

Predictive Factors for Evaluation Diaphragm Injuries Following Left-sided Thoraco-abdominal Penetrating Wounds in Maharat Nakhon Ratchasima Hospital

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Abstract

Background: Diaphragmatic injuries occur in 3% to 5% of patients with penetrating chest traumas. Diagnosing diaphragmatic injuries is difficult based on physical examination and investigation unless obvious signs and symptoms are present. Diagnostic Laparoscopy (DL) is an efficient technique to diagnose and treat diaphragm injuries at the early stage among hemodynamically stable patients. Routine laparotomy for every penetrating thoracoabdominal wound increases the negative laparotomy rate (5% - 40%), leading to more complications, longer hospital stays, and increased costs. Although DL diminishes the negative laparotomy rate, there are some complications. However, laparoscopic intervention is needed to prevent morbidity from unnecessary operations and negative operative findings.

Objectives: The purpose of this study was to determine the predictive factors to evaluate the left diaphragm injuries undergone by Diagnostic Laparoscopy at Maharat Nakhon Ratchasima Hospital (MNRH) and to discuss the outcomes of the findings between patients with diaphragm injuries and patients without diaphragm injuries

Materials and Methods: This Prospective study was conducted among the patients with left-sided thoracoabdominal penetrating wounds admitted to the MNRH from January 1, 2021, to January 31, 2023. The primary outcome of the study was predictive factors of diaphragmatic injuries. The secondary outcome was the length of stays. Stata/SE v11.1 would analyze all data. Chi-square was used to describe predictive factors between the two groups. *P* value less than 0.05 would be considered the statistical significance.

Results: The total of 52 patients were included. Six individuals (11.53%) had diaphragm injuries. The locations of the injuries below ICS 7th had significant predictive factors of diaphragm injuries, with the odds ratio of 8.73 (95% CI 1.02, 74.95) *p* = 0.048. The length of stay of the two groups had no significant differences between 5.51 ± 11.19 days in normal and 12.93 ± 26.91 days in diaphragm injuries (95% CI 0.98, 1.05), *p* = 0.519. There were no significant predictive factors of gender, age, mechanism, CXR, FAST, and multiple sites of injuries.

Conclusion: The locations of injuries below ICS 7th had significant predictive factors of diaphragm injuries. The study limitations were the small population size and the high percentage of unfavorable intraabdominal results. The length of stay of the two groups had no significant differences, similar to other factors.

Keywords: Diagnostic laparoscopy, Penetrating thoracoabdominal injury, Diaphragm injury

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INTRODUCTION

Injuries to the diaphragm occur in 3% to 5% of patients who sustain penetrating chest trauma.^{1,2} Early diagnosis of diaphragm injury is difficult based on physical examination and imaging modalities unless obvious signs and symptoms are present.³⁻⁵ Delayed diagnosis and treatment may lead to a diaphragmatic hernia that may cause morbidity or even death.¹ Diagnostic Laparoscopy (DL) is an efficient technique to diagnose and treat diaphragm injury at early stage⁶ in hemodynamically stable patients.⁷

Routine laparotomy in penetrating thoracoabdominal wounds increases the negative laparotomy rate (5% - 40%), leading to longer hospital stays, more complications, and increased costs.⁸ Although DL diminishes the negative laparotomy rate, there are still some complications.^{9,10} However, individual decision-making for laparoscopic intervention is needed to prevent the morbidity of an unnecessary operation under an emergent setting due to high rates of negative intraabdominal findings.^{9,11} This study aimed to establish the predictive factor for evaluating left diaphragm injuries following left-sided thoracoabdominal penetrating wounds. It may help to reduce negative-non therapeutic exploration/laparoscopy and preventable complications from diagnostic laparoscopy for stable patients in Maharat Nakhon Ratchasima Hospital.

