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ORIGINAL ARTICLE

THE OCCURENCE AND DETECTION OF HEMODYNAMICALLY SIGNIFICANT BLEEDING INTO THE RETROPERITONEUM IN PATIENTS DYING DUE TO BLUNT TRAUMATIC-HAEMORRHAGIC SHOCK

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Summary

Background: The occurrence of retroperitoneal bleeding and the manner of detection was retrospectively evaluated in patients with life-threatening traumatic bleeding.

Methods: The cohort included patients who died in the Trauma Centre of the University Hospital Hradec Kralove in Czech Republic between 2008 and 2012 due to traumatic hemorrhagic shock. Findings of retroperitoneal bleeding and the findings found for life (i.e., CT, FAST, pre-operative findings) were compared.

Results: During the five-year period, deaths due to the post-mortem diagnosis of traumatic hemorrhagic shock were recorded in 75 patients, 26 of which (35%) were verified by post-mortem autopsy to have hemodynamically significant bleeding into the retroperitoneum (HSBR) from 31 sources. HSBR was identified for life in 10 patients with HSBR (38.5%). Sensitivity was 55% in CT angiography and 36% in laparotomy without previous CT. The sensitivity of laparotomy with surgical exploration of the retroperitoneum was 67%. A predisposing factor for hemodynamically significant bleeding into the retroperitoneum, which may escape the surgeon's attention, is high-energy blunt trauma to the trunk.

Conclusions: In the acute stage of treatment of patients with life-threatening bleeding due to high-energy blunt trauma, the surgeon has to decide whether the patient's condition allows CT and whether hematoma of the retroperitoneum should be revised surgically. However, in the present cohort few patients with HSBR underwent surgical exploration of the retroperitoneum because the hematoma was ascribed to the known injury of the pelvis and spine.

Key words: blunt trauma in adult; retroperitoneal bleeding; traumatic hemorrhagic shock; detection of retroperitoneal bleeding; hemostasis

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Introduction

The occurrence of injuries to the retroperitoneum in blunt trauma to the trunk is approximately 44% (1) and the reported mortality rate 18-60% (2). The region is not easily accessible for rapid physical and ultrasound examination by Focused Assessment with Sonography in Trauma (FAST) (3–5). Performing diagnostics on these injuries is difficult, particularly in polytraumatized patients in hemorrhagic shock (6), and in many cases the surgeon is limited by time (7).

The present study aimed to determine the occurrence of hemodynamically, significant, severe bleeding into the retroperitoneum in patients who died of traumatic hemorrhagic shock (THS) in the Trauma Centre of the Faculty Hospital Hradec Kralove which can be cause of death found by section, laparotomy with reptroperitoneal exploration or computed tomography and to compare the sensitivity of computed tomography versus explorative surgery of the abdominal cavity for HSBR. We attempted to determine predictive factors of possible bleeding into the retroperitoneum in traumatized patients.

Methods

A retrospective evaluation was performed in a basic cohort of 986 triage positive (TP) patients with ISS (Injury Severity Score) > 15 (median 23) from the prospectively assembled registry of primary admissions at TC FHN HK from January 1st, 2008 to December 31st, 2012. TP patients are defined as those who fulfill the criteria in pre-hospitalization care for admission to the 1st degree trauma center (8).

75 patients (8% of the basic cohort) were identified as having died because of THS according to findings during post-mortem autopsy. In these patients, clinical documentation and findings from the post-mortem examination were reviewed. The post-mortem autopsy identified the source of bleeding into the retroperitoneum in 40 patients (4% of the basic cohort). These patients were analyzed from the viewpoint of the intensity of bleeding into the retroperitoneum. The HSBR evaluation included lesions in the vascular kidney pedicle in the hilum of the kidney, laceration of the renal parenchyma, injury of the abdominal aorta and *inferior vena cava*, injury of *a. lumbalis, v. iliaca communis, v. iliaca externa, a. iliaca interna*, and bleeding from the adrenal glands. Injuries to the urinary bladder, contusion of the pancreas, and intracapsular hematomas of the kidney were considered to be hemodynamically insevere. In 26 patients (2.6%), at least one source of HSBR was found, and this group represents the evaluated cohort.

