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REVIEW ARTICLE

THE ROLE OF SONOGRAPHY IN EMERGENCY MEDICINE

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Summary

Sonography, thanks to the miniaturization, is increasingly widespread as a bedside examination technique in both hospital and prehospital emergency care. A number of protocols were set up for its effective and fast usage. The article briefly depicts this method and the requirements and ways of its application in the emergency care.

Key words: ultrasound; sonography; FAST; BLE; TTE

INTRODUCTION

Sonography is an imaging technique based on a different speed of sound in different tissues, their different reflectance and attenuation of ultrasound waves emitted to the organism by the electrically stimulated piezoelectric transducer of the examination probe. The picture comes up from the evaluation of the difference of the time when the signal was sent and received after reflection on the interface of two accoustic media with different accoustic impedance. High frequencies in megahertz are used for the diagnostic purposes. (2) Diagnostic usage of sonography in medicine has been expanding over last 20 years thanks to the miniaturization of the devices, increase in the resolution and accuracy and usage of ever more sophisticated computer technology that enables faster and more extensive digital processing of the obtained signal, but mainly also thanks to the decreasing purchase price.

Miniaturization of sonographs into current literally pocket sizes enables their utilization at whatever hospital bedside, but also in the prehospital emergency care where they might be successfully used in diagnostics of many life-threatening conditions and other emergencies with abdominal and heart pathology and helps in differential diagnostic process. Obstacles to the routine availibility of such equipment in ambulance cars are constituted mainly from the purchase price that still remains high, even more than 500 thousand CZK for a brand new unit, and the fact that there is an absence of both undergraduate and postgraduate training in sonography (and also other imaging techniques) for medical doctors except for the physicians who attend to radiology, eventually gastroenterology, cardiology, gynaecology or urology and display just the organs of their interest. Another problem is that many radiologists are unwilling to accept the profit from using sonography by physicians of other specialties or even to train them in taking advantage of using it in their work while emergency sonography is already

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a part of the curriculum of surgical and emergency residents in some countries and is a common clinical challenge for them. (1, 4) Sonography is ever more used also in an intensive care, eg. for navigation in invasive procedures such as central venous cannulation etc. The utilization of sonography in acute care was also inspired by the ATLS protocol in the USTLS – Ultrasound Trauma Life Support what may extend the ATLS.

TRAINING IN SONOGRAPHY

Besides the financial resources for the purchase it is important to provide appropriate training for the physicians what may become another financial burden for the organization as well as problems with releasing the staff for their time-consuming training that, unfortunately, does not exist as an offered product (course etc.) and therefore it is practicable only as a combination of extensive self-study and internship lasting ideally several months under the guidance of an experienced sonographer while a few hundreds of patients would be examined under his or her supervision. Unlike electrocardiography, for example, the sonography is a method requiring sufficient practical skills of the sonographer and cannot be mastered by the sole self-study and sighting the images in the textbooks. Tens of hours spent at the patients with the examination probe in the hand are necessary. I attribute a great importance to the theoretical preliminary, especially the understanding of physical principles of the formation of the image, identification of the artifacts and ability to explain their origin. Artifacts of the images, for example the accoustic shadows, reverberations or the phenomenon of distal amplification are not just a distortion of the image (as it might seem when something is called an „artifact"), but they have their diagnostic importance.

I beg to estimate from my experience that to master the essential ultrasonic anatomy and orientation in the abdomen, work with the patient and the examination probe and recognition of major pathologies, a hundred of examinations performed under the supervision may be enough. Another hundred of examinations is performed more skillfully and with better certainty in cases of common pathology. The third hundred of examination is performed rather routinely and doubts come from rare and uncommon findings only. The practical training itself must be preceded by particular theoretical preparation, mainly in the field of physical principles of sonography and anatomy of peritoneal cavity and its organs. By the way, a thousand of performed examinations is required for licensing in abdominal sonography by the Czech medical chamber.

BENEFITS OF SONOGRAPHY IN EMERGENCY MEDICINE

Contrary to the obstacles of vast utilization of sonography in emergency medicine mentioned above it remains totally safe, non-invasive and painless examination technique with almost no operational costs. It is also the only imaging method applicable in the prehospital setting which, in case of its mastery, provides quite extensive diagnostic use and information in these areas:

- presence of free fluid (blood, ascites...) in peritoneal cavity
- traumatic changes (laceration) of parenchymatous organs
- toxometabolic affliction of liver (steatosis, cirrhosis)
- portal hypertension
- inflammatory changes of organs
- focal affliction of organs by tumors and metastases
- cysts of parenchymatous organs
- presence of concrements in biliary and urinary tract
- urinary stasis in kidneys
- fluidothoraces
- pneumothoraces
- pericardial effusion
- valuation of heart kinetics and dimensions
- evaluation of hydratation
- filling of the urinary bladder
- pathology of great vessels (abdominal aortic aneurysm)
- pathology of lymphatic nodes
- enteral motility disorders
- detection of pregnancy (incl. ectopic).

