Changing Pattern for Management of Severe Blunt Liver Trauma – CT Reconstruction: a Useful Complementary Tool?

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In other fields than the evaluation of the injured abdomen, CT has proved to be a valuabe tool by providing images of the studied structures. We hypothesised that more realistic depiction of lesions by CT could be of interest for surgeons who are treating blunt abdominal trauma and lead to less inappropriate triage especially for blunt hepatic trauma.

Good working relationship between surgeons and radiologists allowed us to perform for the last twenty years emergency assessment of blunt abdominal trauma by ultrasound exam during the early 80s decade and by computed tomography (CT) since 1986. Among 290 patients presenting with blunt abdominal trauma, 146 had sustained blunt hepatic trauma whose CT-based injury scores ranged from grade 1 to 5 according to Mirvis *et al*. classification (median: grade 2).

CT is a first line diagnostic tool for quantifying blunt abdominal traumas and for making the choice between nonoperative and operative treatment. Our experience demonstrates that the majority of severe blunt hepatic injuries, up to and including grade 4 severity correctly assessed by emergency CT, can be managed non operatively in hemodynamically stable patients.

Introduction

Patients with life-threatening injuries make up approximately 10 to 15 percent of all patients hospitalized because of injuries (Trunkey, 1991). If the patient remains hemodynamically stable after initial assessment and proper resuscitation, it is then appropriate to perform diagnostic studies to determine surgical or medical priorities. First of all, it must be determined where occult blood loss is occurring. Three sites of hidden blood loss are the pleural cavities (a possibility that can be easily ruled out by radiograph of the chest), the thigh and the abdomen. Assessment of the abdomen on the basis of physical signs can be extremely misleading inasmuch as 50% of patients with substantial hemoperitoneum have no clinical signs (Trunkey, 1991; Olsen *et al*., 1979; Bivins *et al*., 1978). Common sense dictates that if radiograph of the chest is normal and the femur is not fractured, the patient who remains unstable must be suspected of having ongoing hemorrhage in the abdomen or pelvis. Increasingly, computed tomographic (CT) scan is used to identify and quantify abdominal traumas. The diagnostic use of CT scan in emergency situations may further increase with the availability of newer and faster units.

Emergency initial evaluation of the injured abdomen has most obviously benefited from the introduction of the so-called spiral CT technique. Examination time has been reduced to less than 40 seconds for complete coverage of the abdomen and pelvis, allowing to get better vascular opacification through the entire study with use of lower doses of intravenous contrast medium. Moreover, if the patient is able to hold his breath during the single acquisition, true contiguity of the slices can be achieved, thus avoiding the misregistration artefact that resulted from the variable positions of the diaphragm when sequential slices were performed one after another. Nevertheless, while CT scan is an accurate method for identifying and quantifying splenic, hepatic and renal injuries, CT cannot reliably help predict the outcome of those injuries (Mirvis *et al*., 1989; Becker *et al*., 1994). Treatment choices, either surgical or conservative, should therefore still be based on the hemodynamic and clinical status of the patient and on results of serial laboratory and bedside assessments (Mirvis *et al*., 1989; Becker *et al*., 1994; Roberts *et al*., 1993; Gay *et al*., 1992). We here report our experience over the last fifteen years with blunt hepatic trauma, that has also moved progressively from an aggressive surgical strategy towards a less invasive conservative attitude for even severe hepatic trauma occurring in patients remaining hemodynamically stable. Several illustrative cases will be presented to document the changing pattern of management of severe blunt hepatic trauma thanks to the informations that can be obtained from emergency CT.

Patients and Methods

Patients and Injury Severity Scoring (ISS)

From July 1986 to December 1999, 290 patients (124 women and 176 men) of mean age 34 year (median 27, range 4-85) were admitted in the surgical service for blunt abdominal trauma. The initial injury severity score (ISS) was established according to the scale (Table I) proposed by Baker *et al*., (1974) and revised by Mayer *et al*., 1980. Two hundred and seventy patients (93%) had associated injuries (i.e., thorax, extremities,

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Table I. INJURY SEVERITY SCALE CODE (Baker *et al*., Mayer *et al*.)

Minor – 1	
Neurologic	*Abdomen*
– GCS 15	– Muscle ache, seat belt abrasion
Face and Neck	*Extremities*
– Abrasion/contusion of ocular apparatus, lid	– Minor sprains
– Vitreous or conjunctival hemorrhage	– Simple fractures/dislocations
– Fractured teeth	
Chest	
– Muscle ache or chest wall stiffness	
Moderate – 2	
Neurologic	*Abdomen*
– GCS 13–14	– Major abdominal wall contusion
Face and Neck	*Extremities*
– Undisplaced facial bone fracture	– Compound fracture of digits
– Laceration of eye, disfiguring laceration	– Undisplaced long-bone or pelvic fractures
– Retinal detachment	
Chest	
– Simple rib or sternal fracture	
Severe, not life-threatening – 3	
Neurologic	*Abdomen*
– GCS 9–12	– Contusion of abdominal organ
Face and Neck	– Retroperitoneal hematoma
– Loss of eye, avulsion optic nerve	– Extraperitoneal bladder rupture
– Displaced facial fractures	– Thoracic/lumbar spine fractures
– “Blow-out” fractures of orbit	
Chest	*Extermities*
– Multiple rib fractures	– Displaced long-bone or multiple hand/foot fractures
– Hemothorax or pneumothorax	– Single open long-bone fracture
– Diaphragmatic rupture	– Pelvic fracture with displacement
– Pulmonary contusion	– Laceration of major nerves/vessels
Severe, life-threatening – 4	
Neurologic	*Abdomen*
– GCS 5–8	– Minor laceration of abdominal organs
	– Intraperitoneal bladder rupture
	– Spine fractures with paraplegia
Face and Neck	*Extremities*
– Bony or soft-tissue injury with minor destruction	– Multiple closed long-bone fractures
Chest	– Amputation of limbs
– Open chest wounds	
– Pneumomediastinum	
– Myocardial contusion	
Critical, Survival uncertain – 5	
Neurologic	*Abdomen*
– GCS ≤ 4	– Rupture or severe laceration of abdominal vessels or organs
Face and Neck	*Extremities*
– Injuries with major airway obstruction	– Multiples open long-bone fractures
Chest	
– Laceration of trachea, Hemomediastinum	
– Aortic laceration	
– Myocardial laceration or rupture	

Table I. (Contd.)