The following parameters were evaluated: age, sex, mechanical factor of triage (MFT), time interval between the pre-hospitalization stage and stay at the Emergency Department (ED), blood pressure (BP) when received at the ED, result of FAST, directing the patient from the ED, the type of device used for CT and the result of examination, blood pressure at CT examination or during the laparotomy period, injuries in the individual body systems according to the Abbreviated Injury Scale (AIS) (9, 10), localization and number of sources of HSBR, manner of identification of the sources of HSBR, and the time period since the injury to death. The probability of survival (PS) was evaluated using the Trauma and Injury Severity Score (TRISS) (11). The present study does not include the patients in whom a source of HSBR was revealed, but those who survived.

Results

Injuries

The 26 patients with HSBR comprised 17 males (65%) and 9 females (35%) with an average age of 38 years. In 21 patients (81%), TP criterion M (Mechanism of Injury) was observed. Unmeasurable BP at admission to the ED occurred in 5 patients (19%); in 21 patients the average input BP was 101/67 mmHg. The average stay at the ED was 40 min (median 31 minutes); among the 22 surviving patients the average stay at the ED was 43 minutes (median 35 minutes; Table 1)

In 21 MFT+ (Mechanical Factor of Triage Positivity) patients (81%), the cause was fall from height > 6 m in five patients, being run over by a car in one patient, knocked down by a car at a speed > 35 km/h in five patients, catapulting from a car in one patient, wedging in a car in eight patients, and death of a fellow passenger in one patient (Table 2).

Table 1. Evaluated patient cohort (n=26)

	n	ø	x˜	σ
Males	17 (65%)			
Age (years)		38	35	20
MFT+	21 (81%)			
Pre-hospitalization stage (minutes)		60	60	31
Patients with unmeasurable input BP at the ED	5 (19%)			
Input BP at the ED in 21 patients (mmHg)		101/67	95/60	24/23
Time period at the ED (minutes)		40	31	21

Data are given as n (%) unless otherwise noted. MFT+, positive for some of the mechanical factors of triage in the pre-hospitalization stage.

Table 2. Mechanical factor of triage in 21 patients from the evaluated cohort of 26 patients with HSBR

Fall from height > 6 m	5 (23)
Run over by car	1 (5)
Knocked by car at speed > 35 km/h	5 (23)
Catapulting from car	1 (5)
Wedging in car	8 (38)
Death of a fellow passenger	1 (5)
∑	21 (100)

Data are given as n (%).

The distribution of injuries in the individual body regions with AIS ≥ 3 is shown in Table 3. The average ISS was 51 (median, 50). In all patients it was a blunt trauma.

In 26 patients, post-mortem examination identified 31 sources of HSBR: laceration of the kidney (n = 9, 29%), hilar lesion (n = 8, 26%), injury of the *inferior vena cava* (n = 5, 16%), bleeding from the adrenal gland (n = 2, 6.5%), injury of the abdominal aorta (n = 1, 3.2%), or injury of *v. iliaca communis* (n = 1, 3.2%), *v. iliaca externa* (n = 1, 3.2%), *a. iliaca interna* (n = 1, 3.2%), or *a. lumbalis* (n = 3, 9.7%) (Table 4).

In 23 patients (88.5%), post-mortem autopsy identified only one source of HSBR. In the 3 remaining patients (11.5%), more than one source of HSBR was found: hilar renal lesion, injury of two lumbar arteries, and rupture of the abdominal aorta and *inferior vena cava* in one patient; injuries in the lumbar artery, *v. iliaca communis*, and *externa* in the second patient; and laceration of both adrenal glands in the third patient. With regard to the high percentage of missing data on hematuria upon admission, hematuria is not further dealt with in the present cohort.

Table 3. Injured body regions with AIS ≥ 3

Head (neurocranium) and/or neck	17 (65)
Chest	22 (85)
Abdomen	21 (80)
Extremities and pelvis	19 (73)
Pelvis	10 (38)
ISS ø; x˜	ISS 51; 50

Date are presented as n (%) unless otherwise noted. AIS, Abbreviated Injury Scale; ISS, Injury Severity Score.