SUITABLE EQUIPMENT

Optimal equipment for the sonographic examination in prehospital emergency care is a handheld sonograph with its weight as low as possible (less than approx. 2 kg) equipped with about

5" screen and a sector (or a small convex) probe which is well applicable for both abdominal and heart examination, working with variable frequencies from 2,5 to 5 MHz and depth of 15 cm at least. Tough construction of the device that can be securely and comfortably held in one hand only is very suitable, as well as accessories including protective etui. The M mode (besides the basic dynamic B mode) is an advantage enabling measurement of dimension changes of vessels and heart chambers in time and the frequency of the changes. Function of saving images in the internal memory, recalling and export is implemented generally. A useful function is a „cine loop" – a loop of a few tens or hundreds of images saved automatically before the image is frozen, that can be traced frame by frame. Indispensable feature is the operational time long enough (1 hour at least) for which the device may be operated from the battery, as well as another changable battery and a charger for the cigarette lighter plug (to recharge it eg. in an ambulance) as parts of the accessories. I assume the opportunity and a way of further expansion of sonography in the prehospital care in the development of already existing ultrasonic probes connectable by the USB connector to whatever notebook, netbook or also a smartphone. Their rapid development should make them cheaper too.

Figure 1. Usage of a handheld ultrasound scanner by an emergency physician in emergency medical.

FOCUSED ABDOMINAL SONOGRAPHY IN TRAUMA

Although I suppose that for the performance of the ultrasound examination with a satisfactory accuracy a training in the complete abdominal sonography should be passed, I will present a brief protocol for a quick screening of the presence of free fluid in the body cavities, so called FAST, Focused Abdominal Sonography in Trauma, being used in the polytraumatized patients, when the objective is to examine the presence of fluid collection in the peritoneal cavity and pericardium in a short time. Other diagnostic methods in blunt abdominal trauma

is rather obsolete diagnostic peritoneal lavage (DPL) and a CT scan of the abdomen, which is highly sensitive, specific, but also relatively hardly obtainable and requring expensive equipment and tens of minutes for carrying out and evaluation of the examination. CT scan is not suitable for cardiopulmonary unstable patients and must not be done in the pregnant women.

FAST scan is absolutely non-invasive, can be carried out directly at the patient's bed within a few minutes and reassessed whenever it is needed. Its disadvantage is that it doesn't have to explain the origin of the free fluid, it is not much convenient for imaging of the hollow viscera and its usability may be considerably limited by the habit of the patient or the presence of either subcutaneous or gastrointestinal air (fasting for 6 and more hours is an advantage in this respect).

The examination is focused at the detection of free fluid (besides the blood, urine or stool there may be ascites that was present before the trauma) that is anechogenic, ie. black in the image. The echogenity of coagulating blood increases in time, so its image gets brighter.

Four following areas are standardly visualized and about 30-60 seconds is needed for each view:

- subxiphoid/pericardial view (liver, heart, pericardium)
- right upper quadrant view (perihepatic – liver, right kidney, paracolic gutter)
- left upper quadrant view (perisplenic – spleen, left kidney, paracolic gutter)
- suprapubic/pelvic view (pouch of Douglas – rectovesical or rectouterine).

This basic examination might be done in about 3 minutes only. It is useful to fill the bladder with approx. 250 ml of a sterile normal saline through the urinary catheter which is clamped afterwards to visualize the pouch of Douglas well if the bladder is not filled enough wtih urine.

In a hemodically stable patient who suffered a blunt abdominal trauma, in case of positive or uncertain result (especially w/o signs of peritoneal irritation) a CT scan is indicated before the laparotomy, if available. In case of negativity, the patient should be observed (8 hours at least) and the examination repeated later, a CT scan may be considered.

In a hemodynamically unstable patient with a positive FAST scan (especially with signs of a peritoneal irritation) an urgent surgical revision is indicated. In case of negativity, other sites of blood loss and also other reasons of a (non-haemorrhagic) shock should be considered and the FAST scan repeated, a diagnostic peritoneal lavage might be performed.

In case of a positive FAST scan for pericardial free fluid after a blunt thoracic trauma, a surgical intervention should be performed immediately.

