Pelvic trauma: impact of iodinated contrast material extravasation at MDCT on patient management

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Résumé
Traumatisme pelvien : impact de l’extravasation du produit de contraste iodé au scanner multidétecteur dans la prise en charge thérapeutique
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Objectif. Déterminer l’impact de l’extravasation de contraste sur le scanner multidétecteur avec injection de contraste iodé dans la sélection des patients nécessitant une emboîlisation vasculaire pour la prise en charge des patients avec fractures pelviennes.


Résultats. Soixante-quatorze patients avec fracture pelvienne (âge moyen : 34 ans) ont eu un scanner multidétecteur avec injection intraveineuse de contraste iodé avant décision thérapeutique. Une emboîlisation vasculaire a été réalisée chez 42 patients : 38 d’entre eux présentaient une extravasation de contraste pelvienne au scanner multidétecteur et quatre patients présentaient un choc hémodynamique malgré un scanner sans extravasation. Par ailleurs, un traitement orthopédique a été réalisé en première intention après un scanner multidétecteur négatif chez 27 patients et positif chez 5 patients avec état hémodynamique stable.

Conclusion. Dans notre étude, la présence d’une extravasation de contraste au scanner multidétecteur a été déterminante dans la réalisation d’une emboîlisation vasculaire chez les patients avec fracture pelvienne.


Abstract
Purpose. To determine the impact of iodinated contrast material extravasation at MDCT in selecting patients with pelvic fractures that require vascular embolization.

Patients and methods. All patients with severe pelvic fracture admitted to the trauma unit between 1998 and 2004 underwent contrast enhanced MDCT prior to additional specific treatment. All patients with extravasation underwent immediate vascular embolization for hemodynamic stabilization. Orthopedic management was proposed when no contrast extravasation was demonstrated. The presence or absence of contrast extravasation on MDCT and the hemodynamic status of the patients were recorded.

Results. Seventy-four patients with pelvic fracture (mean age : 34 years) underwent contrast enhanced MDCT prior to therapeutic management. Vascular embolization was performed in 42 patients : 38 showed contrast extravasation and 4 were in hemodynamic shock but showed no extravasation. Orthopedic management was performed in 27 patients after negative MDCT and 5 hemodynamically stable patients with positive MDCT.

Conclusion. In our patient population, the presence of iodinated contrast material extravasation at MDCT was a determinant factor in the selection of patients for vascular embolization.

Key words: Pelvic fracture. MDCT. Contrast extravasation. Arterial embolization.

Pelvic fractures are present in about 5% of hospitalized trauma patients (1). Pelvic fractures are associated with a mortality rate between 5 and 30% (2-6), and up to 50% with open fractures (7). One of the main causes of death is hemorrhagic shock secondary to injuries to the internal iliac artery and/or its branches. Several studies have demonstrated that when hemorrhage was controlled, prognosis was only affected by associated injuries (8, 9). Treatment of arterial injuries is thus a priority in the management of patients with pelvic fractures.

Endovascular embolization, a recently developed technique for the management of pelvic hemorrhage, has shown success rates between 85 and 100% when the hemorrhagic site is identified (1, 10). As such, continued advanced in CT imaging and embolization techniques have improved the management of these critically injured patients.

The purpose of this study was to assess the value of contrast material enhanced...
MDCT in identifying patients requiring endovascular embolization for hemorrhagic control.

**Patients and methods**

We have performed a retrospective review of patients with pelvic fractures admitted to the trauma unit of the Hôpital Edouard Herriot, in Lyon. The search of the hospital information system and radiology information system was conducted using key words. The key words used included: pelvic fracture, CT, arterial embolization. The search period was between January 1998 and October 2004. All charts were reviewed to collect demographic data, mechanism of trauma, nature of traumatic lesions, hemodynamic status (instability defined by a systolic pressure below 90 mm Hg during resuscitation), the ISS score, number of units of packed red cells, duration of hospital stay, and death.

An experienced radiologist blinded to clinical and angiographic data reviewed all MDCT examinations to confirm the presence (positive) or absence (negative) of iodinated contrast material extravasation in the pelvis. These data were compared to angiographic results to determine the sensitivity of contrast material enhanced MDCT. The embolization technique was recorded along with the efficacy of the procedure. Embolization was considered for patients with extravasation on CT and persistent shock after resuscitation.

