

Retrospective analysis of 103 diaphragmatic injuries in patients operated in a trauma center

Análise retrospectiva de 103 casos de lesão diafragmática operados em um centro de trauma

LUCAS FIGUEIREDO CARDOSO²; MARCUS VINÍCIUS CAPANEMA GONÇALVES²; CARLA JORGE MACHADO¹; VIVIAN RESENDE, TCBC-MG¹; MICHAEL PEREIRA FERNANDES²; MARIO PASTORE-NETO²; RENATO GOMES CAMPANATI¹; GUILHERME VICTOR OLIVEIRA PIMENTA REIS¹

ABSTRACT

Objective: to analyze the factors associated with death in patients with diaphragmatic injury treated at a trauma reference hospital. **Methods:** we conducted a retrospective study of patients with diaphragm injury attended at the Risoleta Tolentino Neves Hospital of the Federal University of Minas Gerais, between January 2010 and December 2014. We used The Collector® database of trauma records (MD, USA). We gathered data on demographics, location of the diaphragmatic lesion, site and number of associated lesions, type of therapeutic approach, complications and Injury Severity Score (ISS). The variable of interest was the occurrence of death. **Results:** we identified 103 patients and mortality was 16.5%. Penetrating lesions occurred in 98% of patients. Univariate analysis showed a mortality higher in patients whose treatment was non-operative, without closing of the defect ($p=0.023$), and lower in patients submitted to diaphragmatic suturing ($p<0.001$). The increase in the number of lesions was associated with an increase in mortality ($p=0.048$). In multivariate analysis, $ISS>24$ ($OR=4.0$, $p=0.029$) and diaphragmatic suturing ($OR=0.76$, $p<0.001$) were associated with mortality. **Conclusion:** The findings indicate that the traumatic rupture of the diaphragm rarely presents as an isolated lesion, being frequently associated with injuries of other organs, especially the liver and hollow viscera. Mortality was higher among those with $ISS>24$.

Keywords: Diaphragm. Wounds and Injuries. Death.

INTRODUCTION

Traumatic rupture of the diaphragm is present in 1% to 7% of victims of blunt thoraco-abdominal trauma and in 10% to 15% of patients with penetrating trauma. However, the true incidence is unknown due to the presence of undiagnosed lesions¹⁻³. In blunt trauma, there is a sudden increase in abdominal pressure that may lead to rupture of the muscular or membranous portion of the diaphragm, especially when the trauma is associated with great impact energy²⁻⁵. Most of these lesions occur in the posterolateral aspect of the left side, an area of weakness originating from the pleuroperitoneal membrane. The right side is more resistant and is partially protected by the liver^{1,4,6}. Penetrating injuries may occur by stabbing or gunshot wounds⁷. High-velocity projectiles determine wide, lateral shock waves and temporary cavities, which are sometimes difficult to perceive externally⁸.

All thoracic-abdominal penetrating lesions are at increased risk for diaphragmatic rupture^{1,4}. These tend to be smaller, potentially more dangerous because of the risk of going unnoticed and progressing with diaphragmatic hernia and strangulation in a later stage. Larger ruptures are more likely to result in intra-abdominal organs herniating into the thorax in the acute phase, and the diagnosis is easier both on the left and on the right due to the possibility of following the lesion trajectory and the observation of contiguous lesions^{6,9}.

In trauma acute phase, the clinical examination hardly contributes to the diagnosis, and the injury can easily go unnoticed in the primary evaluation, at a frequency ranging from 7% to 66%^{2,5,6,10}. Computed tomography with multidetectors (MDCT) is the method of choice for stable patients and has sensitivity and specificity of 87% and 72 to 100%, respectively, being more sensitive for detection on the left side¹¹. The visualization of the diaphragm discontinuity depends on the contrast with

1 - Federal University of Minas Gerais, Belo Horizonte, Minas Gerais State, Brazil. 2 - Risoleta Tolentino Neves Hospital, Belo Horizonte, Minas Gerais State, Brazil.

the adipose tissue, being more difficult on the right side, since the liver is iso-attenuating with the diaphragm⁸. The current tendency regarding the nonoperative treatment of intra-abdominal organs blunt lesions can result in a greater diagnosis delay, the diagnosis by imaging being essential to guarantee adequate surgical repair^{2,6}.

Due to the high incidence of associated intra-abdominal lesions, the primary approach is preferably performed by laparotomy, which is a gold standard for the identification of diaphragmatic injuries after penetrating trauma^{5,12}. Thoracoscopy has been proposed as a safe method for evaluating the diaphragm when the diagnosis has not been confirmed and laparotomy is not necessary, with sensitivity and specificity close to 100%, the limiting factors being the presence of hemodynamic instability and the need for general anesthesia⁹.