How to compute the CLASGOW COMA SCALE (GCS)

Eye opening	*Injury Severity Scale*	*Coma correlate*
4 Spontaneous		
3 To speech	0 – No injury	15
2 To pain	1 – Minor	13–14
1 None	2 – Moderate	9–12
Best verbal response	3 – Severe, not life-threatening	|
5 Oriented	4 – Severe, life threatening,	↓
4 Confused	survival probable	5–8
3 Inappropriate	5 – Critical, survival uncertain	≤4
2 Incomprehensible		
1 None		
Best motor response		
6 Obeys command		
5 Localizes pain		
4 Withdraws		
3 Flexion to pain		
2 Extension to pain		
1 None		

How to compute the INJURY SEVERITY SCALE

	Score	Square	**Key**
			0 = No injury
Neurologic	______	______	1 = Minor
Facial and Neck	______	______	2 = Moderate
Chest	______	______	3 = Severe, but not life-threatening
Abdomen	______	______	4 = Severe, life-threatening, survival probable
Extremities and Pelvis	______	______	5 = Critical, survival uncertain

ISS Score ______
(sum of the square of 3 most severe only)

head and face, brain) and 66 (23%) patients were injured while drunk driving. Mean ISS was 22 (median 17, range 3-75). The cause of the trauma was motor vehicle accident (MVA) in 177 patients (61%), from which 23 (7.9%) motorcycle accidents.

Procedure

On admission, all patients underwent complete clinical and neurological assessment, as well as primary survey of airway, breathing and circulation. Only patients who presented with or soon achieved hemodynamic stability with resuscitation progressed to the CT scan. Close monitoring by at least one experienced surgeon from our team associated to a good working relationship with the tomographer led for each patient to prompt and appropriate CT studies. Patients elected for non operative treatment after initial CT scan and remaining in a stable clinical and hemodynamic status had their abdominal lesions evaluated again by a CT scan completed 24 to 48 hours later by spiral CT.

Follow-up CT examinations were performed 48 hours after the emergency initial evaluation on a Somatom-Plus-S CT scanner (Siemens, Erlangen, Germany). All follow-up studies were divided into two parts. The first part, performed after vigorous iodinated contrast medium intravenous infusion, was strictly limited to the organs which had appeared most injured at the initial CT (most often spleen alone or spleen and kidney), and acquisition parameters were adapted so as to maximize both longitudinal and transverse spatial resolutions. This led to proceed with thin collimation (2 or 3 mm) and low table speed (4 to 6 mm/s). Slices were reconstructed with 50 percent overlap while limiting the field of view to the concerned hemiabdomen. The second part of the examination consisted in a global spiral CT survey of the whole abdomen and pelvis without further infusion of intravenous contrast material.

Hepatic Injury Scaling

Among the 290 pateints sustaining blunt abdominal trauma, 146 presented with blunt hepatic trauma whose CT-based injury scores ranged from grade 1 to 5 according to Mirvis *et al*. classification. Median injury-

Table II. CT-based Injury-Severity Grades for Blunt Hepatic Trauma (Mirvis *et al.*)	
Grade	Criteria
1	Capsular avulsion, superficial laceration(s) <1 cm deep, subcapsular hematoma <1 cm maximal thickness, periportal blood tracking only
2	Laceration(s) 1–3 cm deep, central/subcapsular hematoma(s) 1–3 cm diameter
3	Laceration(s) >3 cm deep, central/subcapsular hematoma(s) >3 cm diameter
4	Massive central/subcapsular hematoma >10 cm, lobar tissue destruction (maceration or devascularization)
5	Bilobar tissue destruction (maceration) or devascularization.

Table III. Organ injury scaling: spleen, liver, and kidney (grade and description)	
Spleen	
I	Subcapsular hematoma <10% of surface, laceration <1 cm deep
II	Subcapsular hematoma 10–50% of surface area, laceration 1–3 cm deep
III	Subcapsular hematoma >50% surface area or expanding, intraparenchymal hematoma >5 cm or expanding
IV	Laceration involving segmental or hilar vessels with major devascularization
V	Completely shattered spleen, hilar vaslcular injury that devascularized spleen
Liver	
I	Subcapsular hematoma <10% of surface area, laceration <1 cm deep
II	Subcapsular hematoma 10–50% of surface area, laceration 1–3 cm deep; <10 cm in length
III	Subcapsular hematoma >50% of surface area or expanding, laceration >3 cm deep
IV	Parenchymal disruption involving 25–75% of hepatic lobe or 1–3 Couinaud's segments in a single lobe
V	Parenchymal disruption >75% of lobe or >3 Couinaud's segments, juxtahepatic venous injuries (retrohepatic vena cava/hepatic veins).
Kidney	
I	Contusions: hematuria with normal urologic studies; hematoma: subcapsular, nonexpanding without parenchymal laceration
II	Hematoma nonexpanding, perirenal hematoma confined to retroperitoneum; laceration <1 cm parenchymal depth of renal cortex
III	Laceration >1 cm parenchymal depth of renal cortex without collecting system rupture or urinary extravasation
IV	Laceration: parenchymal laceration extending through the renal cortex, medulla, and collecting system; vascular: main renal artery or vein with contained hemorrhage
V	Laceration: completely shattered kidney; vascular: avulsion of renal hilum that devascularized kidney.

