Blunt abdominal trauma: changing patterns in diagnostic and treatment strategies
van der Vlies, C.H.

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Summary and general discussion
INTRODUCTION

This thesis has focused on the diagnostics and treatment of patients with blunt abdominal injuries. Over the past 40 years, several changes have occurred in the management of patients with blunt abdominal trauma. Traditionally, open surgery was considered the standard of care. Currently, due to its low failure rate, nonoperative management (NOM) has evolved into the treatment of choice in hemodynamic stable patients. Failure is defined as clinical and radiological signs of a rebleeding requiring operative or radiological (re-) interventions. Chapter 1 describes the outlines of this present thesis.

Chapter 2 consists of a literature review, describing the advances in computed tomography (CT) scan and interventional radiology, which have contributed to an improved patient selection for the optimal treatment. Especially, the prominent place of multi-detector computed tomography scanning and the use of angiography and embolization (AE) are highlighted.

Part 1: Diagnostic strategies in blunt abdominal injury

The first part of this thesis describes the various aspects and findings of different diagnostic strategies and its implications for patients.

Other than hemodynamic instability, no reliable indicators, that predict the failure of NOM in pediatric trauma patients, are found in the current literature. Several recent studies in adults suggest that the presence of a contrast blush on CT scan is associated with an increased failure rate of NOM of blunt splenic and/or liver injury. However, the clinical implication of a contrast blush on CT scan with liver and/or splenic injury in the pediatric population has not yet been assessed. Chapter 3 presents a systematic review, which assessed all available literature on failure of NOM in children with splenic and liver injury in whom contrast extravasation is observed on CT scanning. Nine studies, published between 1985 and 2009, were included, describing 117 paediatric patients. Seven studies (including 71 patients) reported a total of 16 patients with failure after NOM without AE. The pooled failure rate was 28.2%. Two studies (including 46 patients) reported a total of 3 patients with failure after NOM with primary AE: a crude failure rate of 6.5%. Despite the current low level of evidence on failure rates of NOM when a contrast blush is present on CT scan, we emphasize that there is a significant number of patients in whom NOM fails. Therefore, the management of splenic and hepatic injury in children should not only be based on the hemodynamic situation, but should include consideration of the presence of contrast extravasation on CT scanning.

In Chapter 4 the history of three patients with a seatbelt sign following a car accident is described. All 3 patients exhibited various injuries that may occur in the case of blunt trauma, including rib fractures. In one patient, symptoms of internal abdominal injury only occurred several days after the accident. Typically, the presence of a seatbelt sign is associated with an increased risk of internal abdominal injury. Therefore, we advise that a CT scan of the abdomen
Chapter 12

needs to be considered in every patient, who presents with a seatbelt sign, even if abdominal ultrasound does not reveal signs of injury.

In Chapter 5 we investigate the inter- and intraobserver reliability between radiologists in classifying splenic injury on CT scanning. This study was performed according to the most widely used AAST grading system and the ‘Baltimore CT grading system’, of which the latter integrates vascular injuries into the score. Prior studies have shown that this system was superior to the AAST system in predicting the need for AE or surgery. CT scans of 83 patients with blunt splenic injury, admitted between 1998 and 2008, were retrospectively reviewed. The inter- and intraobserver reliability of both grading systems were equally high. Due to the integration of vascular injury into the system, the ‘Baltimore CT grading system’ supports clinical decision-making and therefore the use of this system in the classification of splenic injury is recommended.

Chapter 6 is a review of the literature assessing the role of ultrasonography and CT features, such as contrast extravasation, pseudoaneurysms, arteriovenous fistulas or hemoperitoneum, in the selection of patients for AE. The efficiency, technical considerations (proximal versus selective embolization), logistics and complication rates of AE in patients with blunt splenic injury are also discussed.

Part 2: Treatment strategies in blunt abdominal trauma

In the second part of this thesis, the results of NOM in patients with blunt splenic, liver and/or renal injuries, treated in Dutch level-1 trauma centers, are analysed and discussed.

In Chapter 7 the single center results of NOM in patients with blunt splenic injury, treated at the Academic Medical Center Amsterdam (1997–2008), are demonstrated. An analysis of a prospective trauma registry was performed for a 6-year period, both before (period 1) and after (period 2), the introduction of splenic artery embolization. An increased use of splenic artery embolization and a reduction of splenic operations in the second period were observed. The failure and splenic salvage rate were 17% and 89%, respectively, which is similar to the results of large volume studies from other Level I trauma centers. A high failure rate was observed in patients with a high grade injury combined with a contrast extravasation and a significant hemoperitoneum. In the second period, all patients with failure after observation could be successfully treated with splenic artery embolization.

