EDITORIAL

The investigation of abdominal trauma

Recent years have seen exciting changes in the methods of diagnosis and treatment of abdominal injury. However, the optimal method of investigating the injured abdomen remains controversial. When assessing a patient for the presence of abdominal injury, the surgeon seeks to answer two questions. He must determine firstly, whether a significant abdominal injury is present and secondly, what treatment is required. This latter decision is assuming increasing importance with the introduction of conservative management for selected solid visceral injuries. At times injury to the abdominal viscera is obvious on initial assessment, but more frequently serial examination and investigations are required. Prompt diagnosis and definitive treatment of injury is the goal. Failure to achieve this end is common and exposes the patient to the risk of unnecessary morbidity and mortality.

No injury can be considered in isolation: the management and investigation of abdominal trauma is an integral part of that of the patient as a whole and should be conducted along systematic lines such as those laid out in the Advanced Trauma Life Support (ATLS) courses. Rarely, abdominal injuries will require immediate laparotomy or transthoracic aortic clamping to gain control of the circulation and allow resuscitation. In these cases, any delay will rapidly be fatal. A larger minority of injured patients will fulfil the criteria for prompt laparotomy without detailed investigation. These include obvious peritonitis, abdominal expansion, gastrointestinal bleeding or cardiovascular instability in the presence of known abdominal injury. Unnecessary investigation in such cases will result in hazardous delay. Priorities in the treatment of the multiply injured must be determined individually for each case. For these reasons the surgeon must be involved as soon as abdominal injury is suspected or significant hypovolaemia is diagnosed.

In the majority of cases the above criteria are not present and more time is available for the assessment of the abdomen but it should be emphasized that all too often abdominal injuries are missed or only diagnosed after undue delay (Anderson *et al.*, 1988). A high degree of suspicion must be maintained when dealing with any injured patient with a history that could even remotely be associated with abdominal injury, even in the absence of overt signs. The history of the accident may give clues that a powerful injuring force has occurred and there is, therefore, a greater likelihood of serious injury. External marks such as abrasions, bruising, seat belt or tyre marks on the abdomen, injuries in neighbouring body regions and cardiovascular instability without evident haemorrhage are important examination findings. The anatomical extent of the abdomen—nipples to perineum—should be recalled and the examination must be similarly extensive, including back, loins, rectum and urethra. The association with chest injury merits reiteration: 10 to 20% of patients with chest injury will have splenic or hepatic injury (Hill *et al.*, 1988). The inaccuracy of abdominal examination in

eliciting signs of peritoneal irritation in injured patients is considerable: a false positive rate of 40 to 60% is usual, while the false negative rate is 30 to 50% (Bivins *et al.*, 1978). The false negative rate carries with it a mortality of 17% (Fischer *et al.*, 1978). These figures must be borne in mind when considering the need for investigation of the abdomen and when deciding to proceed to laparotomy without investigation. Abdominal wall injury contributes to clinical error in diagnosing injury of the intra-abdominal viscera, but more importantly blood that is free within the peritoneal cavity may, on its own, cause very little peritoneal irritation.

Repeated examination of the patient and his abdomen is essential but investigation of the abdomen is necessary whenever doubt exists. The use of a tape measure is mentioned only to be condemned: each 1 cm of increase may represent up to 3 litres of blood (Collicott, 1988). The absence of bowel sounds is equally valueless, having several possible aetiologies in the injured. Plain radiography of the abdomen plays little part in the investigation of blunt trauma, in contrast to the importance of views of the cervical spine, the chest and the pelvis. The chest radiograph, which should be taken as erect as possible, aids in the diagnosis of free abdominal gas and of diaphragmatic rupture as well as in diagnosing chest injuries. Initial full blood count serves only as a baseline, although an elevated serum amylase level is most suggestive of pancreatic trauma (White & Benfield, 1972).

Specific investigation for abdominal visceral injury is indicated in cases with abdominal pain or tenderness, lower rib fractures, unexplained hypotension, pelvic fractures, spinal injury and in patients with altered mental state whether due to injury, intoxication or anaesthesia. For 25 years, the principal tool in the investigation of abdominal trauma has been diagnostic peritoneal lavage (DPL) and the bulk of the accrued data refers to this technique (Root *et al.*, 1965). Indeed, the only absolute contraindication to DPL is the need for immediate laparotomy, although advanced pregnancy and previous abdominal surgery require a careful and sometimes modified approach (McLellan *et al.*, 1985; Gomez *et al.*, 1987).