Modified from Moore E.E., Cogbill T.H. Jurkovich G.J., *et al.*: Organ injury scaling: Spleen and liver. J. Trauma 28: 1005, 1994; and Moore E.E., Cogbill T.H., Jurkovich G.J. *et al.*: Organ injury scaling: Spleen, liver, and kidney. J. Trauma 29: 1664, 1989.

severity grade for blunt hepatic trauma for these 146 patients was 2 according to the Mirvis classification of CT-based injury-severity grades for blunt hepatic trauma (Table II), which is, in fact, a radiological variant of the intraoperative organ injury scaling (Table III) from Moore *et al*. classification.

Results

One hundred and forty six patients (50.3%) sustained a blunt hepatic: 106 out of the 146 (72%) occurred after MVA and 19 (13%) after motorcycle accident.

Blunt hepatic trauma was associated in 80 (55%) cases to spleen lesions and in 121 cases to some kind of blunt kidney lesions (13%). Comparison of ISS of the 146 patients sustaining hepatic trauma with ISS of the 144 sustaining no hepatic trauma are detailed in Table IV and Figure 1, as well as ISS corresponding to several other combinations of risk factors and/or associated lesions.

Mortality

Overall mortality (Table IV) in the series of 290 patients was 7.3% (21 patients). Three patients (2.1%)

Table IV. Comparison of Injury Severity Score (ISS) and mortality in different subgroups

	n	mean ISS	median ISS	range	Mortality (%)
Overall series	290	22	17	3–75	21 (7.2)
No hepatic trauma	144	14	12	3–50	3 (2.1)
Hepatic trauma	146	30	27	6–75	18 (12.3)
Hepatic + spleen tr.	80	34	34	9–75	13 (16.2)
Hospital deaths	*21*	*52*	*50*	*24–75*	

Table V. Comparison of initial Injury Severity Score (ISS) and mortality in different subgroups from the 146 patients sustaining hepatic trauma

	n	mean ISS	median ISS	range	Mortality (%)
Hepatic trauma	146	30	27	6–75	18 (12.3)
Laparotomy (all indications)	48	37	40	9–75	13 (27.0)
Laparotomy for hepatic tr.	11	51	50	38–66	4 (36.4)
Laparotomy for lesions other than liver trauma but liver trauma present*	22	36	31	17–75	6 (27.2)
Laparotomy in the series of 144 patients without hepatic trauma	15	28	25	9–50	3 (20.0)

* Eight other patients (8/144; 4.16%) died in the emergency department before any surgical operation could be attempted. All six had, among other lesions, hepatic lesion confirmed at postmortem exam (mean ISS 53; median 54; range 36–75).

died in the series of 144 patients without hepatic trauma. Eighteen patients (12.3%) died in the series of in 146 patients sustaining hepatic trauma. Eight of them (8/18; 44%) died during transfer or in the emergency room before any surgery could be attempted; all of them had, among other injuries, severe blunt hepatic trauma confirmed at autopsy.

Forty eight patients had emergency laparotomy for active bleeding (Table V): 11 laparotomies for hepatic lesions (four patients died); 22 laparotomies in patients presenting less severe hepatic trauma but in which laparotomy was indicated for other intra abdominal lesions (small bowel 3, diaphragm rupture 3, spleen 15, pancreas and spleen 1; six patients died).

Among the 144 patients who had blunt abdominal trauma without hepatic lesion, 15 underwent emergency laparotomy. Three patients died ultimately: one from consequence of an associated brain trauma and two from multiple organ failure (MOF). None of the 242 patients who were elected for non operative treatment actually died. Here again it is interesting to compare ISS score assessed in the emergency room for different subgroups of patients (Figures 2 and 3).

Illustrative Cases of Severe Blunt Hepatic Trauma Elected for Conservative Treatment

Even though CT scan is a very useful method for identifying and quantifying abdominal and retroperitoneal injuries, as well as documenting progression of critical injuries, the "ultimate decision for laparotomy should be based on clinical status and not on radiographic findings and scoring" (Mirvis *et al*., 1989; Raptopoulos *et al*., 1991; Umlas *et al*., 1991). However, since the beginning of our experience, we have never expected more from the scoring than the system was intended for, that is to say: the scoring system should not replace clinical evaluation, but should help identify the patients who although initially considered candidates for nonoperative treatment may eventually need surgery. Scoring system should be used with the under-

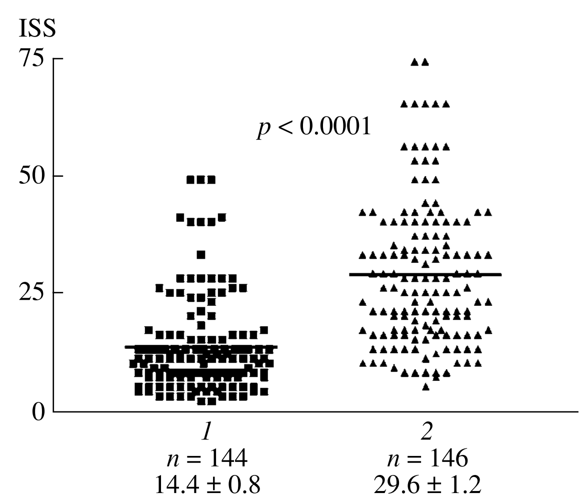

Fig. 1. Comparison of ISS between patients without (*1*) and with hepatic trauma (*2*).

Рис. 1. Показатели ШТП у пациентов без травмы печени (*1*) и с тупой ее травмой (*2*).

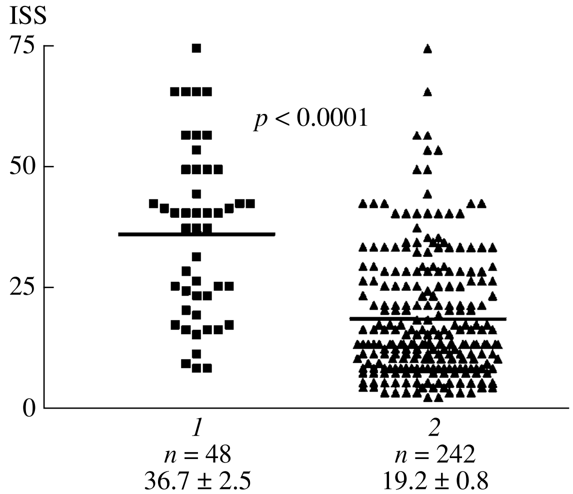

Fig. 2. Comparison of ISS between patients treated by laparotomy or conservatively.

