ULTRASOUND IN MULTIPLE TRAUMA.

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INTRODUCTION

Today, where there is an abundance of diagnostic tools available, rapid and accurate assessment of an injured patient still remains a true challenge. Speed and accuracy are essential, not only to augment the chances of survival and limit morbidity, but also to economize on the use of medical resources.

Diagnostic options range from physical examination to magnetic resonance imaging and from laboratory data to laparoscopic exploration. This diversity of diagnostic options is not always an advantage as it may give rise to confusion and a mix-up in the choice of the right modality at the right time.

There seems to be a lack in common sense in comparing relatively plain bedside methods with high technology examinations (such as CT), which usually involve movement of potentially non-stable patients. This is a violation of the Advanced Trauma Life Support (ATLS) principles, which require stabilization of the airway, breathing and circulation before a patient is moved for reasons other than emergency surgical action.

It is rather odd that so many articles in the literature compare the accuracy of diagnostic modalities, mostly ultrasound (US) and/or diagnostic peritoneal lavage (DPL), with computed tomography (CT) and/or angiography which have a totally different place in the work-up and are at opposite ends of the diagnostic spectrum. Before an injured patient is considered to be a candidate for further diagnostic work-up, one must be convinced that this is beneficial and not detrimental, and a 'filter test' must be implemented. So a much more relevant discussion would be on what objective bedside examination is the modality of choice for that 'filter'.

OBJECTIVE BEDSIDE DIAGNOSTIC MODALITIES IN INJURY: THE PERSPECTIVE

Before specific treatment of an injured patient is initiated, one must have a good idea of the presence and extent of their injuries. This may seem obvious, but in reality it is a commonly held bias that such a patient is not a patient about whom one should be fully informed. Close co-operation between various specialists within the trauma team now makes a swift, yet reliable, survey possible without wasting time when some simple conditions are met.

Any hospital dealing with trauma patients has - or should have - an organization model where the personnel, equipment and environmental requirements are outlined. An integrated and well coordin-

ated approach is essential for a successful outcome. This trauma team should be ready on a 24 h basis. The composition of the team is of course left to local circumstances but it should be small enough to be workable and broad enough to have the main topics covered by experts.

Most institutions boasting a trauma service have emergency rooms bristling with equipment but quite a few lack conventional radiological equipment and do not have an US machine available. Conventional radiographic equipment should at least consist of a ceiling-mounted tube, a bucky table and a C-arm.
If not already digitalised, a development system should be in the close vicinity. Furthermore, there should be a modern US machine with multiple transducers.

The conventional radiological work-up is by protocol and must include chest, upper abdomen, plain abdominal, pelvic and axial skeleton radiographs in - as far as possible -perpendicular directions. Some examinations, such as the chest film and US, are repeated at least once. The radiographic facilities in the emergency room as outlined are capable of producing quality radiographs even in these far from optimal circumstances. These examinations should either depict the abnormality or confidently exclude certain pathological entities so speeding up the entire evaluation process. Poor quality radiographs, however, will give rise to uncertainties and misunderstanding, will delay vital decisions and procedures for the patient or result in unnecessary (pseudo)therapeutic manoeuvres.

The advantages of having this equipment in the emergency room are enormous; radiological assessment can be started as a collateral procedure while the activities of surgical and anaesthesiological colleagues continue unhampered, thereby saving time. The main cause of early death in injured patients is (apart from pneumothorax) exsanguination and all diagnostic efforts should concentrate on excluding or proving a major haemorrhage and, if possible, its source.

This must be done with minimal or no movement of the patient, which can have detrimental effects on other noncatastrophic injuries.
In the vast majority of cases an unstable patient who does not react to appropriate resuscitation is a bleeding patient. Usually such a patient is only really helped by the speediest transition to the operating (or angio!!) room to obtain control of haemorrhage.

It is here where the objective bedside modalities have their impact.
Such a bedside examination must be quick, reliable, repeatable and economical with a low or absent morbidity rate. The sole function is to decide whether the patient is in urgent need of intervention or is likely to survive, and benefit from, further diagnostic work-up.