Diagnostic peritoneal lavage involves placement of a peritoneal catheter within the pelvis. It should be performed by surgical staff using the mini-laparotomy method (Moore *et al.*, 1981; Pachter & Hofstetter, 1981). Following nasogastric and urinary catheterization, the catheter should be placed in the peritoneal cavity under direct vision after cut down through an area infiltrated with lignocaine and adrenaline. One third of the way from the umbilicus to the pubic symphysis, in the midline, is the site of election although pelvic fracture requires a higher approach to avoid puncture of the haematoma (McLellan *et al.*, 1985). If initial aspiration for blood is negative (< 10 ml), one litre of warm saline is instilled and then retrieved by gravity after a period of side to side turning. A positive lavage (more than 100,000 RBC/mm³, more than 500 WBC/mm³, presence of food, bile or bacteria or recovery of lavage fluid through a chest drain or the urinary catheter) has been regarded as an indication for laparotomy. Intermediate results require selective management in the light of other injuries and findings. DPL is an excellent test, being about 97% accurate. False positive results occur in 0.5 to 1% and false negatives in 1% (Fischer *et al.*, 1979; Du Priest *et al.*, 1979). False positives are usually due to traumatic insertion, while retroperitoneal injuries and injuries to bladder and diaphragm account for the false negatives. The detection of blood by DPL is considerably easier than the detection of enteric contents, but bowel perforation gives

more reliable signs on abdominal examination and on the erect chest radiograph. Given the rapidity and ease of performance and the accuracy of its results, diagnostic peritoneal lavage has become the gold standard investigation for blunt abdominal trauma. It has completely replaced blind needle paracentesis (Du Priest *et al.*, 1979).

Peritoneal lavage suffers from drawbacks: it fails to locate the source of haemorrhage and it gives no indication as to the volume of blood lost or the presence of continued bleeding. This results in a tendency for the test to be over sensitive for minor hepatic and splenic injuries and indicated laparotomy will be non-therapeutic in 6 to 25% of cases (Jones *et al.*, 1983). With the growing trend for conservative treatment of selected hepatic and splenic injuries, the over-sensitivity of DPL is made effectively greater. More than ever, DPL identifies the presence of abdominal visceral injury, but not necessarily the need for operation. Finally, DPL is invasive and it fails to evaluate the retroperitoneum. Several other modalities of investigation have gained favour in attempts to remedy these shortfalls.

Computed tomographic (CT) scanning of the abdomen has achieved widespread use in the United States in the investigation of abdominal trauma (Federle, 1983; Wing *et al.*, 1985). CT provides complimentary information to that obtained from DPL and in centres of excellence, high degrees of specificity and sensitivity have been recorded (Wing *et al.*, 1985). It has proved useful in some hands in the identification of selected injuries to liver and spleen which would give a positive lavage result but which may not require surgical treatment (Meyer *et al.*, 1985). This type of management requires continuous and intensive surgical and radiological backup to assess and treat deterioration.

The use of CT as an alternative to DPL in the investigation of stable patients with equivocal examination findings has not, however, been supported by prospective comparative study. Marx *et al.* (1985) found the sensitivity of CT to be only 25% while that of DPL was 100%. CT missed several injuries to the liver and spleen. There is a marked learning curve in the interpretation of CT scans of the injured abdomen and experience of some 200 CT scans of the injured abdomen is an estimated minimum acceptable baseline on which to base acute management decisions (Peitzman, 1989 personal communication). Fabian *et al.* (1986) concluded that even with experienced radiologists, CT offered no diagnostic advantage over DPL. CT is slower, more expensive and third generation scanners are essential for adequate scan quality. For practical utility, the scanner must be located close to the accident department. The cost, lack of expertise and lack of appropriate equipment make the widespread adoption of early CT scanning for abdominal trauma unlikely at present in the United Kingdom. It must be said that abdominal CT scanning has made an enormous impact on trauma care in the United States and that our practice must be seen to be the poorer for our lack of it and the remarkable anatomical delineation of injury which it can offer. In the United States, CT and DPL are seen as complimentary. When time or instability precludes CT, use is made of more rapid DPL. In British practice abdominal CT may be of particular use in the head injured, where CT scanning of the abdomen can follow the head scan directly (Peitzman *et al.*, 1986).