The prognosis of diaphragmatic traumatic rupture is generally good with immediate treatment, but late diagnosis is associated with increased morbidity and mortality, due to herniation of intra-abdominal organs to the chest and strangulation, with respiratory compromise and death ranging from 30 to 60%^{4,6,9}.

The objective of this study was to identify the injuries related to traumatic rupture of the diaphragm and the factors associated with mortality in patients attended at a trauma reference hospital in Belo Horizonte, Minas Gerais, Brazil, over a period of five years.

METHODS

This is a retrospective, case-series, descriptive and analytical study. We searched the trauma records database (Collector®, MD, USA) of the Risoleta Tolentino Neves Hospital to identify patients diagnosed with traumatic diaphragmatic injury admitted between January 1, 2010 and December 31, 2014. The Risoleta Tolentino Neves Hospital is a tertiary center of reference in emergency and trauma surgery in the city of Belo Horizonte (MG).

The diagnosis was based on the data obtained after the surgical procedure. Information on sex and age, location of the diaphragmatic injuries (right, left, bilateral), associated lesions (liver, spleen or hollow viscus), number of associated lesions (none, one, two, three or more), type of

therapeutic approach (chest drainage, transdiaphragmatic lavage, suturing, nonoperative treatment) and complications (empyema, pneumonia). We used the Injury Severity Score (ISS) with cutoff of 25, above which we considered the trauma to be severe or very severe. The outcome response of interest was the occurrence of death. For univariate analysis, we computed averages and proportions and used the Student's t-test, Chi-square test and Fisher's test. To identify predictive factors for the patients' outcome, we used the factors that were significant at a level of 10% ($p < 0.10$) in the univariate analysis. Such factors then formed an initial multivariate model, in which we sequentially excluded the factors whose level of significance were not below 5% ($p < 0.05$) at the Wald test. The multiple binary logistic regression analysis used was the one with penalized likelihood, as has already been used in other studies in the area of trauma surgery. In the regression analysis, we reported 95% confidence intervals. We analyzed the data with the Stata for Mac software, version 12.

The study was approved by the Ethics in Research Committee of UFMG and Risoleta Tolentino Neves Hospital and submitted to Plataforma Brasil (CAAE: 44349515.5.0000.5149).

RESULTS

We analyzed 103 patient records in which the presence of traumatic diaphragm injury was identified between January 2010 and December 2014, of which 93 (90.3%) were male, aged 15 to 58 years (mean and median of 28.3 and 26, respectively, and standard deviation, 25th and 75th percentiles 9.9, 20 and 35, respectively). The trauma mechanism was predominantly penetrating ($n=101$; 98.1%), being blunt in only two cases (1.9%). The diaphragmatic injuries were on the left, on the right and bilateral in 56 (54.4%), 39 (37.9%) and seven (6.7%) patients, respectively. In only two cases (1.9%), the diaphragmatic lesion was isolated, being more commonly associated with injuries of one or more organs (Tables 1 and 2). The mean and median ISS were 18.8 and 18, respectively, and the standard deviation, 25th and 75th percentiles were equal to 6.7, 13 and 25, respectively. The ISS ranged from a minimum of eight to a maximum of 36.

Table 1. Presence of multiple injuries associated with diaphragmatic injury.

Number of associated injuries	Number and percentage (%) of patients
0	2 (1.9)
1	54 (52.4)
2	39 (37.9)
3 or more	8 (7.8)

Regarding the approach, 86 (83.5%) patients had the diaphragmatic lesion sutured versus 13 (12.6%) who did not have the lesion repaired, due either to lack of identification or to a damage control context. Four patients (3.9%) died during surgery. Only one patient who did not undergo diaphragmatic repair needed to be reopened on the fifth postoperative day due to a thoraco-biliary fistula. Thoracic drainage was performed in 82 patients (79.6%), and transdiaphragmatic pleural lavage, in 13 (12.6%). The complications identified were pneumonia (n=8, 7.8%), empyema (n=5, 4.9%) and thoraco-biliary fistula (n=1, 0.9%). There were 17 deaths in the period (16.5%).

Table 3 shows the univariate analysis and indicates the percentage of survivors and deaths of patients according to each characteristic evaluated. The highest number of lesions was associated with higher mortality, and the percentage of deaths among those without lesions was nil. We observed that the mortality gradually increased with the increase in the number of lesions and among those with three or more lesions, it reached 37.5%. Mortality was lower among patients who underwent diaphragm suturing ($p < 0.001$) and higher among those who did not ($p = 0.023$). Finally, mortality was higher among patients with ISS equal to or higher than 25 ($p = 0.058$), although with a threshold significance ($p < 0.10$) (Table 3).

