Annals of R.S.C.B., ISSN:1583-6258, Vol. 26, Issue 1, 2022, Pages. 226 - 235
Received 08 November 2021; Accepted 15 December 2021.

Comparison between 64 Slice CT Scanner and a 256 Slice CT scanner in the Diagnosis of Diaphragmatic Hernia Following Blunt Trauma: a Retrospective Study

Farzana Rahim[1], Nasrullah[2], Allah Rasan[3], Abdul Waheed[4], Sajida Ghilzai[5], Muhammad Khan[6]

1. Farzana Rahim, Consultant Radiologist, Bolan Medical Complex Hospital Quetta Pakistan. email: docfarzanarahim@gmail.com
2. Nasrullah, Senior Registrar Radiology, Sheikh Mohamed Bin Zayed Al Nahyan Institute of Cardiology Quetta Pakistan. email: nasaryaqoob1423@gmail.com
3. Allah Rasan, Assistant Professor Radiology, Jhalawan Medical College Khuzdar Pakistan. email: allahrasanjouher@gmail.com
4. Abdul Waheed, Senior Registrar, Jhalawan Medical College Khuzdar Pakistan. email: abdulwaheed5001@gmail.com
5. Sajida Ghilzai, Consultant Radiologist, Sandeman Provincial Hospital Quetta Pakistan. email: Sajidaghilzai@gmail.com
6. Muhammad Khan, Senior Registrar Radiology, Mekran Medical college Turbat Pakistan. email: mohmmadkhanbaloch@yahoo.com

Corresponding Author: Farzana Rahim, Consultant Radiologist, Bolan Medical Complex Hospital Quetta Pakistan. email: docfarzanarahim@gmail.com

Abstract

Aim: To compare between 64 slice CT scanner and a 256 slice CT scanner in the diagnosis of Diaphragmatic Hernia following Blunt Trauma

Study design: A retrospective comparative study

Place and Duration: This study was conducted at, Bolan Medical Complex Hospital Quetta Pakistan. from March 2020 to March 2021.

Methodology: All the enrolled patients were divided into two groups and preoperatively evaluated with 256 CT scanners and 64 slices CT scanners. Electronic medical records were used for taking information related to demographics, characteristics of injury, and outcomes. The presence or absence of traumatic diaphragm injuries was confirmed after reviewing the operative reports.

Results: Regarding preoperative CT scan, we observed that 61.6% of cases were already detected with CT scan before operative visualization. No significant difference was observed in terms of injury length between the two groups. We observed that only 77 (47.1%) of cases were accurately diagnosed with diaphragmatic injury before operative visualization.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 26, Issue 1, 2022, Pages. 226 - 235
Received 08 November 2021; Accepted 15 December 2021.

Conclusion: Our results concluded that intraoperative diagnosis of traumatic diaphragm injuries is the golden standard for suspected cases of TDI because almost 40% of injuries were not diagnosed preoperatively even with the high-resolution CT.

Keywords: Computed Tomography, diaphragm injury, blunt injury, high-resolution CT

Introduction:

Traumatic diaphragmatic injury is rarely encountered in many regions however it became destructive if not diagnosed accurately. Approximately 3% to 8% of cases of the traumatic diaphragm result from blunt trauma[1]. Approximately 12% to 63% of cases are misdiagnosed on computed tomography [2]. Missed diagnosis at the time of admission is detected when symptoms related to visceral herniation and strangulation are present in patients,however, a 10% mortality ratio has been observed in misdiagnosed patients[1]. The shortage of reliable imaging techniques persuades physicians to recommend operative visualization in suspected cases of traumatic diaphragm injury [3-6]. On contrary, these operative visualizations are highly sensitive. Approximately 60% to 80% of cases of negative diaphragm injury underwent operative visualization[7-9]. There is a high need for cost-effective technology which reduces the risk of unnecessary operations and reduced the mortality ratio. After the injury, CT imaging and plain film are widely used as a radiological assessment. In recent years CT imaging gave poor results in detecting the presence of diaphragm injuries. Many studies reported 14% to 61% sensitivity of CT scans[10-13]. Moreover, these studies reported low diagnostic sensitivity using 4 slices to 32 slice scanners.[12, 14-19] However, 64 slice CT scanner shows better diagnosing sensitivity in many diseases but still results related to traumatic diaphragm injuries are very poor.[20-22] In recent years very limited data has been produced to evaluate the diagnostic accuracy of 256 slices CT scanners in TDI. This advanced technology shows improvement in imaging for the detection of coronary CT angiography due to high resolution and superior image quality.[23, 24] Our study was designed to detect the presence of traumatic diaphragm injuries by using a 64 slice CT scanner and a 256 slice CT scanner. We aimed to target only blunt traumas and evaluate the diagnostic accuracy and sensitivity of both scanners.

Methodology:

This retrospective study was conducted at Bolan Medical Complex Hospital Quetta Pakistan from March 2020 to March 2021 with the collaboration of the trauma department. Permission was taken from the ethical review committee of the institute. All the patients having a traumatic injury and requiring exploratory laparotomy or laparoscopy were recruited. On presentation of trauma, all the patients underwent the evaluation process described by Advanced Trauma Life Support guidelines. In 2019, our hospital upgraded its CT equipment replacing the 64 slice CT scanner. Instead of the old technology, they installed 256 slices of CT scan. All the enrolled patients were divided into two groups and preoperatively evaluated with 256 CT scanners and 64 slices CT scanners. Electronic medical records were used for taking information related to

Annals of R.S.C.B., ISSN:1583-6258, Vol. 26, Issue 1, 2022, Pages. 226 - 235
Received 08 November 2021; Accepted 15 December 2021.

demographics, characteristics of injury, and outcomes. The presence or absence of traumatic diaphragm injuries were confirmed after reviewing the operative reports. We used the American Association for the Surgery of Trauma injury scale for grading the diaphragmatic trauma.[25] The scaling was allocated after evaluation of operative reports given by attending surgeons. In case of missing record of injury length then we graded single deep wound as grade 2 and multiple deep wounds as grade 3. Patients aged >16 years were excluded from the study.

CT imaging obtained at the time of injury was used for preoperative diagnosis of traumatic diaphragm cases. Those reports with an interpretation of ―possible‖ or ―suggestive‖ or ―unable to exclude‖ or identified diaphragmatic injuries were considered as positive diagnoses. However, the examination was identified as negative for the diaphragm if no injury was identified in the reports.

Statistical analysis was performed by using SPSS version 23.0. Median interquartile range and frequency were used for the interpretation of the results. Univariate analysis and Pearson correlation were used for comparing categorical variables. We set a p-value < 0.05 for a statistically significant difference.

Results:

In mentioned timeframe, we observed 900 cases who underwent abdominal surgery with preoperative CT scan. Out of these, we observed a total of 297 cases of diaphragm injuries. Only 120 cases of blunt diaphragmatic injury were reported and included for further analysis. The mean age of patients was observed as 6.5 (3-13 years) in 64 slice CT scanner while in the second group the mean age was reported as 5 years ranging from 2 years to 14 years. The majority were male population (94/120). A total of 103 patients reported hemothorax while 51 reported associated splenic injury. In the group evaluated with 64 slice CT scanner, the severity score of injury was observed as 24. However, no significant differences in use were observed between the two groups in terms of age, gender, associated injuries, and injury severity score (As shown in Table 1). The majority of the patients had an injury to the left hemidiaphragm (57.5%). The 64-slice scanner observed 54.6% cases of left hemidiaphragm while 69.6% cases were detected by using a 256 slice scanner. However, no significant difference was observed between the two groups. Total 61.6% of patients had grade 3 injuries. Regarding preoperative CT scan, we observed that 61.6% were already detected with CT before operative visualization. No significant difference was observed in terms of injury length between the two groups (As shown in Table 2). We observed that only 77 (47.1%) were accurately diagnosed with diaphragmatic injury before operative visualization. The 256- slice scanner accurately observed 56.5% of injuries while 45.5% of injuries were accurately diagnosed with 64 slice scanners (As shown in Table 3). However, no significant difference was observed ($p=0.36$). We observed a significant increase in the ratio of false-positive diagnoses with a 256 slice scanner. On the other side, we observed improved sensitivity and negative predictive value while declined in specificity and

