Blunt diaphragmatic rupture

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Abstract

Objective: To identify (1) predictors of outcome in blunt diaphragmatic rupture (BDR), and (2) factors contributing to diagnostic delay.

Methods: We reviewed the charts and radiographs of 41 patients with BDR treated in our Hospital from 1988 to 1997. There were 35 male (85%) and six female, aged 17–71 (mean: 41) years. BDR was left-sided in 24 cases (58%), right-sided in 15 (36%) and bilateral in two (5%).

Results: Two groups of patients can be identified: group A (n = 36, 88%) with acute BDR, and group B (n = 5, 12%) with post-traumatic diaphragmatic hernia (TDH). In group A, immediate diagnosis was made in 35 cases (97%), but only in 26 (72%) preoperatively. In one case, a right BDR was missed on initial evaluation but became apparent 2 weeks later. Associated injuries were present in 34 patients (94%) involving: spleen (n = 18), rib fractures (n = 17), liver (n = 14), lung (n = 11), bowel (n = 7), kidney (n = 5) and other fractures (n = 21). Injury Severity Score (ISS) ranged from 9 to 66 (mean: 31). BDR repair was accomplished through a laparotomy in 22 cases, thoracotomy in 10 and laparo-thoracotomy in four. The overall mortality rate was 16.6% (6/36). Both patients with bilateral BDR died. The patients who died were older than the survivors (mean age: 54 vs. 39 years, P < 0.05), were more severely injured (mean ISS: 46 vs. 28, P < 0.05) and were in shock (100 vs. 23%, P < 0.05). In group B with TDH, diagnosis was delayed for 7–16 months after injury. Four patients had non-specific clinical signs and one strangulation of hollow viscera. One patient had undergone surgery during acute injury but BDR was overlooked. Location of TDH was on the left in three cases and on the right in two. Delay in BDR diagnosis was 12.5% (3/24) in patients with left-sided and 20% (3/15) in patients with right-sided lesions (P > 0.1). Repair of TDH was achieved through thoracotomy in all cases. No mortality or major morbidity were encountered. Conclusions: (1) Predictors of BDR mortality are: age, ISS and hemodynamic status of the patient. (2) Delay in diagnosis does not influence the outcome and is not influenced by the side of BDR location. (3) BDR can easily be missed in the absence of other indications for prompt surgery, where a thorough examination of both hemidiaphragms is mandatory. A high index of suspicion combined with repeated and selective radiologic evaluation is necessary for early diagnosis. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Blunt trauma; Diaphragm injury; Diaphragmatic hernia; Predictors of outcome

1. Introduction

Blunt diaphragmatic rupture (BDR) is not an uncommon injury most noteworthy as a marker of severe trauma [1]. It occurs in 0.8–5% of hospitalized automobile accident victims and in approximately 5% of blunt trauma patients that undergo laparotomy [1–5].

The diagnosis is often difficult and a delay in diagnosis is implicated in increased mortality and morbidity [1,3,6].

We reviewed the experience with BDR at ‘Evangelismos’ General Hospital of Athens in order to identify: (1) predictors of outcome in BDR, and (2) factors contributing to diagnostic delay.
2. Materials and methods

We reviewed the charts and radiographs of 41 patients with BDR treated in our Hospital from 1988 to 1997. All cases with penetrating injuries of the diaphragm were excluded. The variables studied and correlated with outcome were: patient age, hemodynamic status at admission, Injury Severity Score (ISS), time to diagnosis, and BDR side.

All the films of the radiologic exams (chest X-rays -CXR, computed tomography (CT)-scans) were retrospectively reviewed in order to identify signs suspicious for BDR that were overlooked at the initial radiologic interpretation.

Statistical data analysis was performed with Student’s t-test or Chi 2 test, where appropriate. Statistical significance was determined at $P < 0.05$.

3. Results

3.1. Demographic data

There were 35 male (85.4%) and six female patients, aged 17–71 (mean: 41) years. The causes of injury were: motor vehicle crash ($n = 32, 78%$), pedestrian struck by motor vehicle ($n = 6, 14.6%$), fall from height ($n = 2, 4.9%$), compression by agricultural tractor ($n = 1, 2.4%$). BDR was left-sided in 24 cases (58.5%), right-sided in 15 (36.6%) and bilateral in two (4.9%).

Our material comprises two distinct groups of patients: (i) patients with acute BDR (group A: 36, 88%), and (ii) patients with post-traumatic diaphragmatic hernia (TDH) (group B: 5, 12%).