The final model found that there was a negative and independent association between death and having undergone diaphragmatic repair (OR=0.76, 95% CI 0.67-0.87, $p < 0.001$). The ISS was equal to or higher than 25 as an independent risk factor associated with death (OR=4.02, 95% CI, 1.15-14.0, $p = 0.029$).

Table 2. Associated Injuries.

Organ	Number and percentage (%) of patients
Liver	58 (56.3)
Spleen	33 (32.0)
Hollow viscera (stomach, intestine, colon)	65 (63.1)

DISCUSSION

In the present study, the mortality of patients with diaphragmatic lesions was 16.5%, 15.8% of which were patients with penetrating trauma. Penetrating trauma accounted for more than 98% of the sample. One can cite, as possible reasons for this high proportion of penetrating trauma, the high frequency of undiagnosed diaphragmatic lesions and the increasing mortality rate related to firearm injuries in our country¹³⁻¹⁵.

The findings on mortality are in agreement with other studies evaluating blunt and penetrating trauma, which found incidence of death varying from 7.8% to 32.1%^{3,4,16-19}. These same studies found mortalities ranging from 4% to 20.1% for penetrating trauma^{3,4,16,17,19}.

As observed in other studies^{4,7,16,17}, mortality was also associated with the presence of associated lesions. We observed a clear and sustained dose-response relationship in the univariate analysis: when there was no other lesion associated with the diaphragmatic one, mortality was zero, increasing to 11.1% (one lesion), 20.5% (two lesions) and 37.5% (three or more lesions). However, in the multivariate analysis, we observed no independent effect of the number of lesions, and this result is not surprising, since, in the presence of ISS equal to or greater than 25 – an indicator of severe or very severe trauma¹³ – injuries would not be expected to have an independent effect on death.

Fair *et al.*⁴ identified 3,773 patients with traumatic diaphragmatic injuries in the year 2012, after analyzing 833,309 records from the National Trauma Database of the American College of Surgeons (NTDB). They observed

Table 3. Outcome-related factors of patients with diaphragmatic injury.

	Survivors	Deaths	Total	p value
Age (average; standard deviation)	27.6 (9.2)	31.8 (12.4)	28.3 (9.9)	0.199
Gender (n, %)				
Male	78 (83.9)	15 (16.1)	93 (100.0)	0.069
Female	8 (80.0)	2 (20.0)	10 (100.0)	
Trauma (n, %)				
Blunt	1 (50.0)	1 (50.0)	2 (100.0)	0.304
Penetrating	85 (84.2)	16 (15.8)	101 (100.0)	
Side (n, %)				
Left	47 (83.9)	9 (16.1)	56 (100.0)	0.999
Right	32 (82.0)	7 (18.0)	39 (100.0)	
Bilateral	6 (85.3)	1 (14.3)	7 (100.0)	
Injury associated with (n, %)*				
Liver	46 (79.3)	12 (20.7)	58 (100.0)	0.151
Spleen	33 (81.8)	6 (18.2)	33 (100.0)	0.753
Hollow viscera	52 (80.0)	13 (20.0)	65 (100.0)	0.165
Number of associated lesions (n, %)				
No	2 (100.0)	0 (0.0)	2	0.048
1	48 (88.9)	6 (11.1)	54	
2	31 (79.5)	8 (20.5)	39	
3	5 (62.5)	3 (37.5)	8	
Type of treatment				
Suture	79 (90.8)	8 (9.2)	87 (100.0)	<0.001
No suture	8 (61.5)	5 (38.5)	13 (100.0)	0.023
Thoracic drainage	69 (84.1)	13 (15.9)	82 (100.0)	0.473
LPT**	11 (84.6)	2 (15.4)	13 (100.0)	0.999
ISS (average; standard deviation)	18.4 (6.3)	20.7 (8.1)	18.8 (6.7)	0.133
ISS > 24 (n, %)	21 (72.4)	8 (27.6)	29 (100.0)	0.058
Complications (n, %) ⁵				
Pneumonia	8 (100.0)	0 (0.0)	8 (100.0)	0.223
Empyema	5 (100.0)	0 (0.0)	5 (100.0)	0.588

* p values calculated on the basis of a comparison of patients with each injury/treatment/ISS/complication with patients without that (a) injury/treatment/ISS/specific complication;

**Transdiaphragmatic pleural lavage

that patients with blunt trauma had a greater association of injuries in the thoracic aorta, lungs, spleen and bladder, whereas in penetrating trauma there was a greater frequency of lesions of hollow viscera, hemothorax, pancreas and liver. In the present study, the data of mostly penetrating traumas are concordant with these findings, since the majority were hollow viscera and liver.

