Perisplenic Extravasation of Contrast Medium on Enhanced Helical Computed Tomography: A Reliable Indicator for Early Surgical Management in Blunt Splenic Injuries

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Background: The purpose of this study was to determine the predictive value of perisplenic contrast material extravasation (CME) on contrast-enhanced helical computed tomography (CT) for early surgical management in blunt splenic injuries.

Methods: During a 12-month period, 80 patients who underwent computed tomography (CT) examinations and were discharged with the diagnosis of blunt splenic injury were included in this retrospective study. All CT scans were reviewed for perisplenic CME and the grades of splenic injuries. Their medical charts were independently reviewed for the choice of treatment and the time interval between CT and spleen-related laparotomy.

Results: Of the 80 CT scans, six (7.5%) were positive and 74 (92.5%) were negative for perisplenic CME. Forty scans were of low-grade injuries, 40 were of high-grade injuries. All six (100%) patients with perisplenic CME underwent spleen-related surgery, whereas 29 (39.2%) patients without CME required surgery ($p = 0.005$). The time interval between CT and laparotomy was 1.6 ¡ 1.0 hours for patients with CME, and 7.6 ¡ 12.9 hours for patients without CME ($p = 0.028$). Similar comparisons of the laparotomy frequency and time intervals between CT and laparotomy in the low-grade and high-grade injury groups did not show any significant differences.

Conclusion: Perisplenic CME detected on contrast-enhanced helical CT was a more reliable predictive criterion than the grading scheme based on the depth of lacerations for early surgical management in blunt splenic injuries.

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Key words: blunt splenic injuries, contrast material extravasation, helical CT, perisplenic space.

Computed tomography (CT) has been widely used to evaluate patients with blunt abdominal trauma when they were hemodynamically stable. The sensitivity of conventional CT in detecting splenic injuries has been reported to be as high as 95%.[1] Not only is CT sensitive, it can also accurately define the degree and extent of the injuries. Consequently, various CT grading systems for blunt splenic injuries have been introduced to guide therapy.[2,3] However, none of the grading schemes based

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on the findings of conventional CT is reliable for determining the need for surgical management.[2,4,5] Nevertheless, failure of non-surgical management is anticipated when there is ongoing hemorrhage from the injured spleen or perisplenic vessels.

We therefore postulated that while intrasplenic hemorrhage could be confined and tamponaded, perisplenic vascular injuries that usually lack adequate tamponade would require early surgical intervention. Perisplenic vascular injuries with active bleeding could be detected as perisplenic contrast material extravasation (CME) on a contrast-enhanced helical CT scan. Therefore, the purpose of this retrospective study was to determine whether the depiction of perisplenic CME on contrast-enhanced helical CT of patients with blunt splenic injury was a reliable predictive criterion for early trauma team activation and surgical management even though these patients were hemodynamically stable at the time of CT examination.

METHODS

During a 12-month period, 80 patients who had helical CT studies of the abdomen and discharged diagnosis of blunt splenic injury at a Level I trauma center were included in this retrospective study. There were 21 female patients and 59 male patients with a mean age of 31.3 years (range, 4-83 years).

We used a helical CT, High Speed Advantage scanner (General Electric Medical System, Milwaukee, Wis) to assess patients with blunt abdominal trauma when the patients were hemodynamically stable on arrival or hemodynamically stable after resuscitation according to the Advanced Trauma Life Support protocol. We used 10-mm slice thickness, 10-mm spacing, 1:1 pitch to scan all patients from the diaphragm dome to the inferior edge of the ischial bones. Diluted 500-750 mL of water-soluble oral contrast material was given to the patients 30 to 60 minutes before the CT scan whenever the condition of the patients permitted. The usual contrast enhancement technique consisted of a bolus injection of 100 mL of intravenous contrast material Hypaque-76 (Sanofi Winthrop Pharmaceuticals, NY) at a rate of 1.0-1.5 mL per second depending on the venous access and the tolerance of the individual patient. CT scanning was initiated when 80 mL of the contrast material had been injected.