Annals of R.S.C.B., ISSN:1583-6258, Vol. 26, Issue 1, 2022, Pages. 226 - 235
Received 08 November 2021; Accepted 15 December 2021.

positive predictive value was observed in group evaluated with 256- slice scanner (As shown in Table 3 and 4).

Table 1: Demographic and CT patterns of diaphragm injury[25]

Variables	64-slice CT (N= 97)	256-slice CT (N=23)	P-value
Age (years)	6.5 (3-16)	5.0 (2-14)	0.64
Gender			0.34
Female	28 (28.8%)	3 (13%)	
Male	74 (76.2%)	20 (87%)	
Associated injury			
Splenic	42 (43.2%)	9 (39.1%)	0.55
Hemothorax	86 (88.6%)	17 (73.9%)	0.53
Pancreatic	6 (6.1%)	2 (8.7%)	0.43
Traumatic brain injury	8 (8.2%)	2 (8.7%)	0.67
Colon	20 (20.6%)	4 (17.4%)	0.83
Liver	74 (76.2%)	12 (52.2%)	0.64
Small bowel	14 (14.4%)	1 (4.3%)	0.33
Renal	8 (8.2%)	4 (17.4%)	0.069
Gastric	20 (20.6%)	4 (17.4%)	0.83
Severity score of injury	24.0 (14.0-34.0)	23.0 (16.5-41.0)	0.59

Annals of R.S.C.B., ISSN:1583-6258, Vol. 26, Issue 1, 2022, Pages. 226 - 235
Received 08 November 2021; Accepted 15 December 2021.

Table 2: Preoperative CT imaging

Variables	64-slice CT (N=97)	256- slice CT (N=23)	p-value
Laterality of Diaphragm injury			0.43
Bilateral	2 (2%)	0 (0%)	
Right	42 (43.2%)	7 (30.43%)	
Left	53 (54.6%)	16 (69.6%)	
Injury length (cm)	4.0 (2.0-10.0)	5.5 (2.0-8.8)	0.87
Delay in diagnosis	4 (4.12%)	2 (8.7)	0.21
Visceral herniation with initial diagnosis	23 (23.7%)	6 (26.1)	0.36
Diagnosis with X-ray	9 (9.27%)	0	0.19
Visceral herniation with delay in diagnosis	2 (2.06%)	0	0.55
Injury grade			0.65
5	0	0	
4	20 (20.7%)	2 (8.7)	
3	55 (56.7%)	19 (82.6)	
2	18 (18.5%)	0	
1	4 (4.1%)	0	
Diagnosis with preoperative CT	61 (62.8%)	13 (56.5%)	0.36

Annals of R.S.C.B., ISSN:1583-6258, Vol. 26, Issue 1, 2022, Pages. 226 - 235
Received 08 November 2021; Accepted 15 December 2021.