To analyze risk factors for failure after NOM of patients with blunt splenic injury, we performed a multicenter cohort study, which is described in Chapter 8. In this retrospective analysis of 169 patients the overall failure rate was 17%. Seven patients who failed observation or AE could successfully be treated with (re-)embolization, leading to a splenic salvage rate of 91%.

Increased age (>50 years) and AAST grade of injury ≥3 were associated with failure in the multivariable logistic model. Although contrast extravasation is mentioned as a risk factor for failure and as an indication for AE, in this current study the presence of (intraperitoneal) contrast extravasation was not significantly associated with failure of NOM.
In Chapter 9 the results of NOM of liver injuries, before (period 1) and after (period 2) the introduction and implementation of AE, are described. Despite an increase in high grade liver injuries, NOM increased significantly in period 2 (72% versus 33% in period 1). Overall, liver-related mortality, treatment failure and complication rates remained equal in both periods. In patients with high grade injuries, the outcome improved significantly after the introduction of AE. However, liver infarction and abscess formation were more common after AE than after laparotomy.

Chapter 10 presents the results of a study comparing the diagnostics and treatment of blunt renal injury applied in a Level-1 trauma center with the recommendations of the European Association of Urology guidelines. Non-compliance with the guidelines increased with the severity of renal injury. The general conclusion was that high grade renal injuries were often successfully treated with AE instead of surgery (resulting in preservation of the kidney), which is recommended in the guidelines. In the next update of the guidelines AE deserves a more prominent role.

Complication registration is an important part of monitoring the quality of health care. Therefore, Chapter 11 describes the outcome of an analysis of complications occurring in hemodynamically stable patients, who underwent AE for internal hemorrhage after abdominal trauma or pelvic injury. The failure rate (12%) and incidence of organ-specific (19%) and procedure-related complications (3%) were low and could be managed conservatively or with minimally invasive interventions. In the present study trauma patients undergoing angiography had a high chance (24%) to develop Contrast Induced Nephropathy and future patients should therefore receive optimal prophylactic measures to avoid this complication.

**GENERAL DISCUSSION**

In the present thesis different aspects of the diagnostics and treatment of patients with blunt splenic, liver and renal injury are reported. In the first part various aspects and changing patterns of the diagnostic workup are analyzed and described.

Currently, the role of the CT scanner is very important, because of its high sensitivity (90–100%) to detect injuries to the spleen, liver, kidney and associated (intra-abdominal) injuries. Furthermore, the presence and exact localisation of contrast extravasation can be detected. Advances in CT technology have improved the physician's ability to determine more details of the parenchymatous injury and minor vascular lesions. Since vascular injuries are associated with failure of NOM, improvements in CT technology seem advantageous for the patient selection for the best treatment and thus to prevent failure of NOM. We found a tendency towards increased failure in children with splenic injury with a contrast extravasation on CT scan. However, the question arises if all hemodynamically stable patients with intraparenchymal contrast extravasation on CT scan should be treated with AE. In the multivariate regression analysis,
contrast extravasation was not identified as an independent risk factor for failure of NOM in patients with splenic injury.

Until now, CT scanning has not been able to differentiate exactly between patients who can be treated conservatively, patients who would benefit from AE and patients that would respond best to an operation. This decision should always be based on the clinical situation, the physiological response of the patient to initial resuscitation, the CT findings, the availability of an angio-room and expertise of performing AE.

In the second part of this thesis different studies have shown that patients treated with NOM in Level 1 trauma centers in the Netherlands was successful with success rates around 90%. These results are in accordance with the literature. The results showed that AE was a valuable adjunct to observational management and has increased the success rate of NOM. Most of the patients who failed treatment with observation and AE had high grade injuries combined with a contrast extravasation and a significant hemoperitoneum on the CT scan. Furthermore, these studies showed that the mortality and morbidity have improved after the introduction of AE, resulting in saved patients' lives, with blunt abdominal injury and immune function after splenic trauma.

Although the use of AE is generally reported to increase success rates of NOM, the optimal use of AE, especially in patients with high grade injury and a contrast extravasation, is still a subject of discussion. Future studies will need to focus on the prevention of failure of NOM and optimizing the patient selection for observational management, AE or operation. A well-designed randomised clinical trial is preferable, but is difficult to conduct because of the nature of the trauma population. Therefore, we are currently conducting a Delphi study to obtain experience-based agreement from a panel of independent international experts.