Clinical experience shows that free fluid is well detectable from about 250 ml, in the perihepatic area from about 70 ml and in the pouch of Douglas from as low as 15 ml. The detection of the free fluid is dependent on the patient's position, of course. A prospective study from 1993 (Rozycki et al.) in 358 patients (15 % out of them with proven free fluid by a „gold standard" – CT, laparotomy) investigated the diagnostic value of the FAST scan performed by surgeons in traumatized patients and had these results: PPV of 98,1 %, NPV of 96,2 % and overall accuracy of 96,5 % in detection of hemoperitoneum and hemopericardium. (5) Another study of Soundappan et. al. from 2003 in 85 injured paediatric patients (4 months-4 years,ISS 1-38) turned up with NPV of 97 %, PPV of 100 % and accuracy of 97 % confirming the FAST being a safe and accurate method of diagnostics of the free fluid in peritoneal cavity in blunt trauma by a surgeon. (6)

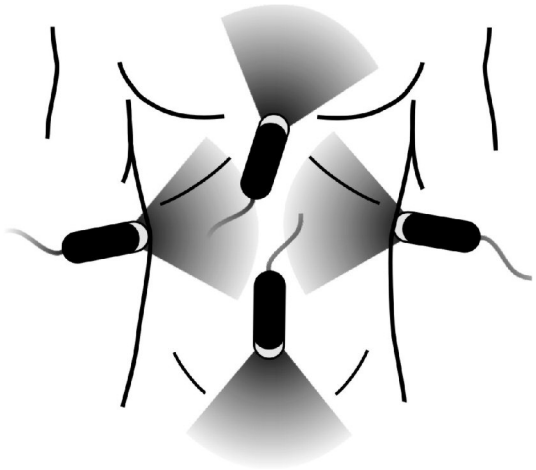

Figure 2. Four standard scanning views in a FAST scan.

The extended version of the protocol is eFAST – enhanced FAST, aimed also at both hemithoraces where a pneumothorax or fluidothorax may be revealed. (The fluidothorax is often also viewable when scanning the upper quadrants of the abdomen and therefore its diagnosis if often made in the FAST protocol.)

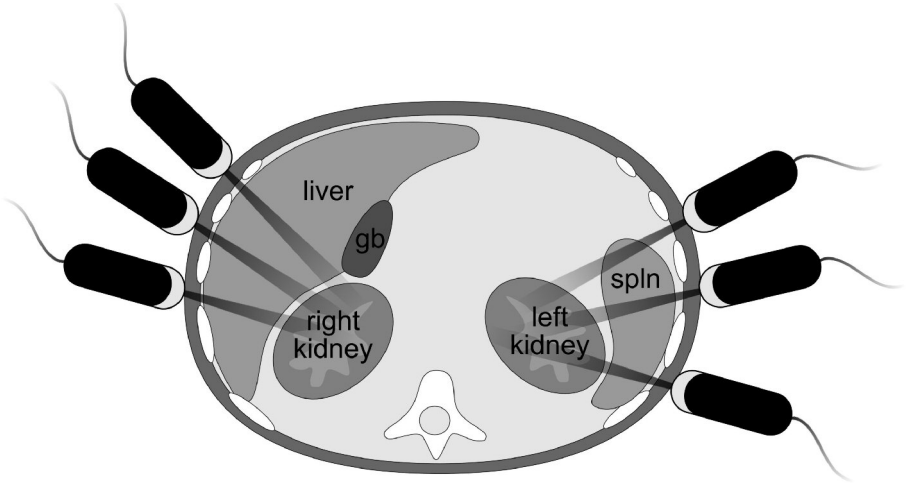

Figure 3. Transversal view of scanning the upper abdominal quadrants in a FAST scan (gb – gallbladder, spln – spleen).

The advantage is that the patient may be well examined in the supine position when the X-ray examination often fails and is false negative. However, more detailed description of the examination, specific findings and possible complications during the examination exceed the potential and objectives of the article.

ECHOCARDIOGRAPHY IN EMERGENCY MEDICINE

Parallel protocol for a fast and basic diagnostics in the transthoracic echocardiography (TTE) is BLE – Bedside Limited Echocardiography or BLEEP – BLE by Emergency Physicians, respectively, aimed at the assessment of the overall heart kinetics rather than local abnormalities, estimation of LVEF – Left Ventricular Ejection Fraction (by measurements of the left ventricle and calculation using the M mode) and assessment of the preload by viewing the inferior vena cava. It is done by scanning in the 2 basic views only – subcostal and parasternal short axis view. It absolutely cannot replace the standard TTE examination and there isn't also any goal like this. Also in case of this examination at least 50 examinations performed under the supervision are advised. A more detailed protocol, for example, is the FATE protocol – Focused Assessed Transthoracic Echocardiography using some more views: an apical and two pleural ones. It is used, in the clinical context, to exclude obvious pathologies, assess dimensions of heart chambers and contractility and visualize pleura on both sides. (3) It should be mentioned that there are one-day courses of echocardiography for intensive care physicians arranged by the Department of Anaesthesia and Intensive Care of the General Teaching Hospital in Prague, only such training available in the Czech republic at present.