Рис. 2. Показатели ШТП у пациентов, оперированных (*1*) и получавших консервативное лечение (*2*).

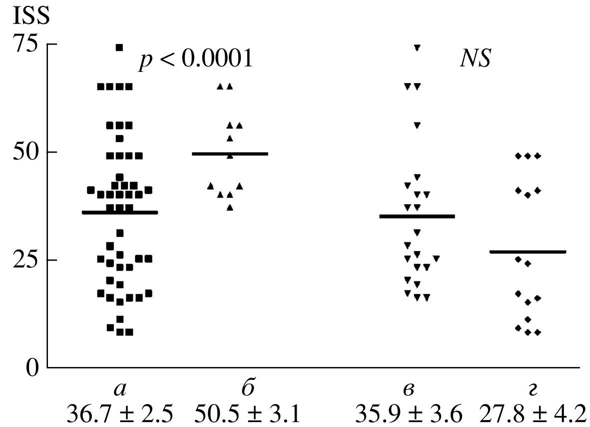

Fig. 3. Comparison of ISS of laparotomy subgroups.

Рис. 3. Сравнение ШТП в подгруппах оперированных пациентов.

а – всего оперированных (*n* = 48); *б* – лапаротомия при травме печени (*n* = 11); *в* – лапаротомия при повреждениях органов брюшной и сочетанной с ними травмой печени; *г* – лапаротомия в группе из 144 пациентов не имевших травмы печени (*n* = 15).

standing that false-negative or false-positive CT results do occur (Federle *et al*., 1987; Pappas *et al*., 1987; Taylor *et al*., 1984; Fagelman *et al*., 1985). Therefore close surgical monitoring is mandatory for patients for whom nonoperative treatment is chosen, whether this choice is based on clinical criteria, CT scoring, or on combination of both. The presentation of the following cases is aimed at demonstrating the return that the surgeons can get, particularly for liver trauma, from the CT imaging while keeping close repeated assessment of blunt abdominal trauma patients.

Case One

The first patient, 27-year-old woman, had an ISS of 35 on admission after a motorcycle (750 cm^3) accident. She sustained facial, cerebral, thoracic, extremities and blunt abdominal injuries. Her liver injury was quantified as a CT injury severity grade IV (Figure 4a). As the patient remained clinically and hemodynamically stable, she was followed up with serial CT scans for her liver injury and discharged 21 days after the accident. A CT scan performed 6 months later showed a normal liver (Figure 4б).

Case Two

The second patient, 41-year-old, had an ISS of 22 on admission, after a MVA while drunk driving. He presented a massive central liver hematoma (17 cm diameter) quantified as a CT injury severity grade IV (Figure 5a). Inasmuch as the patient remained clinically and hemodynamically stable, we decided to pursue conservative treatment. The patient was discharged four weeks after the accident. A CT performed respectively 2 weeks (Figure 5б) and 14 months (Figure 5в)

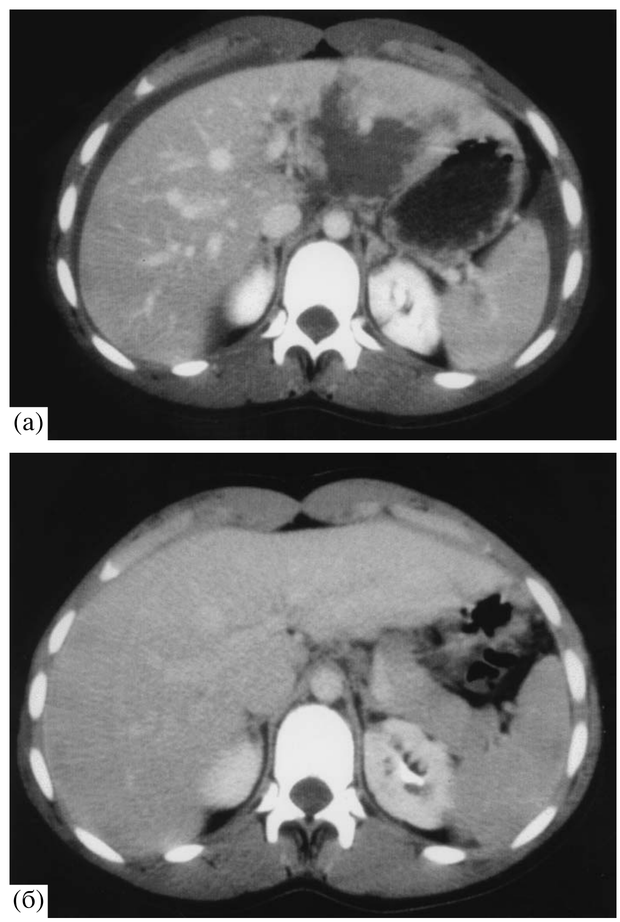

Fig. 4: Case one.

4a. CT injury severity grade IV of the liver

4б. CT 6 months later: complete healing.

Рис. 4. Компьютерная томограмма печени пациентки 27 лет. а – IV степень повреждения печени при наступлении; б – регенерация печени спустя 6 мес.

