomy, laparotomy, and combined approaches based on their own preferences. We believe that if there are clear signs of dislocation of the abdominal organs into the pleural cavity, then it is

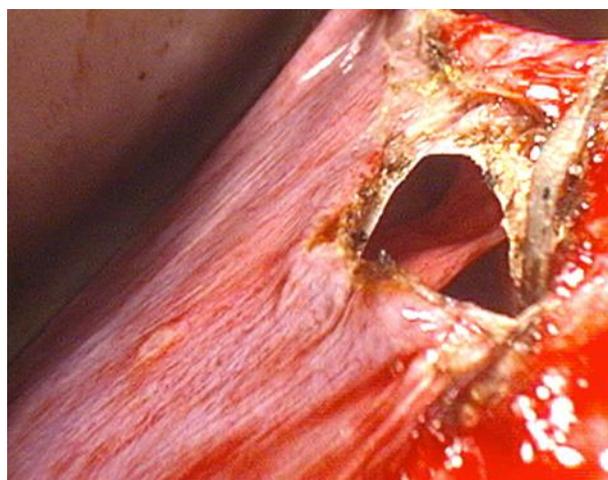


Figure 6: Laparoscopic picture of the left dome of the diaphragm rupture.

necessary to perform a laparotomy since with a thoracotomy it is not always possible to bring the dislocated organs back into the abdominal cavity and it is extremely difficult to fully assess their viability. We used this approach in 43 (69.4%) patients (Fig. 7). In all other cases, the nature of access depended on the results of thoracoscopy and laparoscopy.

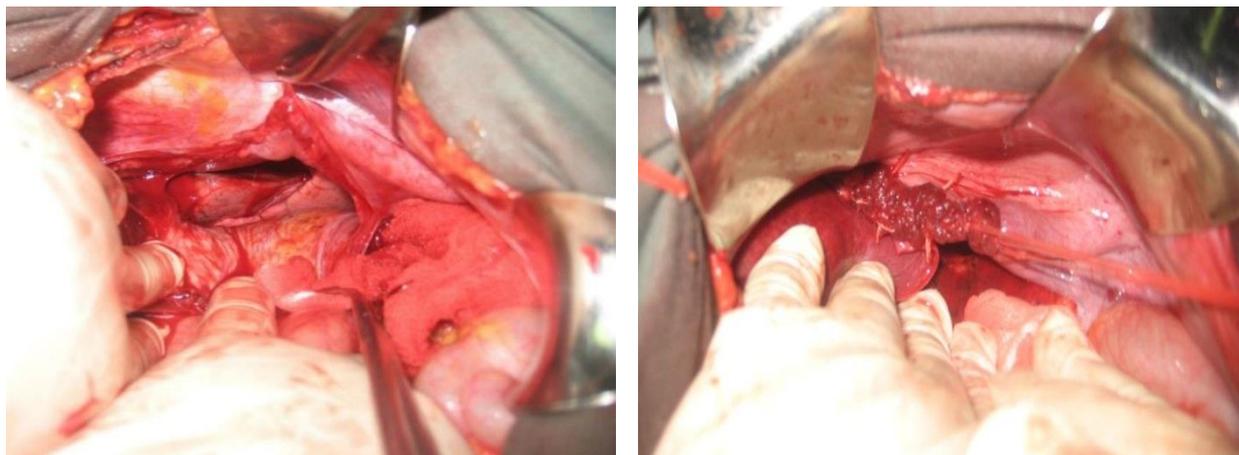


Figure 7: Sewing of the diaphragm defect by laparotomic access.

Thus, in our observations, in 18 (29.0%) patients, according to the results of thoracoscopy, surgeons considered it possible to suture the diaphragm defect by transthoracic access, including 10 (16.1%) patients who were able to perform thoracoscopic suturing (Table 7). In another case, laparoscopic suturing of a diaphragmatic rupture was performed.

Table 7: Surgical approach to suturing a diaphragm defect, n=62.

Surgical access	abs.	%
Laparotomy suturing	43	69,4
Thoracoscopic suturing	10	16,1
Thoracotomy suturing	8	12,9
Laparoscopic suturing	1	1,6

The use of videoendosurgical techniques at the stages of surgical treatment of patients with closed injuries of the diaphragm, in addition to solving diagnostic problems and endoscopic suturing of diaphragm defects, in some cases makes it possible to eliminate intracavitary complications of trauma in a minimally invasive way (Table 8). In particular, the therapeutic possibilities of thoracoscopy and laparoscopy are most well manifested in bleeding from superficial ruptures of the liver (endosurgical hemostasis was successful in 6 (33.3%) patients with this complication), from the intercostal arteries and the wound channel of the abdominal wall (9; 34.6%), removal of a clotted hemothorax (20; 95.2%), suturing of a lung lesion (5; 33.3%), it is always possible to adequately sanitize and drain the pleural and abdominal cavity.