Ultrasound scanning is a third alternative with which to search for abdominal visceral injury and it appears to offer many advantages. It is safe, cheap and rapid and machines are more readily available than are CT scanners. The equipment is portable and can be

used in the resuscitation area or the Intensive Care Unit. Like CT, it can identify the likely source, as well as the presence, of free fluid (presumably blood) within the peritoneal cavity and by repeated evaluation can determine whether haemorrhage is continuing. Its utility is now beyond question (Endoh *et al.*, 1987; Chambers *et al.*, 1986; Chambers & Pilbrow, 1988; Gruessner *et al.*, 1989; Tiling *et al.*, 1989; Jarowenko *et al.*, 1989) but grave doubts exist as to whether it can replace DPL and CT. Experienced operators can detect as little as 50 ml of fluid within the abdomen but emphasize, that again, a considerable learning curve exists. A German group with over 10 years experience found that learning continued for over 5 years even when the end point of their study was the presence of free fluid and not specific visceral damage (Tiling *et al.*, 1989). In most large series a false negative (i.e., missed injury) rate of 1 in 10 is recorded and it is clear that these missed diagnoses have contributed directly to patient death. At times ultrasound has failed to detect exsanguinating intra-abdominal haemorrhage (Jarowenko *et al.*, 1989; Gruessner *et al.*, 1989). Ultrasound thus appears to be safest and most useful when it shows a positive finding in a stable patient. German and Japanese groups perform abdominal ultrasound within minutes of arrival as a screening test, during initial resuscitation and along with other more accepted initial investigations (Gruessner *et al.*, 1989; Tamaka, 1989, personal communication; Tiling, 1989, personal communication). When used in this way it does not interfere with resuscitation as does transfer to the CT scanner. In these centres, the ultrasonography is performed by the surgeons: a point of importance in allowing later audit at operation of the accuracy of the diagnosis. The consensus of considered opinion at the recent meeting of the American Association for the Surgery of Trauma was that ultrasonography inadequately investigates the injured abdomen when used alone but undoubtedly of great value when used in conjunction with DPL and CT scanning, a view confirmed by prospective study (Gruessner *et al.*, 1989). While its ability to define injury anatomically lags behind CT, its safety and portability make it ideal for repeated examination to look for evidence of continuing haemorrhage and to monitor the progress of contained splenic and hepatic injury in the stable patient in whom these injuries are being treated conservatively.

Although CT, and to a lesser degree ultrasonography, can localize sources of haemorrhage and determine quite accurately the volume of free peritoneal blood, they cannot assess, at a single examination, whether that haemorrhage is continuing or not. Laparoscopy has been proposed as an investigation which could determine this while still offering anatomical localization of injury. Using the criteria which indicated DPL, Berci *et al.* (1983) performed mini-laparoscopy on 106 patients, of whom 49 had a haemoperitoneum. Twenty-seven of these had only minor volumes of blood present and a pelvic fracture ($n=7$), a small hepatic or splenic laceration which had stopped bleeding ($n=5$), or no cause ($n=12$) to explain the haemoperitoneum. These patients were managed without complication on an intensive care unit. Mini-laparoscopy requires analgesia and sedation and is moderately time consuming, but can counter the over-sensitivity of DPL at a single examination.

The inability of DPL to specifically evaluate retroperitoneal injury is significant but no method is entirely satisfactory. Serum amylase is elevated in only half the patients who sustain blunt pancreatic injury (White & Benfield, 1972). Clinical examination is also unreliable and hyperamylasaemia may result from injury to several other viscera.

CT followed by ERCP has been advocated for the investigation of patients suspected of having pancreatic injury (Gomez *et al.*, 1987). Pancreatic and duodenal injuries may still be missed by the best CT scanning, even when the scans are performed 2 days after injury and interpreted by expert radiologists. However, Du Priest *et al.* (1979) have indicated that pancreatic and duodenal injuries seldom occur in isolation and positive lavage from concomitant injury aids their diagnosis provided they are actively sought at laparotomy.

Urinary catheterization, once suspected urethral injury has been excluded by urethrography, and examination of the urine for haematuria are always required. Frank haematuria must be investigated, usually by intravenous urography, but this investigation is not required when blunt abdominal trauma results in transient microscopic haematuria in the absence of other indicators of a high likelihood of renal trauma (Kisa & Schenk, 1986; Oakland *et al.*, 1987). The timing of the IVU depends on the clinical state and other injuries sustained. CT scanning offers accurate detection of retroperitoneal injury and the administration of urographic contrast is standard. Where available, CT, as part of a complete abdominal scan, has replaced the IVU. Renal parenchymal and vascular injuries can be delineated and CT urography has obviated the need for angiography in these cases.