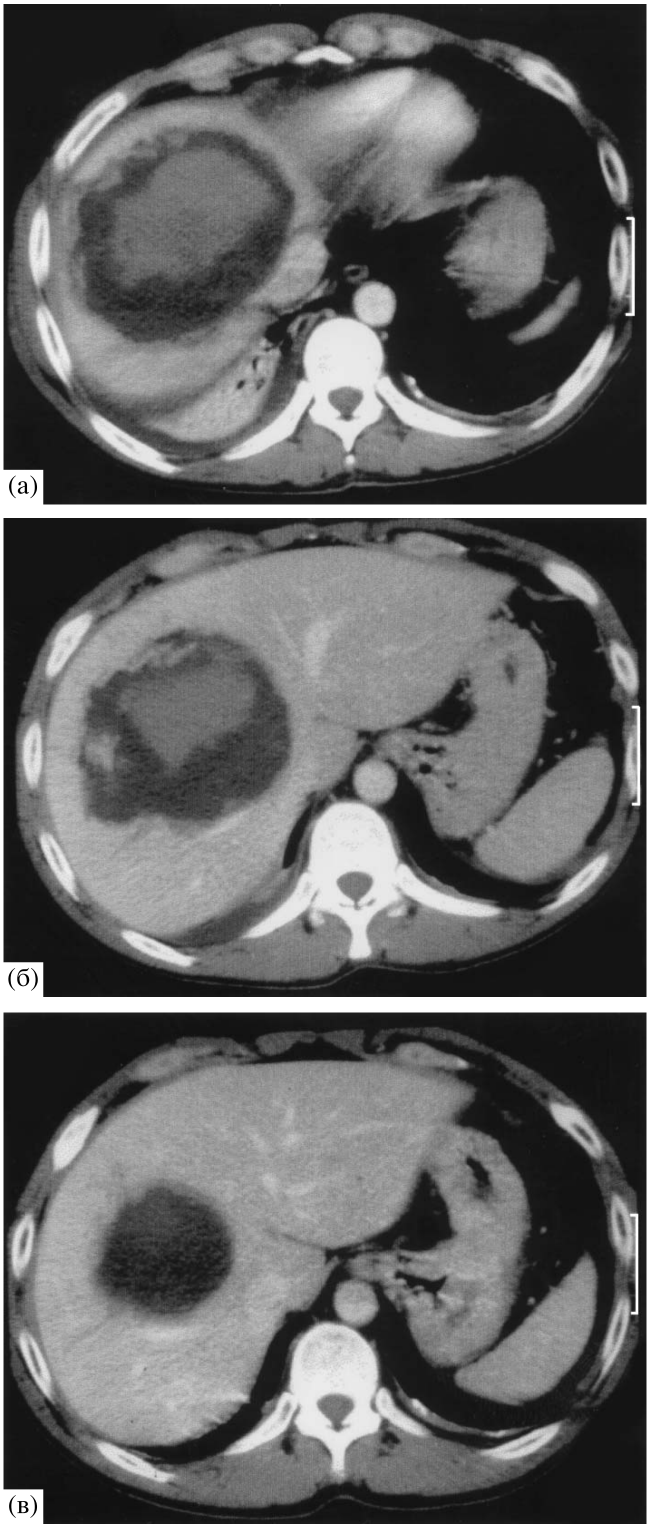

Fig. 5: Case two.
5a. CT injury severity grade IV of the liver: extensive central hematoma.
5б. CT two weeks later.
5в. CT 14 months later.

Рис. 5. Компьютерная томограмма печени пациента 44 лет.
а – IV степень повреждения печени (массивная центральная гематома) при поступлении; б – спустя 2 нед.; в – спустя 14 мес.

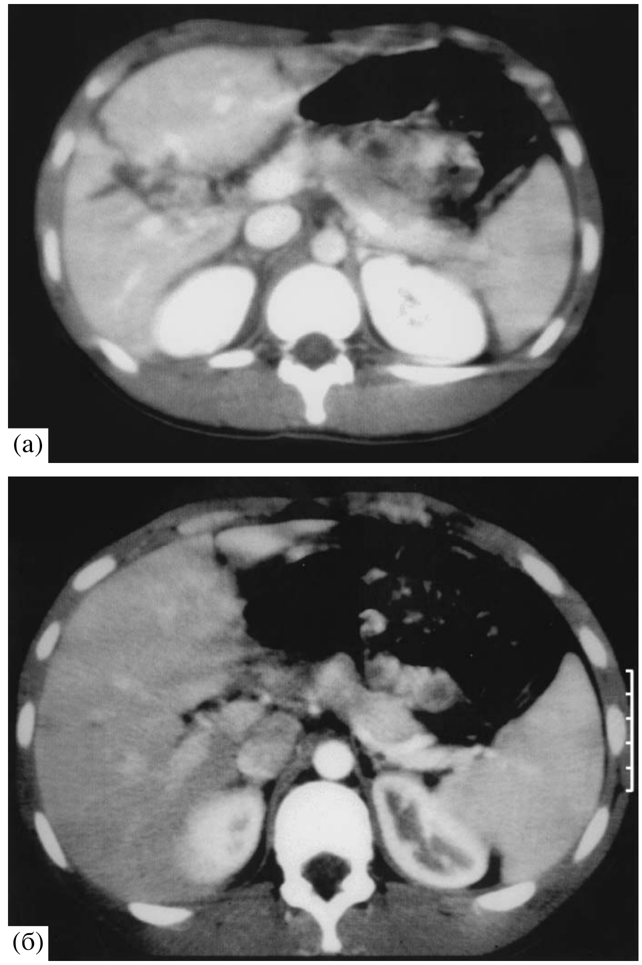

Fig. 6: Case three.
6a. Central laceration of the liver (segments I, IV, V).
6б. *Restitutio ad integrum* of the liver without surgery.

Рис. 6. Компьютерная томограмма печени пациента 17 лет.
а – центральный разрыв печени (I, IV, V сегменты) при поступлении; б – регенерация паренхимы печени.

later showed progressive disappearance of the central lesion in the liver without any consequence for the biliary tree.

Case Three

The third patient, 17-year-old, had an ISS of 25 on admission after a heavy fall while squateboarding. The emergency initial abdominal CT demonstrated a central laceration of the liver at the level of Couinaud's segments I, IV and V (Figure 6a). CT injury severity grade of this blunt hepatic trauma was classified as grade III. Despite the extension of these severe lesions, the patient was hemodynamically stable and free of any symptoms. He was hospitalised for close monitoring. A follow up CT performed on the second months after injury demonstrated complete *restitutio ad integrum* of the liver parenchyma (Figure 6б).