Table 3: Identification of blunt trauma injuries[25]

	True-positive N (%)	False-positive N (%)	True-negative N (%)	False-negative N (%)
256 slice CT (N=23)	1 (4.3)	2 (8.6)	20 (86.9)	0 (0)
64 slice CT (N=97)	4 (4.12)	1(1.03)	88 (90.7)	3 (3)
P- value	0.98	0.001	0.17	0.53

Table 4: Comparative analysis of accuracy, sensitivity, and specificity ratio[25]

	Accuracy	**Sensitivity**	**Specificity**	**NPV**	**PPV**
256 slice CT	91.3%	71.4%	92.8%	97.8%	41.7%
64 slice CT	95.6%	60.9%	98.5%	96.8%	77.8%

Discussion:

In this study, we observed that the 256 slice CT scanner failed to improve the diagnostic sensitivity over the 64-slice. On the other hand, 256-slice CT imaging did not provide a significant negative predictive value compared to 64-slice scans. The need for operative visualization remained constant even after the CT imaging in the evaluation of traumatic diaphragm injury. Furthermore, increased false predictive value has been observed in 256 slice scans along with a significant decline in specificity and positive predictive value. On contrary, the diagnostic accuracy of both scanners remained similar. Overall, the new technology of 256 slides CT does not have much ability to rule out the possibility of suspected diaphragm injury.

For this study, we hypothesized that diagnostic yield would be increased with 256 slice imaging. We hypothesized that we would attain high image quality by using 256 slices of CT as researchers obtained high-quality imaging in coronary artery angiography. However, we also obtained low sensitivity of 71.4%. Our results are comparable with the previous studies which obtained 17% to 67% injury detection sensitivity.[12, 22, 26, 27]We observed that 256 scanners provide better outcomes of blunt injuries when compared with the 64 scanners. We observed

Annals of R.S.C.B., ISSN:1583-6258, Vol. 26, Issue 1, 2022, Pages. 226 - 235
Received 08 November 2021; Accepted 15 December 2021.

several signs to describe TDI including the collar, dependent viscera, and discontinuous diaphragm signs, dangling diaphragm, irregular diaphragm thickness, and diaphragmatic retraction.[28] However, we failed to diagnose focal diaphragm disruptions due to low sensitivity.

Interestingly, on the installation of 256 slices of CT, we observed a high ratio of false-positive diagnosis responses. The high-resolution technology assisted us in the visualization of diaphragm thickness which was not observed previously and treated as a potential injury. Even though the low predictive value of high-resolution technology has not prevented the need for operative exploration for the confirmation of injury type or presence.

In the United States of America majority of the traumatic diaphragm, cases are reported due to penetrating injury[29] however these results are in contradiction to our results. Out of all abdominal injuries, the rate of blunt cases was higher than penetrate injuries (66% vs 32%). The majority of the wounds cause small lacerations in the diaphragm which were unable to detect by radiographs. Previous studies reported that radiograph imaging has low sensitivity (8% to 63%) which causes problems in identification.[7, 16, 25, 26] In our study, we observed 50% sensitivity of 256 slice CT with an overall low detection rate of diaphragm herniation. Past studies reported the successful outcomes of tractography in diagnoses of penetrating trauma.[14, 17, 20] However, we avoid cases of penetrating trauma so unable to validate this point of discussion. With the help of 256 slices of CT, we demonstrated the injury tract which may contribute to diagnostic accuracy. During the duration of trauma intact and surgery timeframe, we did not observe any significant improvement in diagnosing accuracy among all patients.

In past, some studies observed 76% to 100% improved diagnostic sensitivity but these studies were based on retrospective imaging review and need interpretation according to associated diagnostic review bias.[14-21] A study by Leung et al[26] reviewed the prospective imaging retrospectively and observed that 75% of injuries were missed prospectively which were identified in a retrospective review. However, these studies' which observed improved diagnostic sensitivity of CT must be weighed with the potential that increased suspicion for injury may increase the detection rate.

Conclusion:

Our results concluded that intraoperative diagnosis of traumatic diaphragm injuries is the golden standard for suspected cases of TDI because almost 40% of injuries were not diagnosed preoperatively even with the high-resolution CT. Currently, the CT scan abdomen has low sensitivity and is unable to overcome the issue of misdiagnosis and complications.

Conflict of interest

None

Annals of R.S.C.B., ISSN:1583-6258, Vol. 26, Issue 1, 2022, Pages. 226 - 235
Received 08 November 2021; Accepted 15 December 2021.