Table 4. Hemodynamically severe bleeding into the retroperitoneum

Renal parenchyma	9 (29)
Renal hilus	8 (25.8)
A. lumbalis	3 (9.7)
Adrenal gland	2 (6.5)
Aorta	1 (3.2)
A. iliaca interna	1 (3.2)
Inferior vena cava	5 (16.1)
V. iliaca communis	1 (3.2)
V. iliaca externa	1 (3.2)
∑	31 (100)

Date are presented as n (%).

Imaging examinations and directing patients from the ED

The examinations managed to reveal the source of HSBR during life in 10 (39%) of the 26 patients with HSBR. All patients with confirmed HSBR underwent FAST in the ED, which demonstrated a severe hemoperitoneum in 14 (53%) (FAST+). The sources of the hemoperitoneum were liver lacerations (n = 6), spleen lacerations (n = 3), and both liver and spleen lacerations (n = 5). FAST examinations did not reveal HSBR in any of the 26 patients.

Four patients died in the ED (time period at the ED ø 0:24; x 0:22), three of whom were FAST+. Eleven patients were directed to the operating theater for laparotomy (time period at the ED, ø 0:36; $\tilde{x}$ 0:30), all of them FAST+.

For admission CT, 11 patients were dispatched (time period at the ED ø 0:56; $\tilde{x}$ 0:49), none FAST+. Admission CT was performed with an intravenous bolus of contrast medium in 11 patients (42% of 26 patients with HSBR), identifying the source of HSBR in 6 of them (55%). All five false-negative CT examinations concerning HSBR were performed using a Siemens Somatotom Definition AS + (128 spiral) with contrast in both the arterial and venous stage. The average BP in these five patients with HSBR at the time of the CT was 104/65 mmHg (ø).

Table 5. Identification of the source of HSBR by CT

Source of HSBR	Revealed in CT	PS (%)	CT device	BP (mmHg)
Renal parenchyma	Yes	59.2	SSD AS+	89/36
A. iliaca interna	Yes	55	SSD AS+	108/82
Renal parenchyma	Yes	27.6	SSD AS+	103/60
Renal hilus, IVC	Yes	20	SSP 4	80/50
Renal parenchyma	Yes	16.6	SSD AS+	95/80
Renal hilus	Yes	5.9	SSB	55/32
A. renalis duplex	No	84.7	SSD AS+	113/45
Renal parenchyma	No	49.3	SSD AS+	112/80
Suprarenal glands, both sides	No	4.2	SSD AS+	48/31
A. lumbalis	No	0.6	SSD AS+	104/61
A. renalis	No	84.7	SSD AS+	99/70

HSBR, hemodynamically severe bleeding in the retroperitoneum; PS, probability of survival using the Trauma Score and Injury Severity Score; SSD AS+, Siemens Somatom Definition AS+ (128 spiral); SSB, Siemens Somatom Balance (1 spiral); SSP 4, Siemens Somatom Plus 4 (1 spiral).

Of the six positive CT examinations, four examinations used a Siemens Somatotom Definition AS + (128 spiral) and the two others used a Siemens Somatotom Balance (1 spiral) or a Siemens Somatotom Plus 4 (1 spiral). In these six patients with HSBR during the period of CT examinations, the average BP was 88/57 mmHg (ø).

The sensitivity of 11 CT examinations for HSBR amounted to 55%. The sensitivity of CT for HSBR in patients with systolic BP < 90 mmHg at the time of examination was paradoxically higher (75%) than in the patients with BPs > 90 mmHg (42%) (Table 5).

Doubled *a. renalis* without signs of leaking contrast medium (see the patient with BP 113/45 mmHg). *A. lumbalis*, when HSBR was added to the described sources from internal iliac arteries as external to these (see the patient with BP 104/61 mmHg).

On the basis of the post-mortem autopsy findings, all CT descriptions were re-evaluated by an independent radiologist who, upon further reading of CT documentation, did not find any differences compared to the first description.

With regard to the fact that all patients in the cohort suffered from bleeding into the retroperitoneum and false-positive results were not present, the specificity of CT examinations and explorative surgery of the abdominal cavity cannot be determined.

