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THE USE OF ULTRASOUND IN MILITARY TRAUMATOLOGY

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Summary
In the last decade ultrasound (US) has become a very important diagnostic tool in many areas of medicine, including traumatology. US is a reliable method to detect blood in the peritoneum.
When a modern system and a skilled examiner are available the invasive diagnostic abdominal tap has become obsolete. Also hematothorax and hemopericard are easily diagnosed with US and diagnostic or evacuating puncture can safely be performed under US guidance.
US can also evaluate organ damage, in particular of pheripheral anatomical structures. It may guide interventional procedures and is very helpfull in the detection of foreign bodies, not visible on conventional radiographs.
For these reasons 21 portable US systems were purchased by the Netherlands armed forces in 1993, intended for use - next to X-ray equipment - in field hospitals with operating room facilities. Practical experience with the US systems was obtained during two years of "peacekeeping" activities in former Yugoslavia.
Due to modern technology a further reduction in size with development of one hand hold systems with good imaging qualities will soon be realised. This allows US examination of injured patients on the battlefields. In case of many victims and limited capacities US may play an important role in triage.

History.
The use of ultrasound (US) to identify invisible objects is not an invention of mankind. In 1794 the Italian scientist Spazzaloni suggested that flying bats, who in the dark can avoid obstacles and localise their prey, made use of US and he was right. In the development of US imaging to identify invisible objects military institutions played a big role.
After the Titanic disaster (1912) increasing research was performed to detect underwater obstacles. So in World War I experiments with high frequency ultrasound were performed by the French Navy to detect submarines and in World War II the successful SONAR (SOund Navigation And Ranging) system to detect under water obstacles was developed by United States Navy Institutions.
The basic principle is a short emission of ultrasound by activation of a crystal which is received again after being reflected by an object. The time past in between is a measure for the distance of the reflecting object and the amount of reflected US-waves gives some rough information about size and structure of it.
The same principle is used for ultrasound imaging of internal body structures, which are reflecting the US waves emitted the crystals in the transducer on the outside.
imaging system, which could visualise a piece of liver with a nail, a piece of plastic and piece wood pricked in it. Remarkable was the fact that the pieces of plastic and wood were visible as well as the nail, while on a conventional X-ray only the nail could be visualised. This experience suggests already the potential of US in identifying foreign bodies.
The first examinations of patients were performed in a tank with the patient up to his neck immersed in water and an underwater rotating transducer. This construction was for example shown in the "gun turret scanner" (1954), constructed with materials from a B29 bomber aeroplane.
The water was needed as intermedium because the ultrasound waves can not pass a fluid-air barrier was soon replaced by a jelly substance and in the early seventies the first commercial scanners came on the market. They were huge and expensive with poor (B-scan) images.
In the late seventies the strong reduction of the acquisition time, for needed one picture allowed a 'real time-imaging', which promoted diagnostic ultrasound imaging to a dynamic examination with a quick increasing clinical value in areas as gynaecology/obstetrics, cardiology and internal medicine.
The quick development of computer technology allowed the construction of today's light weight, compact US equipment and even portable systems, of which the monitor-screen is the main part in size and weight.

Role of US in modern traumatology.
The application of US to detect blood in the peritoneal cavity following blunt abdominal trauma has become a common practice in the last decade. US equipment is easily transportable and the non invasive examination can rapidly be performed and does not impede other diagnostic and therapeutic procedures.
In experienced hands US is a highly accurate method for evaluation of the abdomen in the blunt trauma patient (2), which makes the diagnostic peritoneal lavage an obsolete technique.
Main places where blood can be identified are Morrison's pouch between liver and right kidney, (the lowest place in upper abdomen in the patient laying on the back, subphrenic areas, right paracolic gutter and the area above and behind the urinary bladder in the lower abdomen (Cavum of Douglas).
Abdominal fluid (blood) in the hemodynamically instable patient means emergency surgical treatment, in particular in case of increase of the amount of intraperitoneal fluid on repeat examination.
The main pitfall is the rather uncommon presentation of clotting or fresh clotted blood as a reflecting material, which is often indistinguishable of hepatic, splenic or

In case of thoracic trauma the diagnosis of hematothorax and hemopericard is also easily made by US with a higher reliability than on conventional x-ray. In the unstable patient US guided evacuating puncture of blood or fluid collection in the pleural or pericardial cavity can be live saving. Furthermore, in the unstable patient with normal findings on US surgical treatment is not indicated but in that situation US should be repeated after a while.
In the stable patient application of US is important for detection and evaluation of organ damage, although Computed Tomography -when available- is mostly preferable for evaluation of abdominal organ damage (3).
When it is impossible to utilise one of the usual places for a central venous access US can be helpful to guide the puncture of a vessel which is otherwise not accessible e.g. the upper femoral vein. This vein is located just behind the artery, but can safely be punctured from a side under US guidance.
The peripheral structures of the body (thoracic and abdominal wall and extremities including the surfaces of bones) can be well visualised with modern US with a good near field transducer for evaluation of traumatic damage, even better than on Computed Tomography can perform.
Muscle and tendon ruptures, haematomas, damage of neurovascular bundles, periferal fractures of bone (also fractures of the cartilage parts of the ribs, invisible on conventional radiographs are mostly easily diagnosed with US.
Also foreign bodies, not visable on conventional X-ray (e.g. lead free glass, pieces of wood and plastic shrapnell) (4) are mostly easily demonstrated on US.

US in the Netherlands Armed Forces.
In the light of the high diagnostic value of US imaging in traumatology in 1993 21 portable US systems were purchased by the Netherlands Armed Forces together with some middle class systems. The systems were intended for use, next to x-ray equipment, in any fieldhospital with operatingroom facilities, also in the smallest ones.
Soon practical experience was got during two years "peacekeeping" activities in the former Yoegoslavian republic. Practical use of US was realised in the daily healthcare for the military men but an even more frequent application was the examination of diseased local civilians in the context of humanitarian medical care.
There were only a few casualties in wich US was used to evaluate the blunt trauma abdomes and for exact localisation of shrapnell, which allowed simple removal by the surgeon.
In the opinion of our expeditionary surgeons the use of diagnostic US systems, in case of modern equipment and skilled examiners, was at least as valuable as availability of conventional x-ray.

New developments.
In the last decade diagnostic US systems are considerably reduced in size with substantial increase in quality of imaging. Due to modern chiptechnology this development will problably even be accelerated in the near future.
A main challange is the replacement of the heaviest and biggest part of the system, the classic glass screen, by a flat, light-weight screen with adequate imaging quality. Illustration is the development of a US system by a leading ultrasound manufacturer in the USA, light and

This project should be realisized within two years and is granted by the USA Department of Defense for half of the costs of USA $ 12 miljons.
Philosophy behind is the intention to better utilize the 'golden' hour, in wich medical care to the victim of violence is most effective. The small US system should be brought to the injured patient on location of severe accidents, disaster and battlefield to evaluate the site and severity of the injuries and guide effective (first) aid.
In particular in case of many victims and limited capacities US could be very helpful in triage of the patients. It is evident that other manufacturers soon will follow or already started similar developments.
So, it is not needed to be a fortuneteller to predict that in the near futher many trauma-teams will be equipment with small, portable ultrasound systems and that US examination of victims on location of the violence will become a common procedure.

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