There is now a dangerous trend in sending these patients directly from the emergency room to CT in the, often remote, radiology department after declaring them 'stable' by nothing more than a physical examination, however thorough, so bypassing 'the filter'. This sets back the clock by at least a decade when Radiology had the dubious reputation of receiving their injured patients alive and returning them (almost) dead.

ULTRASOUND

Since 1971, after the first publication by Kristensen et al., there has been an increasing number of reports stating that US has virtues in assessing injured patients. Most of the early papers have their origin in Western Europe or Japan and it is only in recent years that literature from the USA has become available. The reasons for this time lag one can only guess at, but possible explanations are the fact that most sonographers in the USA are not radiologists, making US unavailable in 'off-hours', and the medico-legal implications of an examination, which is highly operator dependent. In contrast to DPL, US has seen immense developments since the early 1970s, which might as well, for this modality, be considered 'stone age'. Accuracy figures from only 10 years ago must now be considered obsolete. Not only has transducer technology improved immensely but also miniaturization and computerization has made the US machine real-time, easy to handle and no longer an obstacle in the ever crowded emergency room. Owing to these improvements it has become quite possible to examine almost all patients reliably, the possible exception being the excessively obese patient or one with abundant free intra-peritoneal air.

US shares with DPI, such advantages as bedside technique, speed and accuracy. However, US has no complications. A repeat US tells as much as the first as long as other investigations such as DPL, (fluid) or laparoscopy (air) do not interfere. While DPL, only gives gross information about one region, e.g. the intra-peritoneal cavity, US can give quite a lot of information about other areas as well: the celiac space, the pericardium, the pleura, the groin and retro peritoneum are quite assessable with US and all these areas are of interest to the trauma physician.
Ultrasound examination does not hamper other diagnostic or therapeutic activities and can be applied as a collateral procedure, while DPL (and CT!!) calls for a halt - however short - in these endeavours.
The speed and reliability of US promote its use for triage in the case of mass casualties.

The disadvantages of US might be its dependence on the operator and the particular machine augmented by the fact that yet another specialist is involved. However, the fact that a radiologist has

a distinct role here has many advantages. Sonographic quality is optimized, expert reading of sub-optimal radiographs is guaranteed and the composition of an imaging strategy is forwarded. The imaging strategy means the choice of follow-up modalities, their sequence and the use and amount of intravenous contrast material. Through the personal involvement of the radiologist, as a member of the trauma team, this will be executed with the appropriate haste.

US examination should start at the earliest possible moment and consist of a full investigation of the abdominal contents and neighbouring structures. Special attention is given to: (I) Morrison's pouch; (2) right kidney/right paracolic gutter; (3) liver/right dome of the diaphragm/right pleural space; (4) left kidney/Left paracolic gutter; (5) spleen/left dome of the diaphragm/left pleural space/pericardium; (6) bladder/Douglas region; (7) retro-peritoneal space.

For the 'trauma radiologist', however, many things are different from the daily (sonographic) routine. The emergency room is crowded, noisy and brightly lit. An almost real-time report of the sonographic findings is expected. A differential diagnosis is both superfluous and not appreciated. The patient usually cannot move or obey breathing commands. Furthermore, the working space is limited and some areas cannot be touched because of wounds or bandages.
Despite these obstacles, our experience and recent literature prove that US provides practical and reliable results.
Since US (as is DPL) is not a remedy it is important to realize what is expected from these modalities; this is the 'filter' function, nothing more, nothing less. For US this means that two basic questions must be answered: (1) Is there free fluid (presumed to be blood) in the abdominal cavity? (2) Is it enough to warrant a conclusive laparotomy?

If the answer to one or both questions is negative the patient is cleared to undergo further diagnostic activities. This will usually be CT but it is advisable to repeat the US before leaving the emergency room because vigorous resuscitation efforts can give rise to augmented or fresh bleeding, creating another perspective.
Our personal experience with a radiologist as a full member of the basic trauma team has been excellent and we advise this in all cases. Although in the majority of cases US can detect the origin of the bleeding, CT is better equipped to do so.