Practice Management Guideline from the Eastern Association for the Surgery of Trauma recommends for evaluation and management of traumatic diaphragmatic injuries (TDI) (2018)¹²; recommendations were made in favor of laparoscopy over computed tomography for diagnosis, nonoperative versus operative approach for right-sided penetrating injuries, abdominal versus thoracic approach for acute TDI, and laparoscopy (with the appropriate skill set and resources) versus open approach for isolated TDI. No recommendation could be made for the preferred operative approach for delayed.¹²

Correlate with Prospective Evaluation of Laparoscopy in Penetrating Injuries to the Left Lower Chest for Occult Injuries to the Diaphragm (1998), The incidence of occult diaphragmatic injuries in penetrating trauma to the left lower chest is high, 24%. These injuries are associated with a lack of clinical and radiographic findings and would have been missed had laparoscopy not been performed.³ Patients with penetrating trauma

to the left lower chest with no other indication for a celiotomy should undergo a videoscopic evaluation of the left hemidiaphragm to exclude an occult injury.¹³

A retrospective review indication for Using Video-Assisted Thoracoscopic Surgery (VATS) to diagnose Diaphragmatic Injuries (DI) After Penetrating Chest Trauma studied all patients undergoing VATS after penetrating chest trauma at a level 1 trauma center over an 8-year. The diagnostic algorithm was made by if history or physical examination identifies two or more independent predictors of DI (≥ 2 in the algorithm) should undergo VATS to evaluate the hemidiaphragm. Independent predictors of DI are abnormal CXR, associated abdominal injury, high-velocity injury, inferior to nipple line, and right-side wound.²

MATERIALS AND METHODS

This prospective study was conducted in patients with left-sided thoracoabdominal penetrating wounds admitted to Maharat Nakhon Ratchasima Hospital, the 1200-bed tertiary hospital in the Northeast of Thailand with a general surgery residency training program, from January 1, 2021 to January 31, 2023.

The study collected data from electronic medical records and was approved by the Institutional Review Board. All patients met the criteria of being more than 15 years old with hemodynamic stability and no sign of peritonitis, diagnosed with left-sided thoracoabdominal penetrating injuries, and had undergone diagnostic laparoscopic surgery at Maharat Nakhon Ratchasima Hospital. Patients who had a blunt thoracoabdominal injury, hemodynamic unstable, peritonitis, and undergone other surgery were excluded from our study. The following data were collected: age, sex, mechanism of injury, location of the wound, chest X-ray finding as normal or abnormal, FAST/EFAST as normal or abnormal, associated injuries, and length of hospital stay. Patients presented with left-sided thoracoabdominal penetrating wounds who had left diaphragm injuries were assigned to the cases group. Patients who presented with left-sided thoracoabdominal penetrating wounds and did not have left diaphragm injuries were assigned to the control group. The primary outcome of the study was predictive factors of diaphragmatic injuries. The secondary outcome was the length of stays between the two groups.

STATISTICAL ANALYSIS

All data would be analyzed by Stata/SE v11.1. Continuous variables will be presented as mean, SD, median, and IQR where appropriate. Categorical variables will be presented as numbers and percentages. Univariate and multivariate logistic regression were used. Chi-square was used to describe predictive factors between the two groups. Fisher's exact test was used to describe p-value less than 0.05 would be considered as the statistical significance.

RESULTS

From the method of our study, a total of 52 patients were included and received treatment at Maharat Nakhon Ratchasima Hospital. There were 6 individuals (11.53%) who had diaphragm injuries. (5 male patients and 1 female patient). Patients' characteristics were studied and reported in Table 1.