Funding source

None

Permission

The Permission was taken from the ethical review committee of the institute

References:

1. Murray JA, Weng J, Velmahos GC, Demetriades D. Abdominal approach to chronic diaphragmatic hernias: is it safe? Am Surg 2004; 70:897-900.
2. Nchimi A, Szapiro D, Ghaye B, et al. Helical CT of blunt diaphragmatic rupture. AJR Am J Roentgenol. 2005;184:24-30
3. McDonald AA, Robinson BRH, Alarcon L, Bosarge PL, Dorion H, Haut ER, Juern J, Madbak F, Reddy S, Weiss P, et al . Evaluation and management of traumatic diaphragmatic injuries: A Practice Management Guideline from the Eastern Association for the Surgery of Trauma. J Trauma Acute Care Surg 2018; 85:198-207.
4. Karmy-Jones R, Namias N, Coimbra R, Moore EE, Schreiber M, McIntyre R, Croce M, Livingston DH, Sperry JL, Malhotra AK. Western Trauma Association critical decisions in trauma: penetrating chest trauma. J Trauma Acute Care Surg 2014; 77:994-1002.
5. Martin MJ, Brown CVR, Schatz DV, Alam H, Brasel K, Hauser C, de Moya M, Moore EE, Rowell S, Vercruysse G, et al . Evaluation and management of abdominal stab wounds: a western trauma association critical decisions algorithm. J Trauma Acute Care Surg 2018.
6. Como JJ , Bokhari F , Chiu WC , Duane TM , Holevar MR , Tandoh MA , Ivatury RR , Scalea TM . Practice management guidelines for selective nonoperative management of penetrating abdominal trauma. J Trauma 2010; 68:721-33.
7. Mjoli M, Oosthuizen G, Clarke D Madiha T. Laparoscopy in the diagnosis and repair of diaphragmatic injuries in left-sided penetrating thoracoabdominal trauma. Surg Endosc 2015; 29:747-52.
8. McQuay N, Britt LD. Laparoscopy in the evaluation of penetrating thoracoabdominal trauma. Am Surg 2003; 69:788-91.
9. Powell BS, Magnotti LJ, Schroeppel TJ, Finnell CW, Savage SA, Fischer PE, Fabian TC, Croce MA. Diagnostic laparoscopy for the evaluation of occult diaphragmatic injury following penetrating thoracoabdominal trauma. Injury 2008;39:530-4.doi:10.1016/j.injury.2007.10.020
10. Gelman R, Mirvis SE, Gens D. Diaphragmatic rupture due to blunt trauma: sensitivity of plain chest radiographs. Am J Roentgenol 1991; 156:51-7.
11. Murray JG, Caoili E, Gruden JF, Evans SJ, Halvorsen RA, Mackersie RC. Acute rupture of the diaphragm due to blunt trauma: diagnostic sensitivity and specificity of CT. Am J Roentgenol 1996; 166:1035-9.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 26, Issue 1, 2022, Pages. 226 - 235
Received 08 November 2021; Accepted 15 December 2021.