The CT examinations were performed after injection of iodinated contrast material (Xénétix 350, 2 ml/kg; Guerbet, Inc, Aulnay sous bois, France) at 3 ml/sec with delay of 25 seconds. All examinations were acquired using a helical protocol: MDCT (Siemens, Somatom Plus 4, Erlangen, Germany), 5 mm collimation. Based on previously published criteria, a diagnosis of arterial extravasation was made in the presence of spontaneous hyperdensity during the arterial phase (11, 12).

Pelvic angiograms were performed using a Polystar unit (Siemens, Erlangen, Germany) using the Seldinger technique. Endovascular embolization was performed using one or several types of embolization material: coils (Cook, Inc, Bloomington, Ind), Curason particles (Upjohn Pharmac, Kalamazoo, Mich) or embolization particles (Biosphère Médical SA, Roissy, France).

Successful embolization was defined by the absence of extravasation on post-embolization angiograms.

**Results**

Between January 1998 and October 2004, 2753 patients with polytrauma were admitted to the surgical trauma unit of pavilion G of the Hôpital Edouard Herriot for further management. From this population, 74 (mean age of 34 years) (2.7%) had a pelvic fracture. The mechanisms of trauma included motor vehicle accidents (41.9%), falls (37.8%) or direct compression (20.3%). The types of pelvic fracture were classified according to the Young-Burgess classification: 43 cases with anteroposterior compression, 26 cases with lateral compression and 5 cases with vertical shear. From this subgroup of patients, 64 presented associated injuries (table I). All patients with pelvic fracture underwent contrast material enhanced whole body MDCT imaging at the time of initial presentation.

Two management options were considered based on MDCT findings and hemodynamic status: 32 (43.2%) patients underwent orthopedic surgery based on the absence of clinical signs of hemorrhagic shock and absence of contrast extravasation at the pelvic level on CT for 27 of these patients (84.3%) (table II). Five patients did not undergo endovascular embolization despite the presence of extravasation of iodinated contrast material on CT associated with signs of significant blood loss without signs of impending shock. Forty-two patients underwent primary endovascular embolization (table II). All presented signs of hemorrhagic shock. Only 9.5% (4/42 patients) of hemodynamically unstable patients had a negative CT, whereas 90.5% (38/42 patients) had a positive CT (fig. 1).

The mean ISS score was 48.1 ± 5.1 for the group of embolized patients compared to 32.7 ± 5.7 for the group of non-embolized patients. Within the group of embolized patients, the mean ISS score was 48.3 ± 5.2 for patients with positive CT 48.2 ± 22.4 for patients with negative CT. The mortality rate at 24 hours directly related to the pelvic trauma was 5.4% (n = 4) (table III). Two of these four patients showed extravasation of contrast on CT. Ten patients died from other associated injuries, intracranial in 50% of cases.

Forty-three patients showed contrast extravasation on CT (fig. 2). Thirty-eight of these patients underwent pelvic angiography confirming the presence of arterial extravasation in 100% of cases (fig. 3). Endovascular embolization was performed in all cases. The embolized arterial branches are summarized in table IV. Coils and gelatin foam were used in combination in 24 cases, gelatin foam was used alone in 7 cases, coils were used alone in 6 cases, and gelatin foam and microspheres were used ion combination in 1 case. The mean hemoglobin level at the time of embolization was 71.7 ± 6 g/l whereas the level was 91.5 ± 6 g/l 24 hours after embolization. Four patients with negative CT underwent pelvic angiography with embolization because of clinical signs of hemorrhagic shock and presence of large intrapelvic hematomas on CT. Coils were used alone in 3 cases and in combination with gelatin foam in 1 case.

In the group of 42 embolized patients, radiographic success defined by the absence of extravasation on post-embolization angiograms and clinical success defined by the absence of signs suggesting ongoing hemorrhage was achieved in 39 cases. Three patients underwent repeat embolization at 24 hours due to recurrent active hemorrhage.

**Table I**

<table>
<thead>
<tr>
<th>Associated lesions</th>
<th>Patients n=74 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoracic lesions</td>
<td>43 (58,1)</td>
</tr>
<tr>
<td>Abdominal lesions</td>
<td>37 (50)</td>
</tr>
<tr>
<td>Intracranial lesions</td>
<td>20 (27)</td>
</tr>
<tr>
<td>Peripheral orthopedic injuries</td>
<td>20 (27)</td>
</tr>
<tr>
<td>Potentially hemorrhagic lesions</td>
<td>34 (45,9)</td>
</tr>
</tbody>
</table>

**Table II**

<table>
<thead>
<tr>
<th>Patient management in our series</th>
<th>Treatment</th>
<th>Patients N=74 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embolization</td>
<td>42 (56,8)</td>
<td></td>
</tr>
<tr>
<td>Internal fixation</td>
<td>18 (24,3)</td>
<td></td>
</tr>
<tr>
<td>Traction</td>
<td>9 (12,2)</td>
<td></td>
</tr>
<tr>
<td>External fixation</td>
<td>8 (10,8)</td>
<td></td>
</tr>
<tr>
<td>Belt</td>
<td>3 (4)</td>
<td></td>
</tr>
<tr>
<td>C-Clamp</td>
<td>2 (2,7)</td>
<td></td>
</tr>
<tr>
<td>MAST pants</td>
<td>2 (2,7)</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 1: Diagram illustrating the distribution and management of patients based on the presence or absence of extravasation.