All 80 CT scans were reviewed by two radiologists who were unaware of the choice of treatment to identify perisplenic CME. Perisplenic CME was defined as CT evidence of perisplenic collection with an attenuation similar to or greater than that of the aorta or a major adjacent artery, and greater than that of the spleen. The grades of splenic injuries were also recorded according to the CT classification.[2] Splenic injuries were assigned as low-grade for grade I and grade II injuries, and high-grade for grade III and grade IV injuries. They interpreted the CT scans together and recorded a consensus report. The associated abdominal injuries as disclosed by CT were also recorded. Medical records of these patients were independently reviewed for the choice of treatment and the time interval between CT examination and spleen-related laparotomy.

Statistical analysis between groups was done using chi-square test, Fisher's exact test, or Student's *t*-test as appropriate. A p value of less than 0.05 was considered statistically significant.

RESULTS

Among the 80 CT scans that were reviewed, perisplenic CME was identified on six (7.5%) scans (Figs.1 and 2). Forty of them were of low-grade splenic injuries, and 40 were of high-grade splenic injuries (Fig. 3). Of the six patients with perisplenic CME, one (16.7%) had a low-grade injury and five (83.3%) had high-grade injuries.

A total of 35 (43.8%) patients ultimately underwent spleen-related laparotomy. None of the 45 (56.2%) patients who did not undergo spleen-related laparotomy died of spleen-related complication. Of the six patients with perisplenic CME, all underwent spleen-related laparotomy (100%), but only 29 (39.2%) of the 74 patients without perisplenic CME required spleen-related laparotomy; the difference was statistically significant ($p = 0.005$). The mean time interval between CT and laparotomy was significantly different between the group with perisplenic CME and the group without (1.6 ¡ 1.0 vs 7.6 ¡ 12.9 hours; $p = 0.028$).

Of the 40 patients with low-grade splenic injuries, 16 (40.0%) required spleen-related laparotomy. Among the 40 patients with high-grade splenic

injuries, 19 (47.5%) required spleen-related laparotomy. The difference between these two groups was not significant ($p=0.499$). The mean time interval between CT and laparotomy in the group with low-grade splenic injuries was 7.3 ¡ 12.7 hours, whereas it was 5.7 ¡ 11.3 hours in the group with high-grade injuries. The differences were not significant either ($p=0.711$). The results showed that the CT grading scheme of splenic injury based on the depths of lacerations (low-grade or high-grade injuries) was not reliable in guiding the choice and timing of surgical management.

Fig. 1 Contrast-enhanced helical CT of a patient with blunt splenic injury demonstrates high-density contrast medium extravasation (arrow) in the perisplenic space. Notice the splenic laceration (arrowhead) and also massive hemoperitoneum (H). This patient underwent spleen-related surgery due to an unstable hemodynamic condition after CT examination.

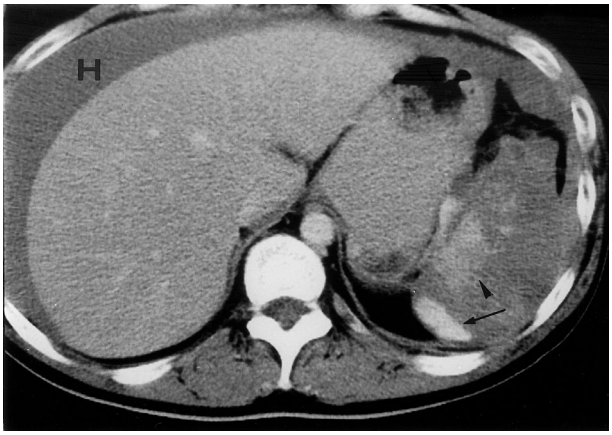

Fig. 2 Contrast-enhanced helical CT of a patient with blunt splenic injury shows the upper pole of a shattered spleen (arrowhead). Pooling of high-density contrast medium extravasation (arrow) is noted in the dependent part of the perisplenic space. Notice the presence of massive hemoperitoneum (H). This patient underwent spleen-related surgery due to deteriorating condition.

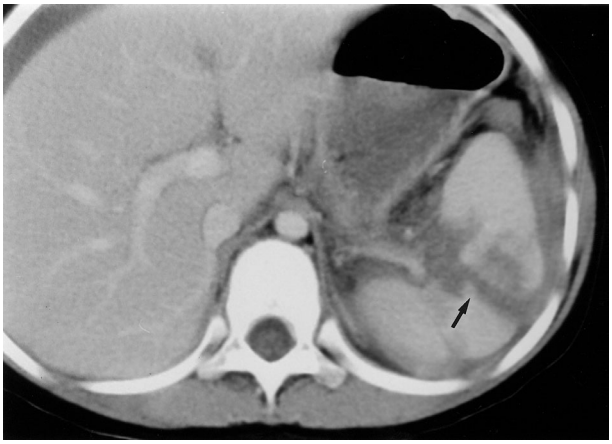

Fig. 3 Contrast-enhanced helical CT of a patient with blunt splenic injury shows deep splenic lacerations (arrow) extending from the lateral surface to the hilum. There is no perisplenic contrast medium extravasation. This patient was treated with surgical management.