12. Berardoni NE, Kopelman TR, O'Neill PJ, August DL, Vail SJ, Pieri PG, Pressman MAS, Singer Pressman MA. Use of computed tomography in the initial evaluation of anterior abdominal stab wounds. Am J Surg 2011; 202:690-6. Discussion 5-6.
13. Corbellini C, Costa S, Canini T, Villa R, Contessini Avesani E. Diaphragmatic rupture: A single-institution experience and literature review. Ulus Travma Acil Cerrahi Derg 2017; 23:421-6.
14. Bodanapally UK, Shanmuganathan K, Mirvis SE, Sliker CW, Fleiter TR, Sarada K, Miller LA, Stein DM, Alexander M . MDCT diagnosis of penetrating diaphragm injury. Eur Radiol 2009; 19:1875-81.
15. Chiu WC, Shanmuganathan K, Mirvis SE, Scalea TM. Determining the need for laparotomy in penetrating torso trauma: a prospective study using triple-contrast enhanced abdominopelvic computed tomography. J Trauma 2001; 51:860-9. discussion 8-9.
16. Liu J, Yue WD, Du DY. Multi-slice computed tomography for diagnosis of the combined thoracoabdominal injury. Chin J Traumatol 2015; 18:27-32.
17. Melo ELA, de Menezes MR, Cerri GG. Abdominal gunshot wounds: multi-detector-row CT findings compared with laparotomy—a prospective study. Emerg Radiol 2012; 19:35-41.
18. Stein DM, York GB, Boswell S, Shanmuganathan K, Haan JM, Scalea TM. Accuracy of computed tomography (CT) scan in the detection of penetrating diaphragm injury. J Trauma 2007; 63:538-43.
19. Yucel M, Bas G, Kulalı F, Unal E, Ozpek A, Basak F, Sisik A, Acar A, Alimoglu O . Evaluation of diaphragm in penetrating left thoracoabdominal stab injuries: The role of multislice computed tomography. Injury 2015; 46:1734-7.
20. Dreizin D, Borja MJ, Danton GH, Kadakia K, Caban K, Rivas LA, Munera F . Penetrating diaphragmatic injury: accuracy of 64-section multidetector CT with trajectography. Radiology 2013; 268:729-37.
21. Ilhan M, Bulakci M, Bademler S, Gok AF, Azamat IF, Ertekin C. The diagnostic efficacy of computed tomography in detecting diaphragmatic injury secondary to thoracoabdominal penetrating traumas: a comparison with diagnostic laparoscopy. Ulus Travma Acil Cerrahi Derg 2015; 21:484-90.
22. Kones O , Akarsu C , Dogan H , Okuturlar Y , Dural AC , Karabulut M , Gemici E , Alis H . Is a non-operative approach applicable for penetrating injuries of the left thoracoabdominal region? Turk J Emerg Med 2016; 16:22-5.
23. Chao SP, Leu JG, Law WY, Kuo CJ, Shyu KG. The image quality of 256-slice computed tomography for coronary angiography. Acta Cardiol Sin 2013; 29:444-50.
24. Oda S, Katahira K, Utsunomiya D, Takaoka H, Honda K, Noda K, Oshima S, Yuki H, Namimoto T, Yamashita Y . Improved image quality at 256-slice coronary CT angiography in patients with a high heart rate and coronary artery disease: comparison with 64-slice CT imaging. Acta radiol 2015; 56:1308-14.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 26, Issue 1, 2022, Pages. 226 - 235
Received 08 November 2021; Accepted 15 December 2021.

25. Uhlich R, Kerby JD, Patrick Bosarge P. Diagnosis of diaphragm injuries using modern 256-slice CT scanners: too early to abandon operative exploration. BMJ. 2018; 3(1).
26. Leung VA, Patlas MN, Reid S, Coates A, Nicolaou S. Imaging of Traumatic Diaphragmatic Rupture: Evaluation of Diagnostic Accuracy at a Level 1 Trauma Centre. Can Assoc Radiol J 2015; 66:310-7.
27. Hammer MM, Flagg E, Mellnick VM, Cummings KW, Bhalla S, Raptis CA . Computed tomography of blunt and penetrating diaphragmatic injury: sensitivity and inter-observer agreement of CT Signs. Emerg Radiol 2014; 21:143-9.
28. Desir A, Ghaye B. CT of blunt diaphragmatic rupture. Radiographics 2012; 32:477-98.
29. Fair KA, Gordon NT, Barbosa RR, Rowell SE, Watters JM, Schreiber MA . Traumatic diaphragmatic injury in the American College of Surgeons National Trauma Data Bank: a new examination of a rare diagnosis. Am J Surg 2015; 209:864-9. discussion 8-9