Exploration of the abdominal cavity

Urgent exploration of the abdominal cavity, without previous CT examinations, were performed in 11 patients (42% of 26 patients with HSBR), during which the source of HSBR was revealed in 4 (36%). Of seven patients with a preoperatively unidentified source of HSBR, two underwent surgical exploration of the retroperitoneum. During surgery, the seven patients had an average BP of 80/40 mmHg. For the four patients in which the source of HSBR was found preoperatively but underwent surgical exploration of the retroperitoneum, their average BP was 80/45 mmHg. In two patients the preoperative arterial pressure was unmeasurable.

The sensitivity of explorative laparotomy for the sources of HSBR amounted to 36% and is associated with surgical exploration of the retroperitoneum, achieving 67%, and no severe difference was found in the arterial pressure. The sensitivity of laparotomy for HSBR was lower in patients with systolic BP < 90 mmHg at the time of surgery (70%) than in the patients with systolic BP > 90 mmHg (80%).

Table 6. Patients with identified sources of HSBR

Source of HSBR	Recognized preoperatively	PS (%)	Revision of RP	Hematoma in RP (Zone)	BP (mmHg)
Renal parenchyma	No	92	No	I, III	90/50
Renal parenchyma	No	55	No	I, III	90/50
Renal parenchyma	No	44	No	II	60/30
Renal parenchyma	No	36	Yes	II	80/50
Renal pedicle	No	11	Yes	III	70/30
Inferior vena cava	No	6	No	Without hematoma	95/65
Renal parenchyma	No	1	No	Without hematoma	80/40
Renal parenchyma	Yes	85	Yes	II	90/40
Renal hilus	Yes	3	Yes	I	†††
Inferior vena cava	Yes	16	Yes	I	70/50
Inferior vena cava	Yes	55	Yes	I	†††

HSBR, severe bleeding into the retroperitoneum; PS, probability of survival using the Trauma and Injury Severity Score; RP, retroperitoneum; BP, blood pressure at the start of laparotomy; †††, unmeasurable pressure.

Surgical explortion of the retroperitoneum was performed in 6 patients (55%) and allowed identification of one source of bleeding in four of them: inferior vena cava (n = 2), laceration (n = 1), pedicle lesion of the kidney (n = 1). In two patients, the exploration of the retroperitoneum did not reveal the source of HSBR (n = 1 renal laceration, n = 1 pedicle lesion of the kidney).

Of five patients who did not undergo surgical exploration of the retroperitoneum (45%), a perceptible hematoma of the retroperitoneum was ascribed to the known associated injury of the pelvis or spine in three of them, and revision was not indicated. In two patients no suspicion of retroperitoneal injury was stated and exploration not advised (Table 6).

Thus, exploration of the retroperitoneum was HSBR-positive four times and false-negative twice. The sensitivity of exploration of the retroperitoneum was 67%.

Probability of survival (Preventability of death)

PS was calculated using the TRISS calculator for pro blunt traumas. In the evaluated cohort of 26 patients with HSBR, PS was 34% on average (median 24%). In 13 patients (50%), PS was < 25% (unpreventable). Nine patients (35%) had a PS of 25-75% (potentially preventable deaths). In 4 patients (15%), the PS was > 75% (preventable) (Table 7).

Table 7. Times of deaths and probability of survival

	n (%)	ø	x˜	σ
Time from trauma to exit (h:min)		6:25	3:49	6:14
PS according to TRISS in the whole cohort		34%	24%	31%
PS < 25%	13 (50%)			
PS 25 – 75%	9 (35%)			
PS > 75%	4 (15%)			