3.2. Acute BDRs

3.2.1. Location of acute BDRs

In group A, there were 21 left-sided (58.3%), 13 right-sided (36.1%) and two bilateral BDRs (5.5%).

3.2.2. Diagnosis of acute BDRs

Diagnosis of BDR was made in less than 12 h in 33 cases (91.6%), and in less than 24 h in two cases with isolated BDR (5.5%). Preoperative diagnosis was made in only 26 cases (72.2%), and was based, partly on physical examination (absent respiratory sounds, audible enteric sounds in the chest, tympany/dullness on percussion of the chest), and mainly, on CXR findings (hemidiaphragm elevation, gas shadow in the (lower) chest, fusion/blurring of the diaphragm and lower lung fields, collapse/consolidation of basal lung segments, mediastinal shift, nasogastric tube in the chest) (Fig. 1).

CT scan performed in 17 cases supported the diagnosis in 13 (76.5%), and was equivocal in four cases (23.5%).

In the two cases with isolated BDR, the initial CXR was suspicious for BDR. This suspicion became stronger after the second CXR, obtained within the first 24 h, and diagnosis was confirmed with CT scan or/and upper GI contrast studies.

Intraoperative diagnosis of BDR was made in nine cases (27.2%). Physical examination was unreliable and, although CXRs (obtained in seven cases) were not normal, a preoperative diagnosis of BDR was not considered.

Diagnostic peritoneal lavage (DPL) was performed in 19 cases, and was positive for intraabdominal bleeding in 18 cases (94.7%). Hence, it was indirectly diagnostic for BDR.

In one patient with right lower rib fractures, pneumomediastinum, pneumopericardium, a right femoral fracture, and a negative DPL, a right BDR became apparent on CXR on hospitalization day 14 (Fig. 2A), 11 days after the patient had been weaned of the ventilatory support. The first CXR was completely normal (even in retrospective look). Diagnosis was confirmed with MRI (Fig. 2B). He underwent a right thoracotomy, which revealed a large posterior–central musculotendinous BDR and a healed, grade I, laceration of the liver dome. BDR was repaired with interrupted absorbable sutures and the patient had a completely uneventful recovery.

3.2.3. Associated injuries in acute BDRs

Associated injuries were present in 34 patients (94%) and included: spleen ($n = 18, 50%$), rib fractures ($n = 17, 47.2%$), liver ($n = 14, 38.9%$), lung ($n = 11, 30.5%$), head ($n = 10, 27.7%$), pelvic fractures ($n = 10, 27.7%$), other fractures ($n = 11, 30.5%$), bowel ($n = 7, 19.4%$), kidney ($n = 5, 13.9%$), major vessel ($n = 4, 11.1%$). Two patients had isolated left BDR. Injury Severity Score (ISS) ranged from 9 to 66 (mean: 31).

Thirteen patients (36.1%) were in hypovolemic shock on arrival. All our patient belonged to ASA Physical Status classification IV or V [7].

Fig. 1. Herniation of the stomach into the left hemithorax (left diaphragmatic rupture).
3.2.4. Surgical management of acute BDRs

BDR repair was accomplished through a laparotomy in 22 cases (61.1%), thoracotomy in 10 (27.7%), and laparothoracotomy in four (11.1%). Both interrupted and running techniques with both absorbable and non-absorbable suture were used.

An intraoperative description of the BDR was available in 27 cases with 29 acute BDRs (including the two patients with bilateral BDR). The length of the BDR ranged from 3 to 20 cm. The parts of the hemidiaphragm involved were: the muscular part in 11 cases (37.9%), the tendinous part in two cases (6.9%) and both in 16 cases (55.2%). The location was postero-central in 19 cases (65.5%), and antero-lateral in 10 cases (34.5%) with pericardial involvement in one case.

Management of associated injuries in 31 patients who survived the operation included: splenectomy (n = 11), suture of the spleen (n = 4), suture of the liver (n = 7) with or without tissue debridement, packing of the liver (n = 2), lung lobectomy (n = 3, atypical lobectomy: 2), nephrectomy (n = 2), partial nephrectomy (n = 1), transverse colectomy (n = 2) with Hartman colostomy (n = 1), suture of sigmoid (n = 1), partial excision of jejunum (n = 1) or ileum (n = 1), suture-repair of ileum (n = 1) or mesocolon (n = 2), suture-repair of the inferior vena cava (n = 2) or the common hepatic artery (n = 1), proximal ligation of the splenic vein (n = 1), ligation of intercostal arteries (n = 2), rib fractures fixation with wire (n = 2), craniotomy for sub-/ epidural hematoma drainage (n = 1), long-bone fractures fixation (n = 8).