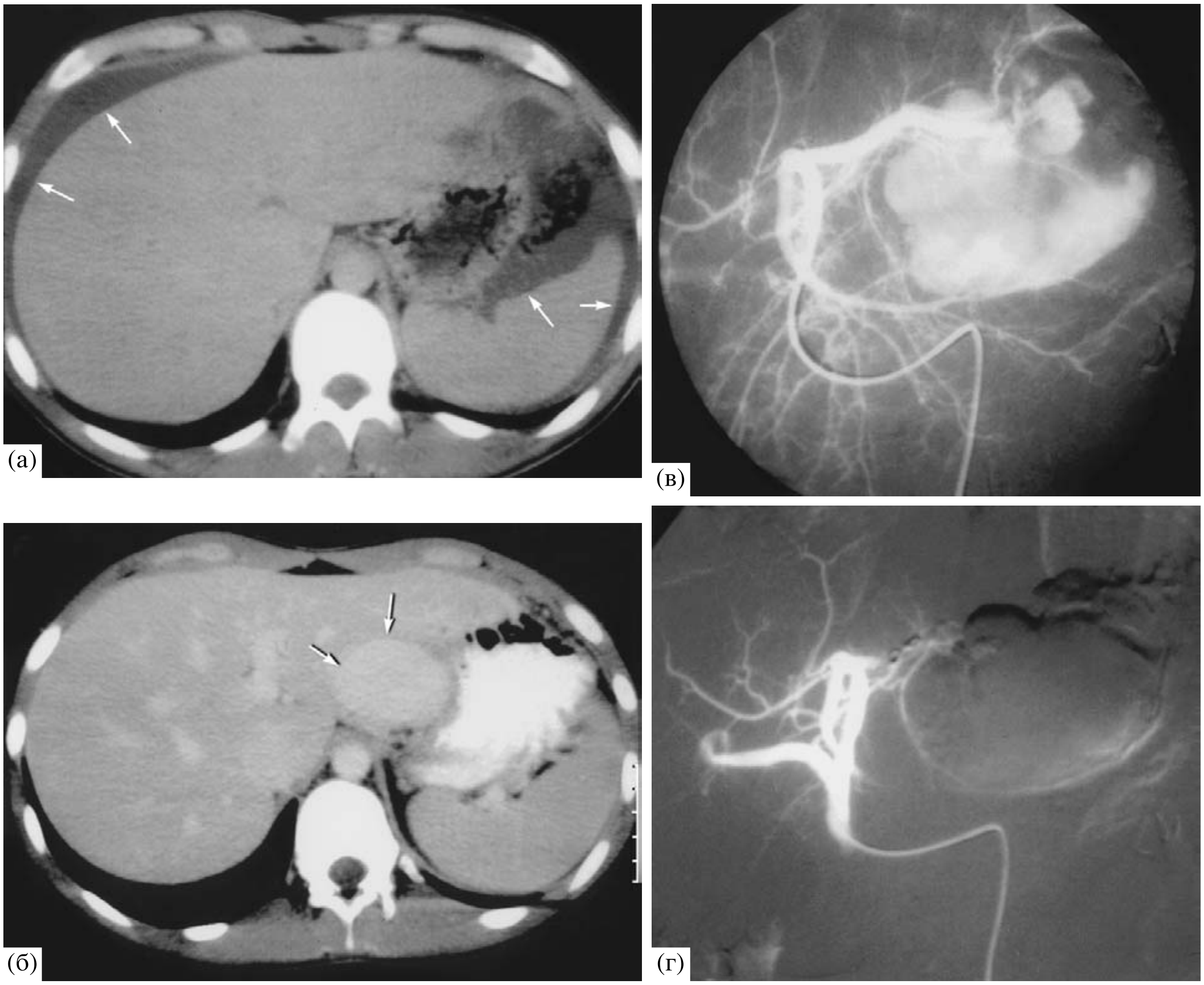

Fig. 7: Case four.

7а. Initial CT: no hepatic lesion but some blood around the liver and the spleen (arrows).
7б. Days later, apparition of an intrahepatic mass in segments III and IV (arrows).
7в. Selective angiography showing a post-traumatic aneurysm of the left hepatic artery.
7г. Selective embolisation devascularizing the aneurysm.

Рис. 7. Компьютерная томограмма печени пациента 22 лет.

а – при поступлении: повреждения печени нет, незначительное количество крови вокруг печени и селезенки (отмечено стрелками); б – через 48 ч: появление объемного образования в III и IV сегментах (отмечено стрелками); в – селективная ангиография: посттравматическая аневризма левой печеночной артерии; г – эмболизация аневризмы.

Case Four

The fourth patient, 22-year-old, had an ISS of 24 on admission after a motorcycle accident (1500 cm^3) while drunk driving on new year evening. The initial CT did not show any intrahepatic lesion, but well some blood around the right lobe of the liver (Figure 7а) and the spleen. The patient was stable and admitted for close monitoring. Some days later, before being discharged, a follow up CT was performed that revealed a circumferential mass at the posterior aspect of segments III and IV of the liver (Figure 7б). Selective angiography showed that this mass was in fact a post-traumatic aneurysm of the left hepatic artery (Figure 7в). Selective embolisation was performed in order to devascularized the aneurysm and avoid any risk of delayed rupture (Figure 7г).