Table III
Comparison of patient features between patients with extravasation (extravasation +) or without extravasation (extravasation –) on CT.

<table>
<thead>
<tr>
<th>Features</th>
<th>Extravasion + (n=43)</th>
<th>Extravasion – (n=31)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>32 (25 – 53)</td>
<td>38 (22 – 57)</td>
<td>0,996</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female (%)</td>
<td>21 (48,8)</td>
<td>13 (41,9)</td>
<td>0,557</td>
</tr>
<tr>
<td>Male (%)</td>
<td>22 (51,2)</td>
<td>18 (58,1)</td>
<td></td>
</tr>
<tr>
<td>ISS</td>
<td>50 (29 – 59)</td>
<td>29 (20 – 42,3)</td>
<td>0,001</td>
</tr>
<tr>
<td>Fracture stability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stable (%)</td>
<td>5 (11,6)</td>
<td>4 (12,9)</td>
<td>0,928</td>
</tr>
<tr>
<td>Unstable (%)</td>
<td>38 (88,4)</td>
<td>27 (87,1)</td>
<td></td>
</tr>
<tr>
<td>Patients with associated lesions (%)</td>
<td>36</td>
<td>26</td>
<td>0,633</td>
</tr>
<tr>
<td>Patients with potentially hemorrhagic associated lesions (%)</td>
<td>20 (46,5)</td>
<td>10 (53,5)</td>
<td>0,159</td>
</tr>
<tr>
<td>Duration of stay in trauma unit (days)</td>
<td>8,5 (3 – 18)</td>
<td>6 (3 – 16)</td>
<td>0,616</td>
</tr>
<tr>
<td>Global mortality at day 28 (%)</td>
<td>12 (16,22)</td>
<td>7 (9,46)</td>
<td>0,605</td>
</tr>
<tr>
<td>Mortality directly due to pelvic injuries (%)</td>
<td>4 (5,41)</td>
<td>5 (6,76)</td>
<td>0,375</td>
</tr>
</tbody>
</table>
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I Kamaoui et al.

Fig. 2: Axial contrast material enhanced MDCT of the pelvis showing a sacral fracture with extravasation of hyperdense contrast in the presacral space (long arrow). Note the presence of a large left iliac hematoma.

Fig. 3: Left internal iliac angiogram prior to and following embolization. 
(a) Angiogram showing areas of arterial blush due to active bleeding. 
(b) Post-embolization angiogram showing successful control of the bleeding.

Table IV
Summary of embolized arterial branches.

<table>
<thead>
<tr>
<th>Embolized arterial territory</th>
<th>Patients n=42 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal iliac artery</td>
<td>19 (46,3)</td>
</tr>
<tr>
<td>Unilateral</td>
<td>27 (65,9)</td>
</tr>
<tr>
<td>Bilateral</td>
<td>14 (34,1)</td>
</tr>
<tr>
<td>Internal iliac artery branches</td>
<td>22 (53,7)</td>
</tr>
<tr>
<td>Embolization of at least 2 sites</td>
<td>21 (50)</td>
</tr>
</tbody>
</table>

Discussion

The incidence of pelvic fractures is low. They affect younger patients and typically occur in relation to motor vehicle accidents. Pelvic fractures in the setting of abdominopelvic trauma are associated with a mortality rate between 5 and 15% (13, 14). The causes of death are mixed with shared responsibility from pelvic trauma and associated non-pelvic injuries (8, 9, 15).

The main cause of death is hemorrhagic shock, with death within the first 24 hours (1, 16). Uncontrollable hemorrhage resulting in death is pelvic in origin in 62% of cases and extra-pelvic thoracic and/or intraperitoneal in 38% of cases (17, 18). Organs most frequently injured and causing hemorrhage are the spleen (22%), the liver (20%), the bladder (15%), the mesentery (10%) and the kidneys (7%) (6, 19).