3.2.5. Outcome in acute BDRs

The hospital mortality rate in group A (acute BDRs) was 16.6% (6/36). Three patients died intraoperatively due to non-reversible hypovolemic shock. The rest three patients died on postoperative day (POD) 6, 59 and 94, due to ARDS, sepsis, and septic intraabdominal complications requiring multiple surgical interventions, respectively.

Both patients with bilateral BDR died. They had multiple intraabdominal injuries and were in shock at admission. One died intraoperatively due to non-reversible hypovolemic shock, and the other one on POD 94 due to multiple intraabdominal abscesses requiring multiple surgical interventions.

Postoperative complications encountered among 16 survivors were (morbidity rate: 53.3%): pneumonia (n = 6, 20%), urinary tract infection (n = 4, 13.3%), ARDS (n = 3, 10%), multiple organ failure (n = 2, 6.7%), renal failure (n = 2, 6.7%), intraabdominal abscess (n = 1, 3.3%), stress ulcer bleeding (n = 1, 3.3%), temporary phrenic nerve palsy (n = 1, 3.3%).

The hospital stay for the survivors was 8–53 (mean: 16) days. The ICU stay was 0–46 (mean: 5.8) days. The time
spent on mechanical ventilation was 0–45 (mean: 4.8) days.

3.2.6. Predictors of outcome in acute BDRs

Of the variables tested as predictors of outcome in group A (acute BDRs), only age, hemodynamic status at admission, and ISS were predictive (Table 1).

The patients who died: (a) had a mean age of 54 years compared with 39 years of the survivors \( P < 0.05 \) (b) all (100%) were in shock at admission (systolic blood pressure <90 mmHg and heart rate >120 bpm and/or clinical signs of shock) compared with only 23% of the survivors in shock \( P < 0.05 \), and (c) were more severely injured, as indicated by a mean ISS of 46 compared with 28 of the survivors \( P < 0.05 \).

3.3. Traumatic diaphragmatic hernias (TDHs)

3.3.1. Location of TDHs

In group B (patients with TDH), location of TDH was in the left hemidiaphragm in three cases and in the right in two.

3.3.2. Diagnosis of TDHs

Diagnosis was delayed for 7–16 months after injury. In all cases the BDR was missed during the initial hospitalization. One patient with a left TDH had undergone surgery for intraabdominal trauma during the acute phase of injury but BDR was overlooked. Four patients had non-specific and inconstant symptoms as abdominal or/and chest pain, abdominal discomfort, dyspnea, respiratory infections. One patient presented with strangulation of hollow viscera. Diagnosis was made with CXR \( (n = 4) \), upper GI studies \( (n = 2) \), CT scan \( (n = 2) \). In one case, the patient presented with dyspnea at the Emergency Department. The CXR demonstrated gas shadow (the gastric bubble) in the left hemidiaphragm in three cases and in the right in two.

3.3.3. Surgical management of TDHs

Direct closure of the diaphragm using interrupted non-absorbable sutures was achieved through a thoracotomy in all cases. No mesh was required in order to cover the diaphragmatic defect. The viscera found to be herniated were: stomach \( (n = 2) \), transverse colon \( (n = 2) \), liver \( (n = 2) \), small bowel \( (n = 1) \) and spleen \( (n = 1) \). No resection of any part of the gastrointestinal tract was necessary.

3.3.4. Outcome in TDHs

No mortality or major morbidity were encountered.

3.3.5. Location and delay in diagnosis of BDR

Considering delay in BDR diagnosis and location of BDR, no meaningful conclusions can be drawn, as three of 24 (12.5%) patients with a left-sided lesion and three of 15 (20%) patients with a right-sided one had a delay in BDR diagnosis (difference not statistically significant).

4. Discussion

Early morbidity and mortality from BDR is due to the associated injuries [3,8]. Mortality in our series was 16.6%, within a reported broad range of 3.6 to 41% [1,3–20]. No death was directly attributable to BDR and this is in accordance with the literature [1,3,8–14,16,19] [20]. Age, severity of injury (expressed by ISS), and hemodynamic status at admission were proved to be significant predictors of mortality in our series. Age and ISS, as well as head injury, have been confirmed as strong prognostic factors of mortality by others [3].