CONCLUSION

Sonography is a very efficient diagnostic tool for emergency physicians that could be, thanks to the miniaturization and decline of purchase price of the machines, widely used in their daily practice and a training in sonography should become a part of their curriculum and training like it is in other countries. Unfortunately, there are still many obstacles that prevent sonography from its wide-spread and routine use in both pre-hospital and hospital emergency medicine in our country, mainly the purchase prices still remaining quite high and a lack of both undergraduate and postgraduate training in sonography. Czech physicians interested in this method are now reliant foremost to self-study and an individual internship. Besides coping with the theory of the abdominal sonography or also echocardiography and particular internship or a course, it is important to practise the examination afterwards regularly as well as deepen the theoretical knowledge. There is no sense in conceiving the basics of the examination without the possibility of taking advantage of it in daily practice routinely and evolving own skills – similarly to someone who has passed a driving school but has no opportunity to drive a car.

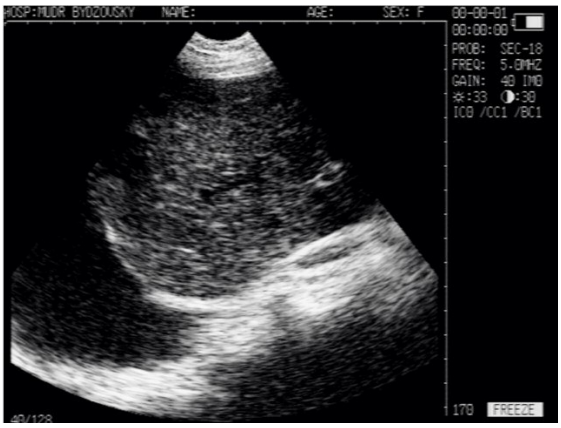

Figure 4. Fluidothorax on the right side.

Figure 7. Pancreatic effusion with a stripe of free fluid in acute pancreatitis.

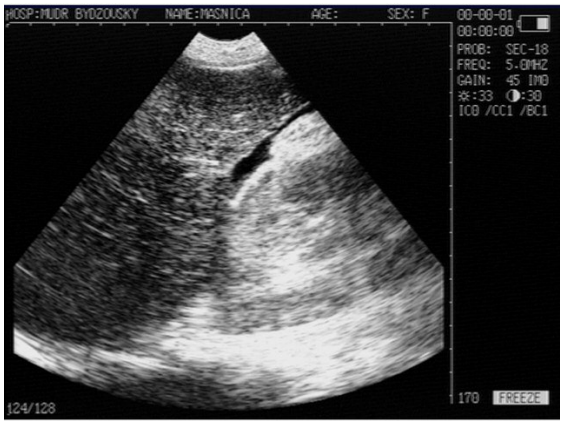

Figure 5. A stripe of free fluid in the hepatorenal recess.

Figure 8. Abdominal aortic aneurysm (99 mm, lumen 44 mm).

Figure 6. Intestinal loops with mesenterium floating in ascites.

Figure 9. Severe hydronephrosis.

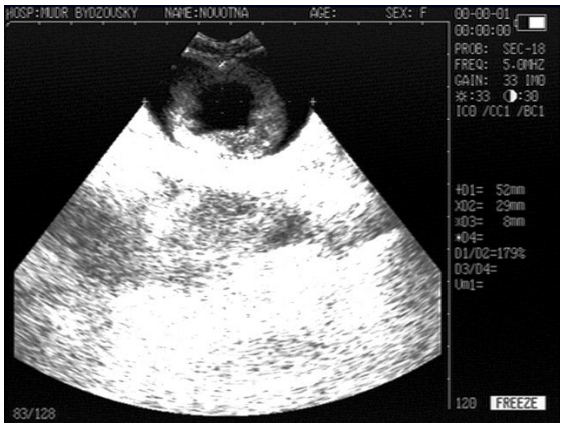

Figure 10. iIcarcerated umbilical hernia – intestinal effusion and hernial sac filled with fluid.

Figure 11. Concrements in gallbladder with their acoustic shadows.

Figure 12. Gall stone in a distended bile duct.

Figure 13. 15th week of the gravidity.

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