Table 1 Patient characteristics

Variables	Normal (n = 46)	Diaphragm injury (n = 6)	Total (n = 52)	p-value
Gender (n %)				
Male	44 (95.65)	5 (83.33)	49 (94.23)	0.588
Female	2 (4.35)	1 (16.67)	3 (5.77)	
Age (n %)				
< 29 y	11 (23.91)	3 (50.00)	14 (26.92)	1.000
≥ 29 y	35 (76.09)	3 (50.00)	38 (73.08)	
LOS (n %)				
< 14 days	44 (95.66)	5 (83.33)	50 (96.15)	0.448
≥ 14 days	2 (4.34)	1 (16.67)	2 (3.85)	
Mechanism (n %)				
Stab	42 (91.30)	6 (100)	48 (92.31)	0.456
GSW	4 (8.70)	0 (0.00)	4 (7.69)	
Weapon (n %)				
Knife	39 (84.78)	6 (100.00)	45 (86.54)	0.355
Gun	4 (8.70)	0 (0.00)	4 (7.69)	
Other	3 (6.52)	0 (0.00)	3 (5.77)	

There were no statistically significant differences in baseline characteristics between the two groups, indicating that the patient characteristics of the entire study population were not variables that would affect the primary and secondary outcomes.

The majority of the injuries discovered were caused by stabbing (92.31%), with knives accounting for 86.54% of the stabbing mechanism and other close objects such as iron, wood, glass bottles, darts, and other sharp objects. Another 7.69% were shot with a gun. The injuries were caused by physical assault, accidents, self-harm, and

traffic accidents, in that order.

We found that the location of injuries below ICS 7th was significant for diaphragmatic injury ($p < 0.027$). Positive FAST has the risk of diaphragmatic injury ($p < 0.017$).

The LOS of patients without diaphragmatic injury was significantly shorter than that of diaphragmatic injury (5.51 ± 11.19 day and 12.93 ± 26.91 day for $p = 0.830$) but had no statistical significance. However, other factors had no statistically different (Table 2).

Table 2 Univariable logistic regression for predictive factor

Variables	Normal (n = 46)	Diaphragm injury (n = 6)	Total (n = 52)	Odds ratio	p-value	95% CI
Gender (n %)						
Male	44 (95.65)	5 (83.33)	49 (94.23)	4.43	0.206	0.44, 44.52
Female	2 (4.35)	1 (16.67)	3 (5.77)			
Age (mean ± SD)	32.04 ± 12.42	31.64 ± 12.16	32.01 ± 12/36			
Median Age (IQR)	29 (21-39)	28.5 (23-34)	29 (21.5-39)	0.90	0.903	0.17, 4.74
LOS (mean ± SD)	5.51 ± 1.19	12.93 ± 26.91	6.16 ± 13.33	0.71	0.830	0.03, 17.04
Median LOS (IQR)	3 (2-5)	5.5 (4-7)	4 (2-5.5)			
Mechanism (n %)						
Stab	42 (91.30)	6 (100.00)	48 (92.31)	0.92	0.943	0.08, 9.91
GSW	4 (8.70)	0 (0.00)	4 (7.69)			
CXR (n %)						
Normal	26 (56.52)	2 (33.33)	28 (53.85)	4.16	0.105	0.74, 23.30
Abnormal	20 (43.48)	4 (66.67)	24 (46.15)			
FAST (n %)						
Normal	43 (93.48)	5 (83.33)	48 (92.31)	1.44	0.722	0.19, 10.64
Abnormal	3 (6.52)	1 (16.67)	4 (7.69)			
Location ICS (n%)						
Above ICS 7 th	20 (43.48)	1 (16.67)	21 (40.38)	1.00		
Below ICS 7 th	26 (56.52)	5 (83.33)	31 (59.62)	9.30	0.038*	1.44, 76.27
Location site (n%)						
Anterior	31 (67.39)	5 (83.33)	36 (69.23)	0.50	0.437	0.09, 2.88
Posterior	15 (32.61)	1 (16.67)	16 (30.77)			
Multiples (n%)						
Single	38 (82.61)	5 (83.33)	43 (82.70)	1.12	0.910	0.16, 7.90
Multiple	8 (17.39)	1 (16.67)	9 (17.30)			

However, we need to study which factors are associated with diaphragmatic injury in left penetrating thoracoabdominal injuries, so we used a multivariable survival analysis and regression model that included all of the factors to determine the association for diaphragmatic injury. Especially the location of injuries below ICS 7th was significant for diaphragmatic injury in both univariable and multivariable logistic regression.