DISCUSSION

The purpose of non-surgical management for splenic injury was to preserve the immunologic and hematologic functions. Non-surgical management also contributed to a shorter hospital stay and fewer transfusions of blood products. Furthermore, with the accumulated experience of clinical observation over the years, the spleen has shown an impressive capacity to heal even after fragmentation. These arguments collectively support a trend towards the non-surgical management for blunt splenic injuries when the hemodynamic condition of the patient is stable.[6-8]

Although the success rates of non-surgical management for blunt splenic injuries in pediatric patients are generally high and encouraging, the reported success rates of non-surgical management in adult patients vary widely, ranging from 43% to 97%.[7,9] To date, the choice between surgical and

non-surgical management for splenic trauma is mainly based on clinical criteria of the patient, including the age, hemodynamic status, and injury severity scores (ISS). In addition to the hemodynamic instability that always warrants an emergent surgical intervention, a high ISS which quantifies trauma to both abdominal and extra-abdominal injuries is also an indication for surgery because a high ISS can result in a high failure rate of non-surgical management. On the other hand, children in general are preferably treated with non-surgical management whenever condition permits. Nevertheless, although the clinical criteria of a patient on arrival or after resuscitation are favorable for non-surgical management, this decision may change during the course if the hemodynamic status suddenly deteriorates caused by an ongoing hemorrhage from the injured spleen.

With the advent of conventional CT, various CT grading schemes for blunt splenic injuries have been introduced to guide therapy. Patients with low-grade splenic injuries who initially were conservatively managed might deteriorate later due to delayed splenic rupture and hence require operations. On the other hand, patients with high-grade injuries but are hemodynamically stable might not necessarily undergo surgical treatment. Therefore, none of those grading schemes has proved reliable.[2,4,5] However, active bleeding as a result of splenic vessels injury could be depicted on CT scans as a focal intrasplenic or perisplenic CME.[10-12] These patients are usually hemodynamically stable at the time of CT examination but about 40% to 90% of them may become hypotensive shortly thereafter.[10,12-14] In our series, contrast-enhanced helical CT scans of six patients (7.5%) demonstrated perisplenic CME. All (100%) of them underwent operations due to deteriorating hemodynamic conditions although they were stable at the time CT was performed. The differences were statistically significant compared with the group without perisplenic CME in which only 39.2% underwent spleen-related laparotomy. Not only was perisplenic CME a reliable predictive criterion to terminate the observation management and proceed patients to spleen-related laparotomy, the time interval between CT examination and laparotomy in this group of patients was also significantly shorter than that of the group without CME (1.6 ¡ 1.0 hours vs 7.6 ¡ 12.9 hours). In one of the reports related to splenic CME, 50% of the cases with contrast blush within the splenic parenchyma were successfully managed without surgical intervention.[12] It implied that the intrasplenic vascular hemorrhage could be well confined and tamponaded. Spontaneous thrombosis of the intrasplenic traumatic pseudoaneurysm has also been reported.[15] None of our cases in this series demonstrated intrasplenic contrast blush. Hence, we were unable to compare the outcome between patients with perisplenic CME and patients with intrasplenic contrast blush. However, our observations indicated that patients with perisplenic CME on CT scans were prone to ongoing bleeding into the peritoneal cavity. In other words, in contrast to the intrasplenic contrast blush, perisplenic CME was an indicator of active bleeding that lacked adequate tamponade effects.