PS, probability of survival; TRISS, Trauma and Injury Severity Score

Discussion

For all patients, the authors conformed to ATLS principles (12); the first examination and resuscitation with evaluation of the trend of hemodynamic response is followed, on the basis of identified priorities, by either urgent surgical cavity hemostasis (persistent hemorrhagic shock with cavity bleeding) or CT angiography (at least temporary improvement in hemodynamics without demonstration of cavity bleeding), followed by surgical or endovascular hemostasis according to the character of the proven sources of bleeding. Nevertheless, transcatheter arterial embolization may include some risk. In pelvic injuries, which were present in 38% of patients in our cohort, transcatheter arterial embolization is suitable for patients with type B1 fractures ("open book") (13) after laparoscopic exploration of the abdominal cavity (14). However, some studies point out that the seriousness of pelvic trauma is due to associated injuries (15–18). The occurrence of pelvic traumas in blunt injuries has been reported to be 2%, with an incidence of 23/100,000 inhabitants of big cities (19,20). Most are stable fractures, and only 10% of pelvic fractures are responsible for hemodynamically severe bleeding into the retroperitoneum (19). Practical application of a standardized proactive protocol for massive transfusions, improving hemodynamics and decelerating the development of coagulopathy, establishes the conditions for the performance of CT in patients who died already in the ED or were indicated for emergence surgery (21–23). In addition, technical progress and a new algorithm for the whole-body CT trauma protocol (with contrast) has shortened the duration of CT and made it possible to increase the number of patients examined in this manner (24,25). CT examinations in both our study and the literature can be limited, despite the signs of hypoperfusion in CT, just due to false-negatives (26). However, even in negative ultrasound examinations of cavities in a patient with unexplained life-threatening acute blood loss, CT angiography can reveal the source of bleeding despite low systemic BP and direct causal treatment in the right direction (27). In the present case, it means into the retroperitoneum, which is worse observable by FAST examination. Certain sources (parenchyma or renal hilus, inferior vena cava) require urgent surgical procedures, but others require endovascular treatment (*Aa. lumbales* etc.). Thus, finding the source of severe retroperitoneal bleeding early makes early activation of the vasographic team possible, and they are able to stop bleeding that would otherwise be difficult to stop surgically by using the pertinent technical equipment, possibly even in the operating theater.

No relationship was demonstrated with either the degree of technical development of the device (see the origin of all false-negative examinations from the most technically advanced device), or the hemodynamic situation (see the higher values of the average BP in patients with false-negative results). The remaining question is the indication of surgical exploration of retroperitoneum hematoma in blunt traumas during laparotomy without previous CT angiography, particularly in patients with associated injuries and more sources of bleeding. In laparotomy, exploration of the retroperitoneum is indicated in the case of supracolic and infracolic hematoma in Zone I, and hematoma in Zone II is revised in the case of palpably increasing expansion from the kidney or palpable pulsating hematoma. A hematoma of the retroperitoneum in Zone III is revised in the case of pulsating and expanding hematoma or disappearance of pulsations of ipsilateral *a. iliaca communis* (28). Quite long prehospital time (average 60 minutes) is in our study due to of our older prehospital care system, in now days we have prehospital care about 35 minutes.

Conclusion

A predisposing factor for HSBR, which can escape attention, is high-energy blunt trauma to the trunk with positivity for MFT. The typical patient suitable for CT of the retroperitoneum is a TP patient with blunt trauma of the trunk with MFT+ 81%, despite grave hypotension with a distribution of injuries in the thorax, 85%, abdomen, 80%, pelvis and extremities, 73%. In particular, patients with a negative or unclear finding in FAST, in which the source of bleeding is not identified and FAST is false-negative, are indicated for CT. Even systemic hypotension (BP < 90 mmHg) does not exclude possible good detection of a leak of the contrast medium 29. CT examinations with contrast medium may, despite possible false-negative CT descriptions in an unstable patient, be another clue for the surgeon not to confuse HSBR with hematoma caused by pelvic or spinal trauma. When circulatory instability continues (intensification of THS) in the patient despite surgical hemostasis of the known sources of bleeding, it is necessary to consider a possible source in the retroperitoneum and to revise a possible hematoma, particularly expanding ones. Quite long prehospital time (average 60 minutes) is in our study due to of our older prehospital care system, in now days we have prehospital care about 35 minutes.

With regard to the time-consuming demands for the description of whole-body CT, it is necessary in unstable patients suspected of bleeding into the retroperitoneum to communicate with the describing radiologist and to select the region of the cavity and retroperitoneum as the primary region. Early identification of the source of HSBR in this case may help in the decision-making process regarding further directing of the patient and early activation of the vasographic team.

Declarations

Ethics Approval and Consent to Participate

Ethic Comimmitte´s opinion – Favourable my opinion Reference Number 201805 S13P 3May2018.

The ethics committee waived patient consent to review their medical records and was the data de-identified, because all the patient died early.

Competing interests

The authors declare that they have no competing interest. The authors declare that they have no fundings, no publications of manuscript in any other journal.

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