The locations of the injuries below ICS 7th had sig-

nificant predictive factors of diaphragm injuries, with the odds ratio of 8.73 (95% CI 1.02, 74.95) $p = 0.048$. After analyzing the data, it was found that gender, age, mechanism of injury, chest X-ray results, Focused Assessment with Sonography for Trauma (FAST) findings, entrance wound location, number of injury sites, and length of hospital stay did not have any significant predictive value (Table 3).

Table 3 Multivariable logistic regression for predictive factor

Variables	Normal (n = 46)	Diaphragm injury (n = 6)	Total (n = 52)	Adjusted Odds ratio	p-value	95% CI
Gender (n %)						
Male	44 (95.65)	5 (83.33)	49 (94.23)	3.62	0.271	0.37, 35.85
Female	2 (4.35)	1 (16.67)	3 (5.77)			
Age (mean ± SD)	32.04 ± 12.42	31.64 ± 12.16	32.01 ± 12/36			
Median Age (IQR)	29 (21-39)	28.5 (23-34)	29 (21.5-39)	0.98	0.515	0.91, 1.05
LOS (mean ± SD)	5.51 ± 1.19	12.93 ± 26.91	6.16 ± 13.33			
Median LOS (IQR)	3 (2-5)	5.5 (4-7)	4 (2-5.5)	1.01	0.519	0.98, 1.05
Mechanism (n %)						
Stab	42 (91.30)	6 (100)	48 (92.31)	0.75	0.813	0.07, 8.07
GSW	4 (8.70)	0 (0)	4 (7.69)			
CXR (n %)						
Normal	26 (56.52)	2 (33.33)	28 (53.85)	3.63	0.136	0.67, 19.70
Abnormal	20 (43.48)	4 (66.67)	24 (46.15)			
FAST (n %)						
Normal	43 (93.48)	5 (83.33)	48 (92.31)	1.35	0.765	0.19, 9.52
Abnormal	3 (6.52)	1 (16.67)	4 (7.69)			
Location ICS (n%)						
Above ICS 7 th	20 (43.48)	1 (16.67)	21 (40.38)	8.73	0.048*	1.02, 74.95
Below ICS 7 th	26 (56.52)	5 (83.33)	31 (59.62)			
Location site (n%)						
Anterior	31 (67.39)	5 (83.33)	36 (69.23)	0.56	0.518	0.09, 3.29
Posterior	15 (32.61)	1 (16.67)	16 (30.77)			
Multiple site (n%)						
Single	38 (82.61)	5 (83.33)	43 (82.70)	1.19	0.861	0.17, 8.47
Multiple	8 (17.39)	1 (16.67)	9 (17.30)			

In the prospective study from 2021 to 2023, of the 52 patients with left-sided thoracoabdominal penetrating wounds, 6 patients had diaphragm injuries. The majority of these injuries were 90% stab wounds and 5% gunshot wounds. The causes of injuries were body assaults, accidents, self-harm, and traffic accidents, respectively. The populations were male 94.23%, female 5.77%. The average age was 32 years old.¹⁴

The 33.33% (2 patients) of cases with diaphragmatic injuries were successfully treated by laparoscopic repair, while 66.67% (4 patients) of cases were converted to exploratory laparotomy. The reason for conversion to lapa-

rotomy was concomitant injury to other intraabdominal organs, e.g., colon (50%), stomach (50%), spleen (25%), omentum (25%), and large diaphragmatic laceration (25%).