In contrast to the perisplenic CME, the grading scheme of splenic injuries in this series whether of low-grade or high-grade had no significant value to predict the success or failure of non-surgical management. Furthermore, the correlation of grades of injury with the time interval between CT and laparotomy also did not show any statistical significance with a p-value of 0.711. Regardless of the injury grades, the indications of spleen-related laparotomy in patients with blunt splenic injuries were the deteriorating hemodynamics and the falling of hematocrit attributable to continuous bleeding or inadequate tamponade. Consequently, perisplenic CME was a more reliable predictive criterion than injury grading scheme for the need of early activation of the trauma team as well as surgical management. Although the grading scheme based on the depth of lacerations was not helpful in guiding the management, our observations showed that perisplenic CME was more frequently encountered in patients with high-grade injuries than low-grade injuries (83.3% vs 16.7%). The implication was that the shearing impact of a high-grade splenic injury might cause perisplenic vascular tearing. Therefore, perisplenic CME must be meticulously sought if a high-grade splenic injury was recorded.

When the six patients with perisplenic CME were excluded, only 29 (36.2%) patients out of 74 who were initially stable and enrolled for conservative management failed in the non-surgical management. In recent years, active hemorrhage resulting from splenic injuries have been successfully con-

trolled by means of transcatheter arterial embolization (TAE) of the splenic artery.[16-19] Embolization of the main splenic artery can lower splenic perfusion pressure but does not devascularize the spleen because of the rich collaterals.[20] However, none of our patients in this series was given the option for TAE. Had TAE been performed in those patients whose hemodynamic conditions were stabilized with continuous resuscitation, and surgical intervention would have been reserved for patients whose hemodynamic conditions were unstable despite continuous resuscitation, then the failure rate of non-surgical management would be further reduced.[18]

Perisplenic CME was infrequently described in the era of incremental dynamic CT due in part to slow scanning speed and slow table translation. The bolus effect of the intravenous contrast material was therefore often missed especially when the injection rate was slow. With the utilization of a helical CT scanner in our Emergency Department, perisplenic CME was readily identified in this study while using an injection rate of 1.0-1.5 mL of contrast material per second. This was attributable to the facts that helical CT enabled a more rapid acquisition of a volumetric data and the perisplenic space was the uppermost peritoneal space to be scanned before the bolus effect was washed out.[21]

In the era of a newer generation of CT scanners, a multi detector-row CT (MDCT) can not only provide a shorter acquisition time for a larger anatomic coverage than a single slice helical CT (SSCT), but also makes retrospective reconstruction of volumetric data into thinner slices possible. Therefore, we can anticipate a more frequent encounter of perisplenic CME on a MDCT than on a SSCT in patients with major torso trauma.

In conclusion, perisplenic CME on contrast-enhanced helical CT of patients with blunt splenic injuries indicated active hemorrhage without adequate tamponade. Identification of perisplenic CME is important because it is a reliable predictive criterion for early surgical management in these patients despite the fact that their initial hemodynamic condition was stable at the time of CT examination.

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螺旋式電腦斷層上發現脾臟週圍顯影劑外漏：脾臟鈍傷病人需早期手術的可靠依據

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背 景： 研究螺旋式電腦斷層攝影中所發現外漏在脾臟週圍的顯影劑，是否爲預測脾臟鈍傷病人，需要早期手術治療的可靠依據。

方 法： 此回溯性研究的對象是80位脾臟鈍傷的住院病人(在12個月期間)，這些病人的電腦斷層影像皆經覆閱，並記錄是否有外漏在脾臟週圍的顯影劑與脾臟鈍傷的分級，所有病歷皆獨立回顧病人最後的治療方式，以及從電腦斷層檢查至因脾臟受傷而手術治療的時間間隔。

結 果： 80位病人當中，6位有外漏顯影劑而74位則無此發現。有40位病人是輕度脾臟鈍傷，40位爲重度鈍傷。所有6位有外漏顯影劑的病人，皆需要手術治療。而74位無外漏顯影劑之病人，僅29位需要手術治療，此一結果有統計學上的顯著差異 ($p=0.005$)。從電腦斷層至手術的時間間隔，在有外漏顯影劑的病人爲1.6±1.0小時，而無外漏顯影劑的病人爲7.6±12.9小時，此一結果亦有統計學上的顯著差異 ($p=0.028$)。而比較輕度及重度脾臟鈍傷的病人，其接受手術治療的百分比及從電腦斷層至手術的時間間隔，則無顯著差異。

結 論： 螺旋式電腦斷層攝影發現有外漏在脾臟週圍的顯影劑，比基於裂傷深度所作出之鈍傷的分級，更能預測脾臟鈍傷病人需要早期手術治療。
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關鍵字： 脾臟鈍傷，外漏顯影劑，螺旋式電腦斷層，脾臟週圍腹腔。

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