Several authors have tried to develop predictive clinical and imaging signs to identify patients at high risk of arterial hemorrhage. These signs include hemodynamic response to initial resuscitation (14), type of pelvic fracture (6, 20), volume and location of pelvic hematoma on CT (21, 22) and contrast extravasation on CT (12, 23-26). The association of hypotension, pelvic fracture, poor response to initial resuscitation and contrast extravasation on CT is most predictive of significant post-traumatic arterial injury at the pelvic level (14).

Helical CT is the standard of reference for comprehensive evaluation of visceral, vascular and osseous injuries (21, 22). In cases of pelvic trauma, the goal is to detect findings suggesting arterial injury in order to direct patients to pelvic angiography with embolization. Arterial injury is suspected in the presence of contrast extravasation at the arterial phase of contrast distribution. Stephen et al. have reported sensitivity, specificity, positive predictive and negative predictive values of 80%, 98%, 80% and 98% respectively to identify patients requiring arterial embolization (25), and several studies reported similar results (12, 26).

CT also allows mapping of the sites of arterial injuries. Yoon et al. have demonstrated that CT allowed detection of contrast material extravasations in locations that were predictive of injuries to specific arterial branches of the internal iliac artery (27). This knowledge could lead to more rapid embolization of bleeding arteries.

Our study, performed on patients with pelvic trauma, has assessed the ability of
contrast material enhanced MDCT to detect patients requiring endovascular embolization to control hemorrhagic shock. During this time period, pelvic trauma was present in 2.7% of patients admitted to the surgical trauma unit. All patients underwent a “body scanner” with injection of iodinated contrast material. Forty-three patients (58%) showed contrast extravasation (blush) in the pelvis on CT, and 38 (88.3%) of these patients underwent embolization. From the 31 patients without extravasation on CT, 4 (12.9%) underwent embolization due to significant hemodynamic shock unresponsive to initial resuscitation. The diagnostic value of contrast extravasation on CT cannot be assessed from this retrospective study, but the sensitivity of MDCT could be calculated at 90.5%. We can therefore conclude that contrast material enhanced MDCT at initial presentation is appropriate to identify polytrauma patients with pelvic fractures requiring endovascular embolization.

Recently, angiography has become a fundamental tool in the management of post-traumatic arterial hemorrhage. It allows accurate mapping of arterial injuries prior to embolization (28). Angiography can also help evaluate additional extra-pelvic vascular injuries. An aortogram can be performed to detect areas of active hemorrhage for embolization.

Arterial embolization provides hemostasis to arterial injuries from an endovascular approach. The purpose is to transiently reduce the local perfusion pressure to promote endogenous hemostasis and reduce blood losses and transfusion related complications (5). In our study, embolization provided hemorrhagic control with improved hemoglobin levels.

The angiogram is performed using the Seldinger technique, with uni- or bilateral puncture of the common femoral artery using a 5F system. A frontal aortogram is first obtained with the catheter tip placed in the infra-renal aorta to exclude extra-pelvic sites of hemorrhage such as from splenic, hepatic or renal injuries. Then, the internal iliac arteries are selectively catheterized. The external iliac and lumbar arteries may at times be selected as well due to the presence of collateral supply. After the lesion is identified (contrast extravasation, vasospasm, pseudoaneurysm, or arteriovenous fistula), super-selective angiography is performed prior to embolization. In patients with diffuse hemorrhage, difficult vascular access or uncontrollable shock, it may be necessary to perform a more proximal embolization in the internal iliac artery or its anterior or posterior trunk (29). This less selective technique provides faster control of hemorrhage compared to a superselective approach in such patients. In our study, a third of patients underwent bilateral embolizations because of hemodynamic instability and frequency of multiple bleeding sites non-amenable to superselective embolization. A post-embolization aortogram is then performed to assess the results of the procedure and detect potential additional sites of hemorrhage (30) initially overlooked.

Different materials are used for embolization. Curaspon® and Hémacol® are hemostatic gelatin foams resulting in temporary vascular occlusion between 48 hours and one week. Coils result in permanent occlusion. Particles such as Embospheres are also available. These are usually reserved to non-selective iliac artery embolizations or selective embolization of major arterial branches. Both materials may be used in combination, as was the case for some of our patients.

Several publications report success rates between 85% and 100% (31-33). The best imaging criteria of success is the demonstration of permanent and durable reduction of arterial flow on post-embolization angiograms. Clinical criteria include hemodynamic stability, reduced need for or discontinuation of vasopressors and blood transfusions. Once the hemorrhage was controlled, prognosis was only related to other associated lesions (8, 34-36).

References

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