Since nonoperative treatment of blunt or penetrating thoraco-abdominal injuries has increased, there is evidence that the additional use of techniques such as laparoscopy and thoracoscopy is necessary to prevent important lesions from go unnoticed^{4,19,17}. Currently, the idea that laparoscopy is associated with an increased risk of complications is considered outdated, since exploratory laparoscopy can avoid delays in more resolute treatments²⁰.

Once the diagnosis has been made, the nonoperative approach to diaphragmatic rupture is not recommended. Surgical treatment can be done by laparotomy, thoracotomy or by the combination of both, traditionally with the use of non-absorbable sutures^{9,16,19,21}. The surgical correction of a diaphragmatic rupture is simple if performed immediately, this being the main justification for the operative approach.

However, there is controversy. Experimental animal studies have observed the occurrence of spontaneous scarring in a percentage of diaphragmatic injuries, especially when small and located on the right side²². Nevertheless, in our univariate analysis, mortality was significantly associated with cases without diaphragmatic suture repair, higher (38.5%) than the

one in repaired cases (9.2%), thoracic drainage (15.9%), and transdiaphragmatic pleural lavage (15.4%). In the multivariate analysis, diaphragm suturing was an independent predictor of survival, and mortality among those undergoing suturing was 24% lower than among those without it (OR=0.76), regardless of whether the trauma was severe or not. Perhaps in this finding lies the greatest contribution of the present study.

Despite the evidence contained in the data presented, we advise caution. This study does not allow inferring if suturing the diaphragm or not implies lower mortality and morbidity, because as the diaphragmatic injury itself is not the cause of death, this cause is much related to the number of visceral lesions. The diaphragmatic injury in the acute phase cannot by itself be considered a cause of death, whether sutured or not.

As limitations to this work, we can mention that it is a retrospective analysis, with a database based only on records coming from the surgical act, therefore not contemplating patients submitted to nonoperative treatment. The small number of cases in which transdiaphragmatic pleural lavage was performed also did not allow for a relevant association with the outcome or other possible complications, and further studies are needed to establish its importance in cases of diaphragmatic injuries associated with gastro-biliary-enteric contamination.

We conclude that the traumatic rupture of the diaphragm rarely presents as an isolated lesion, being commonly associated with injuries in other organs, mainly liver and hollow viscera. Mortality was higher among those with ISS equal to or higher than 25.

R E S U M O

Objetivo: analisar os fatores associados ao óbito em pacientes com lesão diafragmática atendidos em hospital de referência para o trauma. **Métodos:** estudo retrospectivo de pacientes com lesão do diafragma atendidos no Hospital Risoleta Tolentino Neves da Universidade Federal de Minas Gerais entre janeiro de 2010 e dezembro de 2014. Foi utilizado o Banco de Registros de Trauma *Collector*® (MD, USA). Utilizaram-se dados demográficos, localização da lesão diafragmática, lesões associadas de outros órgãos, número de lesões associadas, tipo de abordagem terapêutica, complicações e o escore de gravidade *Injury Severity Score* (ISS). A variável de interesse foi a ocorrência de óbito. **Resultados:** foram identificados 103 pacientes e a incidência de óbito foi de 16,5%. Lesões penetrantes ocorreram em 98% dos pacientes. Em análise univariada a mortalidade foi maior em pacientes cujo tratamento foi não operatório, sem rafia (p=0,023), e menor em pacientes submetidos à rafia diafragmática (p<0,001). O aumento do número de lesões associou-se ao aumento da incidência de óbitos (p=0,048). Em análise multivariada, ISS>24 (OR=4,0; p=0,029) e rafia do diafragma (OR=0,76; p<0,001) associaram-se à mortalidade. **Conclusão:** os achados indicam que a ruptura traumática do diafragma raramente se apresenta como lesão isolada, estando associada frequentemente à lesão de outros órgãos, especialmente fígado e vísceras ocas. Pode-se afirmar que a mortalidade foi mais elevada entre aqueles com ISS>24.

Descritores: Diafragma. Ferimentos e Lesões. Morte.

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Mailing address:

Carla Jorge Machado

E-mail: carlajmachado@gmail.com / carlajm@ufmg.br