It is reiterated that this is of relatively minor importance, while most surgeons admit that 'The most important preoperative objective in the management of the patient with abdominal trauma is to ascertain whether or not a laparotomy is needed and not the diagnosis of a specific organ injury".

The consequences of not doing the necessary operation may be severe. It is less well understood that performing a non-conclusive laparotomy in this group of patients results in significant morbidity.

New developments, such as the implementation of Doppler ultrasound and power colour Doppler and US contrast studies are under investigation but it is too early to say that they will have an impact on clinical decision-making.

Who should perform the ultrasound examination? As in all other fields of trauma care, it is a question of finding the right person for the right job. Non-radiologists, such as trauma surgeons and emergency physicians, have shown steep learning curves, sometimes with remarkably and almost unrealistically short training times. However, the investigator's experience will naturally influence the results and a learning time of at least 2 years seems realistic. Our personal experience with a radiologist as a full member of the basic trauma team has been excellent and we advise this in all cases.

IN SUMMARY

Ultrasound is one of several modalities useful in the work-up of an injured patient. It is a bedside technique, which is quick, economical and highly reliable in filtering out the patients who are in urgent need of laparotomy. For the moment, this is the prime and only function of this modality. The US examination can and should be repeated with a very low threshold.

Apart from the complication rate, which is zero for US, it shares many virtues with DPL. Ultrasonography in a badly injured victim is a challenging investigation, which should be done by an expert. In most situations, this will be a radiologist whose presence in the emergency room could further be used for expert film reading and development as well as the unhampered implementation of a rational follow-up imaging strategy. Follow-up modalities, however impressive, should not be compared with first-line investigations.

In expert hands, accuracy figures between DPL and US do not differ decisively but one must bear in mind that DPL spans only one compartment while US gives information about much more vital areas. DPL is complementary to US; it is of paramount importance to understand that DPL spoils the US examination (and CT as well) but is not hindered by repeated US. DPL can and should be used to investigate the nature of free intra-peritoneal fluid when the amount does not warrant laparotomy. Neither US, DPL nor CT are substitutes for sound clinical judgement.

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Sonography in a clinical algorithm for early evaluation of 1671 patients with blunt abdominal trauma

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OBJECTIVE: The purpose of this study was to evaluate the efficacy of sonography in our algorithm when differentiating patients with blunt abdominal trauma who need immediate surgery from patients who would benefit from further diagnostic workup or who need no treatment. SUBJECTS AND METHODS: We performed abdominal sonography as the primary screening tool in 1671 consecutive patients in our prospective study. Radiologists performed sonography in the trauma room within minutes of the arrival of each patient. Hemodynamic instability in conjunction with positive sonographic findings led to emergency laparotomy. Otherwise, positive sonographic findings warranted additional diagnostic tests. Observing free fluid or organ injury caused us to categorize sonographic findings as positive. RESULTS: Sonography correctly identified all patients requiring emergency laparotomy. No inconclusive laparotomies were performed in this group. The sensitivity of sonography for revealing intraabdominal injury was 88%, the specificity was 100%, and the accuracy was 99%. In 132 patients (8%), abdominal CT was performed. CT revealed relevant posttraumatic abnormalities in 61% of all patients. Four hundred seventy patients with negative sonographic findings were discharged approximately 12 hr after admission; two of these patients (0.4%) were mistakenly discharged. Trauma scores did not influence the efficacy of sonography. CONCLUSION: Our algorithm that uses sonography as the primary diagnostic tool provides accurate, fast, cost-effective, and noninvasive initial management of patients with blunt abdominal trauma. Our test characteristics were excellent indicators of the need for emergency laparotomy. Sonography also achieves high values in revealing relevant injury. Our algorithm produced medically satisfactory and economically prudent management of patients with blunt abdominal trauma.

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