DISCUSSION

The location of the injury below the 7th intercostal space was associated with the diaphragm injury: odds ratio 8.73 (95% CI 1.02, 74.95, $p = 0.048$) consistent with a position below ICS 4² and the location of the wound at the 6th-7th intercostal spaces caused a significant injury to the diaphragm.⁴

Patients with left diaphragmatic injuries had a longer hospital stay compared to patients without diaphragmatic injuries, which is not statistically significant.¹⁵

However, it can last longer with the patient's underlying disease, such as cirrhosis, hepatic encephalopathy, or other complications, such as pneumonia and atelectasis.

The use of diagnostic laparoscopic surgery to detect diaphragmatic injuries in 80 patients with thoracoabdominal penetrating injuries, 72.5% of cases had no diaphragmatic injuries and did not require further open abdominal surgery, while 27.5% had a diaphragmatic injury. In this group, open abdominal surgery was performed to evaluate other abdominal injuries. Among patients with diaphragmatic injuries, other organ injuries were 23% of the spleen, 9% of the liver, and 14% of the stomach.^{15,16}

Our study's limitation is an inadequate sample size due to just launching a case series, so some of the data may be different compared to other studies. Moreover, incomplete medical records such as operative technique, site of injury, or size of diaphragmatic defect need to correct and methodically recorded for further study. For the General surgery department of our hospital, we could hopefully obtain more information on a larger sample size and longer period for surveillance to overcome limitations.

CONCLUSION

We recommended a laparoscopic approach for the diagnosis of diaphragmatic injury in left-sided thoracoabdominal penetrating patients, especially below the 7th ICS position, with stable hemodynamics and without peritonitis. This approach may help to reduce negative-non therapeutic exploration/laparoscopy, minimal invasiveness, and the ability to treat diaphragmatic injury. In this research, other organs injury can be found in these penetrating patients, such as the colon, stomach, spleen, and omentum.

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บทคัดย่อ ปัจจัยทำนายการบาดเจ็บต่อกะบังลมจากบาดแผลแทงทะลุในตำแหน่งช่องอกและช่องท้องด้านซ้ายในโรงพยาบาลมหาราชนครราชสีมา

กองศัลปี แวงสันเทียะ, พบ., ปรัชญา อินทร์หมื่นไวย, พบ.

กลุ่มงานศัลยกรรม โรงพยาบาลมหาราชนครราชสีมา

ความเป็นมา: การบาดเจ็บของกะบังลมในผู้ป่วยบาดเจ็บจากบาดแผลแทงทะลุพบได้ร้อยละ 3-5 การวินิจฉัยการบาดเจ็บของกะบังลมจากการตรวจร่างกายหรือการส่งตรวจเพิ่มเติมทำได้ยากหากไม่มีอาการและอาการแสดงของการบาดเจ็บที่ชัดเจน การผ่าตัดส่องกล้องเพื่อการวินิจฉัย (Diagnostic laparoscopy) สามารถวินิจฉัยและให้การรักษารอบการบาดเจ็บของกะบังลมตั้งแต่ระยะแรกในผู้ป่วยที่มีสัญญาณชีพคงที่ การผ่าตัดช่องท้องในผู้ป่วยที่บาดเจ็บจากบาดแผลแทงทะลุบริเวณช่องอกและช่องท้องทุกราย พบว่าให้ผลผ่าตัดเป็นลบได้ถึงร้อยละ 5-40 ทำให้เกิดภาวะแทรกซ้อนมากขึ้น ระยะเวลาอนในโรงพยาบาลเพิ่มขึ้น และเพิ่มค่าใช้จ่ายที่มากขึ้นด้วย ถึงแม้ว่าการผ่าตัดส่องกล้องเพื่อการวินิจฉัยสามารถลดอัตราการผ่าตัดที่ให้ผลลบ แต่ก็ยังอาจเกิดภาวะแทรกซ้อนจากการผ่าตัดได้ อย่างไรก็ตามการผ่าตัดแบบส่องกล้องก็มีความจำเป็นในการป้องกันการบาดเจ็บหรืออันตรายจากการผ่าตัดช่องท้องที่ไม่จำเป็นและการผ่าตัดที่ให้ผลเป็นลบได้