Diagnostic means for BDR including CXR, DPL, pneumoperitoneum, fluoroscopy, upper GI studies, ultrasound, CT scan, MRI, liver-spleen scintigraphy, peritoneo-scintigraphy lack both sensitivity and specificity [3,17,21–25].

CXR is currently the most valuable simple test, although, it can be diagnostic or suggestive of BDR in only 28–70% of cases [21,22]. Sensitivity of the initial CXR interpretation can be increased by heightened awareness of this injury [22]. Patients in our series had all but one abnormal CXRs in the retrospective review. Repeated CXR during hospitalization, as well as some days after discharge, is necessary in order to detect a herniation slowly increasing, as it happened in one of our patients.

CT scan is the second choice imaging technique, although the axial oriented diaphragm is not always well demonstrated with conventional CT. Wide ranges of sensitivity and specificity are reported as 54–73 and 86–90%, respectively [23]. The limitations of CT include difficulty in delineating hemidiaphragms from adjacent soft-tissue

<table>
<thead>
<tr>
<th>Variable</th>
<th>Survivors ( (n = 30) )</th>
<th>Non-survivors ( (n = 6) )</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age</td>
<td>54 Years</td>
<td>39 Years</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Hypovolemic shock</td>
<td>7 (25.3%)</td>
<td>6 (100%)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Hypovolemic shock</td>
<td>46</td>
<td>28</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Time to diagnosis &lt;12 h</td>
<td>27 (90%)</td>
<td>6 (100%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Time to diagnosis &gt;24 h</td>
<td>2 (6.7%)</td>
<td>0</td>
<td>n.s.</td>
</tr>
<tr>
<td>BDR location</td>
<td>Left 19 (63.3%)</td>
<td>2 (33.3%)</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>Right 11 (36.4%)</td>
<td>2 (33.3%)</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>Bilateral 0</td>
<td>2 (33.3%)</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

n.s., Non-significant.
structures (i.e. atelectatic lung), big slice thickness (8–10 mm), and respiratory motion around the diaphragm [25]. Helical CT with axial, sagittal and coronal reformations is possibly superior to conventional CT in diagnosing BDR [23]. In our series, a CT diagnostic value of 76.5% in BDR was obtained. The ‘collar sign’ around herniated organs was observed in one fourth of our cases.

Studies have shown that MRI is helpful in equivocal cases of BDR [21,24,25]. Interruption of the diaphragmatic signal due to laceration may confirm a BDR. Unfortunately, MRI is not always available in the acute setting and even if it is, many trauma patients require support devices that are not compatible with MRI. In our series MRI was helpful in one case when we used it (a late appearance of a right BDR), MRI should be done in the acute setting when the diagnosis remains uncertain after CT, or for non-acute, clinical, or radiological presentation suggesting BDR [25].

Since 1993, when video-assisted thoracoscopic surgery (VATS) was first used to diagnose BDR [26], it has been proposed as a safe, expeditious, and accurate method of evaluating the diaphragm in trauma patients, comparable in diagnostic value to exploratory celiotomy (specificity, sensitivity and positive predictive value of 100%) [27]. But VATS has two important limitations: it cannot be performed in hemodynamically unstable patients, and it requires general anesthesia. In our Hospital VATS has been employed in our practice only recently and not in the trauma field yet.

A lesson demonstrated in the present series should be emphasized: a meticulous inspection of both hemidiaphragms must take place during any exploratory laparotomy for trauma [1,5]. One of our patients presented with a left TDH had undergone surgery in the acute setting for intraabdominal injuries, but the BDR was overlooked. Missed BDR results inevitably in herniation of abdominal contents into the chest due to the intra-abdominal to intrathoracic pressure gradient reaching up to 100 mmHg during Valsalva manoeuvre (normal: 2–10 mmHg) [3,6,16]. Progressive herniation results to respiratory embarrassment, chronic abdominal complaints, and strangulation of abdominal viscera, contributing to the late morbidity and mortality of the missed injury. In our series late diagnosis and repair of a TDH had no influence in morbidity and mortality, and this is in accordance with others’ observations [18].

5. Conclusions

(1) Predictors of BDR mortality are: age, ISS, and hemodynamic status of the patient. (2) In our series, delay in diagnosis did not influence the outcome and was not influenced by the side of BDR location. (3) BDR can easily be missed in the absence of other indications for prompt surgery, where a thorough examination of both hemidiaphragms is mandatory. A high index of suspicion combined with repeated and selective radiologic evaluation is necessary for early diagnosis.

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