Case Five

The fifth patient, 29-year-old, had an ISS of 56 after a car accident when admitted in another hospital. The initial surgery performed in this hospital consisted in packing of massive lacerations with partial devascularization and maceration of the right lobe of the liver. A cholecystectomy was also performed and a T-tube was placed in the common bile duct. At this time, he had already been transfused of 20 units of blood. The next day, he was transferred to our hospital, still comatose. Figure 8а shows the extension of the lesions in the

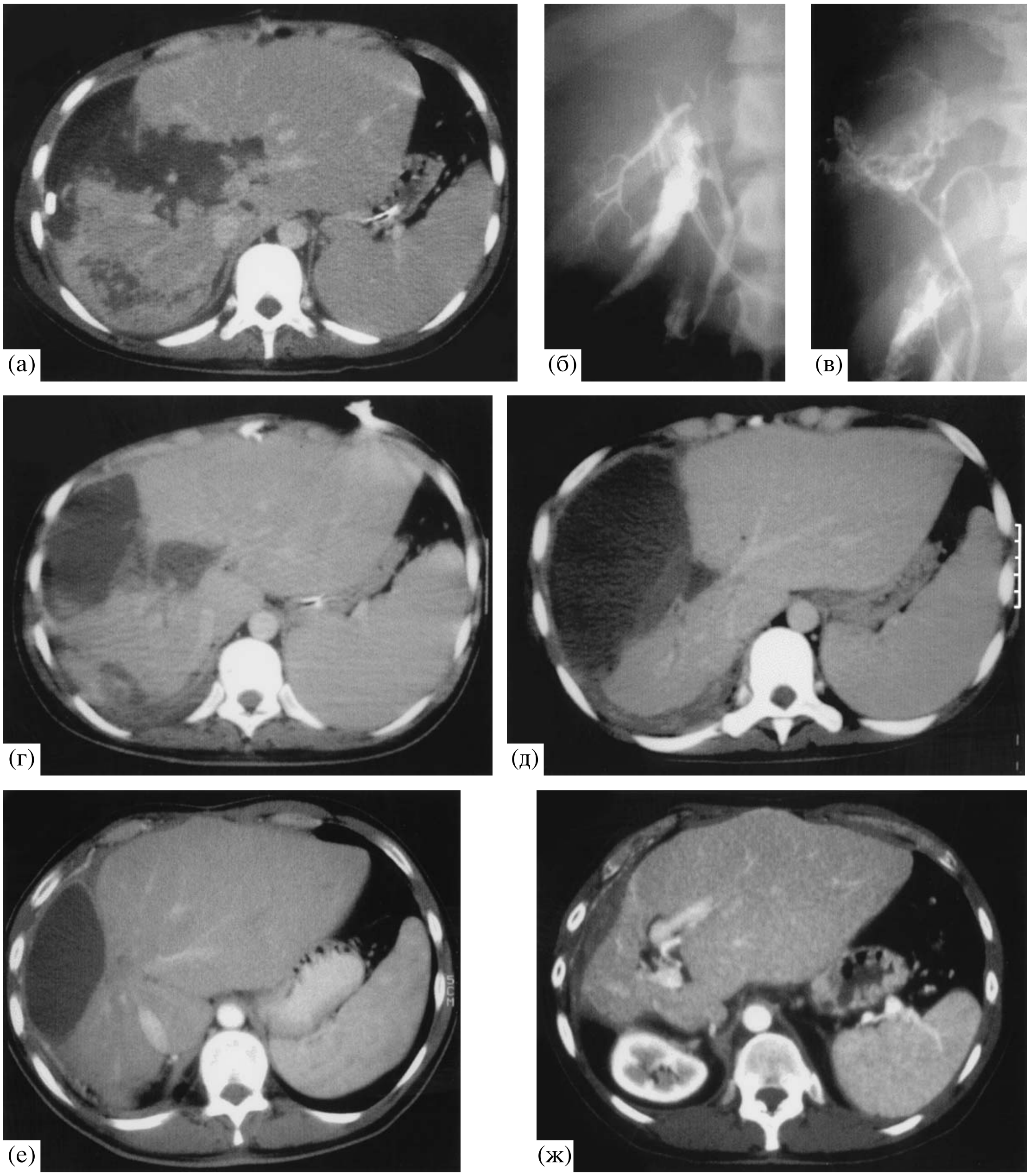

Fig. 8: Case five.

8a. Complete laceration and maceration of the right lobe of the liver.
8б. T-tube cholangiogram performed on the 2nd week showing biliary leakage from secondary right intrahepatic ducts.
8в. T-tube cholangiogram at 6 week showing persistent biliary leakage.
8г. CT one month after the second look operation.
8д. Progressive reduction of a large bilioma four months after the 2nd look operation.
8е. Continuing reduction of the bilioma eight months after the 2nd look operation.
8ж. The bilioma was entirely replaced by a compensatory hypertrophy of the remaining left lobe of the liver 18 months after the 2nd look operation.

Рис. 8. Компьютерная томограмма печени пациента 27 лет.

а – полный разрыв и повреждения паренхимы правой доли печени; б – холангиограмма через 2 нед.: истечение желчи из протока; в – холангиограмма через 6 нед.: истечение желчи; г – через 1 мес. после повторной операции; д – прогрессирующее уменьшение значительного скопления желчи (через 4 мес.); е – уменьшение скопления желчи (через 8 мес.); ж – полное исчезновение скопления желчи (компенсаторная гипертрофия оставшейся паренхимы левой доли печени) через 18 мес.

right lobe of the liver. Five days after the accident, we performed a second look operation in order to remove the packing made of tissue compresses. Devascularized liver tissue were removed without making any attempt to perform an anatomical resection of the shattered right lobe of the liver. Then a new thorough packing was made af several layers of collagen sponges (Lyostypt[R], Braun Surgical GmbH, D-34209 Melsungen), absorbable gelatin sponges (Spongostan[R], Johnson and Johnson Medical Ltd, Gargrave, Skipton, BD23, UK) and absorbable hemostatic cellulose sponges (Surgicel[R], Ethicon, Johnson and Johnson Medical Ltd, Gargrave, Skipton, BD23, UK) over all the area of crushed liver tissue. This type of packing was completed by mesh hepatorraphy wrapping the right lobe of the liver with a synthetic absorbable mesh made of polyglycolic acid (as it is used successfully in many splenorrhaphy), and using the falciform ligament as a point of attachment for the wrap. Posterior drainage with two Jackson-Pratt drains was installed. Figures 8a and 8б show the persisting biliary leakage from secondary right intrahepatic ducts at the time cholangiograms were performed via the T-tube (respectively 2 and 6 weeks after the second look operation). The patient remained in a profound coma for the next three months and eventually recuperated a complete cortical function despite residual motor deficit of the lower limbs. The liver lesions healed progressively during the same period of time without any further operation. Figures 8в, 8г, 8д, 8ж illustrate the progressive reduction and resorption of a large bilioma, respectively one month (Figure 8г), four months (Figure 8д), eight months (Figure 8e) and 18 months (Figure 8ж) after the second look. The bilioma was progressively replaced by a compensatory hypertrophy of the remaining left lobe of the liver (Figure 8ж). So far this patient is doing well seven years after his accident.