In penetrating trauma, an even greater distinction is made between abdominal and retroperitoneal injury. Laparotomy is mandatory for all abdominal gunshot wounds while the criteria for laparotomy for abdominal stab wounds are similar to those for blunt trauma with the addition of evisceration. In the equivocal case of stabbing, where local wound exploration has failed to refute the possibility of peritoneal penetration, DPL is, again, very useful. Feliciano *et al.* (1984) found DPL accurate in 91% of 500 such patients. Specificity was reduced to 88% on account of haemorrhage from the parietal wound, but the authors noted that this cause contributed to only one-fifth of all the non-therapeutic laparotomies in their series, the vast majority being due to erroneous clinical assessment. CT scanning has proved useful in the evaluation of the need for laparotomy following abdominal stab wounds but was shown not to be sufficiently accurate to rule out visceral injury on its own (Rehm *et al.*, 1989).

Penetrating injury to the flank and back carries a far lower risk of major injury than anterior abdominal wounds. Surgery in these cases is selective unless signs of shock or peritoneal irritation are present. Posterior and flank wounds may be evaluated by contrast enhanced CT enema (CECTE). Simultaneous opacification of the upper and lower gut, the renal tract and vessels allows identification of missile tracks, haematomata and perhaps occult bowel perforation in the difficult case (Phillips *et al.*, 1986).

Pelvic fractures merit special mention: they typify the range of severity of abdominal injuries, may be assessed by several methods and their good management exemplifies the multi-disciplinary approach necessary for successful trauma care. When exsanguinating haemorrhage is present, application of a pneumatic anti-shock garment often provides successful tamponade (Moreno *et al.*, 1986). Laparotomy and aortic cross clamping may be necessary for ongoing catastrophic haemorrhage and laparotomy will be necessary for patients with other injuries. In less severe cases, DPL can be used. Standard DPL may be falsely positive in one-third of cases, putting the patient at risk from major haemorrhage or sepsis from unnecessary surgery (Hubbard *et al.*, 1979). The accuracy of DPL can be increased by insertion at or above the umbilicus and only

accepting egress of free blood on insertion as a criterion for laparotomy. CT scanning is useful in the assessment of lesser degrees of haemoperitoneum. External fixation of the fracture provides valuable control of haemorrhage whether intra- or extra-peritoneal. Percutaneous angiography and arterial embolization is proving useful in stopping haemorrhage from the fractured pelvis. Matalon *et al.* (1979) and Moreno *et al.* (1986) found it very successful in selected patient groups, while Panetta *et al.* (1985) obtained haemostasis in 87% of patients with ongoing haemorrhage.

When laparotomy is carried out it must be used to make a full assessment of all the abdominal viscera and particular search for the injuries commonly missed is advisable. These include rupture of the dome and posterior surface of the right lobe of the liver, diaphragmatic tears, pancreatic injuries and bowel injury at fixed and inaccessible sites: the duodenum and duodeno-jejunal flexure, ileocaecal valve, splenic flexure and the extra-peritoneal portion of the rectum. Negative laparotomy carries some risk, but often the 'associated' morbidity and mortality results from concomitant injuries, despite their treatment (Peterson & Sheldon, 1979; Du Priest *et al.*, 1979). This risk of negative laparotomy also fails to reflect the avoided morbidity and mortality from the prompt treatment of injuries.

Each investigative tool has its own attributes and drawbacks, but it would appear that our priority must be to use one of these methods to reduce our incidence of missed injuries. For the present, a greater appropriate use of diagnostic peritoneal lavage and the presence of a well-trained surgeon to treat the injuries found, would improve the management of abdominal injury considerably. The other investigations discussed should find increasing use in our practice but the evidence suggests that they will remain complimentary to DPL even once their considerable learning curves have been mastered. As trauma systems and expertise develop, the specific method of choice in each setting will become more obvious. Finally, it should be noted that those with the most sophisticated diagnostic and supportive systems for trauma care advocate laparotomy as the safe option when doubt exists as to the presence of abdominal injury or when such injury is treated by those who meet it infrequently (Hill *et al.*, 1988).

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