วัตถุประสงค์: เพื่อหาปัจจัยทำนายการบาดเจ็บต่อกะบังลมด้านซ้ายโดยผ่านการผ่าตัดส่องกล้องเพื่อการวินิจฉัยในโรงพยาบาลมหาราชนครราชสีมาและอภิปรายผลที่ได้ระหว่างกลุ่มผู้ป่วยที่มีการบาดเจ็บของกะบังลมและในกลุ่มที่ไม่มีการบาดเจ็บของกะบังลม

วิธีการศึกษา: เป็นการศึกษาแบบไปข้างหน้าในผู้ป่วยที่ได้รับบาดเจ็บแบบแทงทะลุบริเวณช่องอกและช่องท้องด้านซ้ายที่เข้ารับการรักษาที่โรงพยาบาลมหาราชนครราชสีมาระหว่างวันที่ 1 มกราคม 2563 ถึงวันที่ 31 มกราคม 2565 ผลการศึกษาหลักคือปัจจัยทำนายการบาดเจ็บต่อกะบังลมด้านซ้าย ผลการศึกษารองคือระยะเวลาการนอนรักษาตัวในโรงพยาบาล ข้อมูลที่ได้จะถูกวิเคราะห์โดยใช้โปรแกรม Stata/SE v11.1 ใช้ Chi-square อธิบายปัจจัยทำนายระหว่างข้อมูลประชากรสองกลุ่ม โดยกำหนดให้มีความสำคัญทางสถิติเมื่อค่า p -value น้อยกว่า 0.05

ผลการศึกษา: ผู้ป่วยจำนวน 52 รายถูกนำเข้ามาในการศึกษา พบว่า 6 ราย (ร้อยละ 11.53) มีการบาดเจ็บของกะบังลม โดยตำแหน่งการบาดเจ็บที่ต่ำกว่าช่องที่ 7 ของกระดูกซี่โครงเป็นปัจจัยทำนายการบาดเจ็บของกะบังลมที่สำคัญ โดยมีอัตราส่วนความเสี่ยง(ความเชื่อมั่นร้อยละ 95): 8.73 (1.02, 74.95); $p=0.048$ ระยะเวลาการนอนโรงพยาบาลไม่มีความแตกต่างกันระหว่างกลุ่มที่ไม่มีการบาดเจ็บของกะบังลม 5.51 ± 11.19 วัน และ 12.93 ± 26.91 วันในผู้ป่วยที่มีการบาดเจ็บของกะบังลม (ความเชื่อมั่นร้อยละ 95) : 0.98, 1.05; $p=0.519$ ปัจจัยด้านเพศ อายุ กลไกการบาดเจ็บ ผลเอกซเรย์ทรวงอก ผลการตรวจด้วยคลื่นเสียงความถี่สูงของช่องท้อง และจำนวนของบาดแผลไม่มีผลต่อการทำนายการบาดเจ็บของกะบังลม

สรุปผลการศึกษา: ตำแหน่งการบาดเจ็บที่ต่ำกว่าช่องที่ 7 ของกระดูกซี่โครงเป็นปัจจัยทำนายการบาดเจ็บของกะบังลมที่สำคัญ ข้อจำกัดคือประชากรในการศึกษามีขนาดเล็กและมีการบาดเจ็บในช่องท้องที่ไม่พึงประสงค์สูง ระยะเวลาการนอนโรงพยาบาลของทั้งสองกลุ่มและปัจจัยอื่นๆ ไม่มีความแตกต่างกัน

คำสำคัญ: การส่องกล้องเพื่อการวินิจฉัย, การบาดเจ็บช่องอกและช่องท้องแบบแทงทะลุ, การบาดเจ็บของกะบังลม