Discussion

CTs can of complex abdominal lesions suffers in many cases from the limitations inherent to its representation of the reality as a stock of transverse slices. Underestimation or overestimation of the craniocaudal extent of spleen, hepatic or renal lesions can lead to inappropriate triage of blunt abdominal trauma patients for conservative or surgical treatment. It can also lead to inappropriate surgical strategy when the priority for laparotomy is straightforward. As we already mentioned, even though CT scan is a very useful method for identifying and quantifying abdominal and retroperitoneal injuries, as well as documenting progression of critical injuries, the “ultimate decision for laparotomy should be based on clinical status and not on radiographic findings” (Mirvis *et al.*, 1989; Raptopoulus *et al.*, 1991; Umlas *et al.*, 1991). Furthermore, some authors, who proposed scoring system for abdominal trauma, have expected more from the scoring than the system was intended for, that is to say: the scoring system should not replace clinical evaluation, but should help identify the patients who although initially considered candidates for nonoperative treatment may eventually need surgery. Scoring system should be used with the understanding that false-negative of false-positive CT results do occur. This has been particularly well demonstrated for spleen injury (Federle *et al.*, 1987; Pappas *et al.*, 1987: Taylor *et al.*, 1984; Fagelman *et al.*, 1985) and it is probably the case also for blunt liver trauma. Therefore close monitoring is mandatory for patients for whom nonoperative treatment is chosen, whether this choice is based on clinical criteria, CT scoring, or on combination of both. More specifically, for spleen injuries Umlas *et al.* (1991) made things even more complicated by forcefully trying to differentiate between subcapsular and pericapsular fluid. Meanwhile they remained skeptical about the utility of spleen CT, because in their experience some patients with delayed splenic rupture had a normal spleen or minimal injury at the initial CT scan.

The initial goal of our preliminary study in the mid eighties was to answer the following question: “Is the CT technology just an other invention in search of a use, or is it a potential solution to an unsolved problem?”. In other words, we designed our protocol in order to identify that which is a new gadget and that which has the capacity to improve care of blunt abdominal trauma patients. This led us to consider also the potential usefulness of an early follow-up CT examination (i.e., 48 hours after the emergency post-resuscitative CT scan), including a lesion-oriented dedicated 3D spiral CT study, aiming both at a refined evaluation of the lesions and at precocious detection of their eventual worsening. So far our results show non debatable benefits emerging for the patients even though rigorous evaluation by teams from all over the world on larger groups of patients should be undertaken. One of our recent papers describes our preliminary results with this approach of lesion-oriented dedicated 3D spiral CT study for blunt renal and splenic trauma. Nevertheless, the new tomodensitometric imaging techniques are promising for improving the emergency work up of blunt liver trauma.

Early in the eighties, we used abdominal sonography as the sole primary screening test for blunt abdominal trauma, because of the unavailability of CT scan in our hospital (i.e. pre CT period). Sonography was then performed by an expert senior radiologist. When CT became available, the primary screening test shifted progressively towards CT (i.e. CT period), because CT provides informations that are less radiologist dependent, and that can be interpreted by a trained surgeon regularly involved in an emergency department (ED). Furthermore follow-up CT provide sequential data easier to compare. The initial injury severity scores (ISS) were statistically identical for both periods (pre CT period: mean ISS 21, median 14, range 6-75 versus CT period: mean ISS 22, median 16, range 8-72). Nevertheless, the overall number of patients correctly identified as requiring emergency laparotomy remained the same during the pre CT and CT period. No patients were mistakenly discharged in each period.

Sonography as the primary diagnostic tool provides fast and non-invasive initial assessment of trauma patients, with the limitation, however, that it should be performed by a full trained sonographist, which is rarely the case around the clock in an ED. We are less convinced that sonography is cost-effective, considering that cost containment is sometimes just cost displacement. Indeed, when the initial sonography is not conclusive it is often difficult to compare its initial dynamic informations with those from a follow-up sonography as the examiner could have changed. Therefore it is not surprising that initial evaluation of our blunt abdominal trauma patients has benefited from the introduction of the spiral CT technique, especially for liver trauma.

It now appears that the pendulum is swinging back to a less aggressive surgical approach in the management of severe liver injuries. In fact, armed with a CT imaging of the nature of the liver wound, we can now reasonably attempt nonoperative management. When bleeding is such that laparotomy is indicated, temporary perihepatic gauze packing may be done to stop bleeding and to prevent the development of acidosis, hypothermia and coagulopathy associated finally with massive transfusion. We currently prefer to complete the perihepatic packing with absorbable material by a mesh hepatorraphy wrapping the right lobe of the liver with a synthetic absorbable mesh made of polyglycolic acid (as it is used successfully in many splenorrhaphy), and using the falciform ligament as a point of attachment for the wrap (Reed *et al.*). In extreme situation, when the emergency operation has consisted in temporary perihepatic gauze packing, it is possible to reoperate the patient three to four days later in order to perform a mesh hepatorraphy when the clinical situation is under better control. This is what we did for the fifth case (massive lacerations of the right liver) that has been presented, who was actually transferred to our hospital for transplantation. Transplantation is the ultimate challenge for trauma, that has already been attempted, but the experience is thus far very limited. It will probably remain limited due to the fact of the wide shortage of liver for transplantation.

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