Table 8: The nature of surgical procedures performed at the thoracic and abdominal stages of the intervention.

Surgical procedure	Surgical access, abs. (%)			
	Thoracoscopy	Thoracotomy	Laparoscopy	Laparotomy
Coagulation/suturing of liver rupture, n=18	-	1 (5,6)	6 (33,3)	11 (61,1)
Splenectomy, n=17	-	-	-	17 (100)
Closure of a hollow organ, n=9	-	-	-	9 (100)
Bladder closure, n=3				3* (100)
Suturing and/or coagulation of a bleeding vessel, n=26	7 (26,9)	17 (65,4)	2 (7,7)	-
Removal of clotted hemothorax, n=21	20 (95,2)	1 (4,8)	-	-
Lung lesion suturing, n=15	5 (33,3)	10 (66,7)	-	-
Sanitation and drainage of the pleural and/or abdominal cavity, n=62/61**	49 (79,0)	13 (21,0)	13 (21,3)	48 (78,7)

* - In one case, the extraperitoneal part of the bladder was sutured by suprapubic access after completion of diagnostic laparoscopy.

** - In one case, the revision of the right subdiaphragmatic space and coagulation of the liver rupture was performed through a diaphragm defect during thoracotomy without subsequent abdominal intervention.

In cases where it was possible to limit the use of endovideosurgical techniques in both adjacent cavities, both specific and nonspecific postoperative complications developed much less frequently (Table 9). Thus, in the group of endosurgical interventions in the early postoperative period, only one case of intrapleural bleeding from the intercostal arteries, which required thoracotomy, and one case of pneumonia, were noted,

while in the groups of hybrid and open interventions, the frequency of specific complications exceeded 2 times, and nonspecific - 4.8-7.0 times. In the victims, in whom it was possible to successfully apply the treatment and diagnostic capabilities of thoracoscopy and laparoscopy in both adjacent cavities, we did not note a lethal outcome. At the same time, in the group of patients in whom surgeons were forced to resort to open

interventions, the mortality rate ranges from 26.2% (with hybrid interventions) to 40.0% (with open operations in both cavities).

Table 9: The nature and frequency of postoperative complications depend on surgical access to adjacent cavities in patients with diaphragmatic ruptures.

The nature of the complication	The number of complications, abs. (%)		
	Endosurgical e, n=10	Hybrid, n=42	Open, n=10
Specific complications			
Suppuration of the wound	-	4 (9,5)	1
Pleural empyema	-	3 (7,1)	1
Bleeding	1	1 (2,4)	-
Peritonitis	-	1 (2,4)	-
Total	1 (10)	9 (21,4)	2 (20)
Non-specific complications			
Pneumonia	1	8 (19,0)	2
Pulmonary embolism		1 (2,4)	1
Uncontrolled shock, ACF (Acute Cardiovascular Failure)		10 (23,8)	4
AMI		1 (2,4)	
Total	1	20 (47,6)	7
Died		11 (26,2)	4 (40)

CONCLUSION

In the structure of the causes of closed injuries of the diaphragm, highly kinetic types of injuries predominate - road accidents (77.4%) and high-altitude injury (17.7%). Diaphragmatic ruptures are characterized by a high frequency (98.4%) of multiple and combined injuries of various organs and systems, among which fractures of the ribs (77.4%) and other bones of the skeleton (56.5%) prevail, as well as TBI (54.8%). X-ray sign of diaphragm rupture (viscerothorax) is detected only in 45.2% of the victims. The expansion of indications for MSCT of the chest and abdomen, emergency video thoracoscopy, and video laparoscopy contribute to the timely diagnosis of diaphragm injuries. The use of endovideosurgical technique at the stages of surgical treatment in patients with closed diaphragm injuries in 83.9% of cases reduces the number of wide surgical approaches, which favorably affects the course of the postoperative period and the outcome of the disease.

diaphragm). The Bulletin of Emergency Medicine, Tashkent, 2014; 4: 5-8.

REFERENCES

1. Abakumov MM, Lebedev NV, Malyarchuk VI. (Abdominal injuries in combined trauma). Mosk Meditsina, Moscow, 2005; p. 176.
2. Aliev SA, Bairamov NYu, Aliev ES. (Features of diagnostics and tactics of surgical treatment of ruptures of the diaphragm in closed combined trauma of the chest and abdomen). Vestn khir im. Grekova Moscow, 2014; 173(4): 66-72.
3. Kubachev KG, Kukushkin AV. (Diaphragm injuries in open and closed thoracoabdominal trauma). Siberian Medical Journal Irkutsk, 2009; 91(8): 145-149.
4. Florikyan AK, (Surgery of breast injuries). Kharkov Osnova, 1998; 437.
5. Khadjibayev AM, Altyev BK, Shukurov BI, Kuchkarov OO. (Surgical tactics for ruptures of the