EchoScopy in scanning abdominal diseases; a prospective single center study

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Abstract

Background and aims: The introduction of a new type of small handheld ultrasound device brings greater portability and affordability in a different setting. The basic ultrasound approach with these handheld devices has been defined by European Federation of Societies of Ultrasound in Medicine and Biology (EFSUMB) as “EchoScopy”. The current study aimed to assess the image quality, indications and limitations of a portable pocket “EchoScopy” performed first compared with a high-end ultrasound system (second) in abdominal diseases.

Material and methods: Three hundred consecutive patients (158 males and 142 females, age 55±19 [18-96] years) were included. The ultrasound examinations were performed firstly by an EchoScope (Vscan™ Dual Probe) and secondly with a high-end ultrasound system (HEUS, GE Logiq E9). Compared with the always excellent image quality using HEUS, the image quality of the EchoScope was graded as good, sufficient or non-sufficient. Results: Out of all 300 patients, 221 had focal lesions, 31 patients were found with diffuse pathological findings, 20 with ascites, 25 after liver puncture and 45 without any pathological findings. The image quality of the pocket device was considered as being good or sufficient to delineate the pathology in 265/300 (88%). The detection rate of the EchoScope for abdominal focal lesion was 172/221 (78%). The higher frequency of the Dual Probe was helpful in 35/300 (12%). Conclusions: EchoScopy has proven to display sufficient image quality to answer specific questions, e.g., detection of ascites, splenomegaly, bile duct enlargement, hydronephrosis and other pathological findings which can be judged by “yes/no”.

Keywords: guidelines; mobile ultrasound; point of care; EchoScopy

Introduction

The basic ultrasound (US) approach with handheld devices has been defined by the European Federation of Societies of Ultrasound in Medicine and Biology (EFSUMB) as “EchoScopy”, to distinguish the use of EchoScopy from conventional ultrasound and point of care examinations, the latter being US examinations performed bedside with conventional equipment and interpreted directly by the clinician [1-9]. Early studies were reported on mobile ultrasound equipment in a laptop format with promising results [10-12].

More recently a new category of handheld devices of pocket size similar to a smartphone were developed, therefore, the data are not comparable to the much larger equipment used in earlier studies. Currently the smallest device is the Vscan™ (GE Healthcare) more recently as a dual probe. The EchoScope provides conventional B-mode and colour Doppler imaging (CDI). The compact size of the EchoScope makes it possible to carry the ultrasound device almost like a stethoscope under most clinical circumstances including visiting patients [5,13-37]. Owing to this convenience, the EchoScope can be used as an adjunctive tool for physical exami-
nation [8,38]. The objectives of the present prospective study were as follows: To assess the B-mode (including measurements) and colour Doppler image quality of the EchoScope compared with a high end ultrasound system (HEUS), to evaluate the diagnostic accuracy of EchoScope in scanning defined abdominal diseases, to evaluate the detection rate of focal liver lesions (FLL) of EchoScope, to define and confirm indications for EchoScope and to identify indications where EchoScope may not be recommended.

**Material and methods**

**Patient recruitment**

Three hundred consecutive patients (158 males and 142 females, age 55±19, range 18-96) years were recruited requiring an US examination of the abdomen for different reasons. The feasibility study was approved by the institutional board. Informed consent was received from all patients. The investigated organs included the hepatobiliary-pancreatic, gastrointestinal, urogenital and large vessels (aorta) as previously described [2].

**Equipment**

Two different US systems were used: A Vscan™ Dual Probe pocket device (GE Medical Systems, Milwaukee, WI, USA) and the GE’s Logiq E9 ultrasound system (GE Medical Systems, Milwaukee, WI, USA), an exemplary high-end ultrasound system.

As already mentioned, Vscan™ Dual Probe is a handheld pocket-sized US equipment with unit size of 135x73x28 mm and a total weight of 436 g including a fixed broad-bandwidth phased array transducer (1.7-3.8 MHz) and a second broad-bandwidth linear array transducer (3.4-8.0 MHz) (fig 1). For more comparing figures we refer to the EFSUMB atlas (www.efsumb.org). The size of the display is 3 inches with resolution 240x320 pixels. It has a rechargeable battery with a mean run time of B-mode images of 90 minutes and B-mode (80%) and CDI (20%) of 60 minutes.

The entire unit including transducer can fit into a white coat pocket and it is designed to be operated with one hand. All the recorded images and MP4 videos are stored in a SD memory card and can be reviewed on its display unit or copied easily to a PC via the included docking station or directly from the SD-card. This device provides conventional B-mode and CDI. Further functions such as pulsed wave and continuous wave Doppler are lacking.

The fully equipped high end ultrasound system Logiq E9 allows the visualization of structures regardless of the depth due to its increased penetration and sensitivity. This is especially important for scanning obese patients and to examine superficially located structures.

**Data acquisition and analysis**

One experienced physician (Deutsche Gesellschaft für Ultraschall in der Medizin [DEGUM] 3 level, CFD) performed the examinations in this study. With a comprehensive knowledge of the medical history and symptoms of the patient, the physician performed an US investigation first with the Vscan™ Dual Probe for scanning the abdominal organs and made a diagnosis. Then the US investigation was performed using HEUS. The examination time with Vscan™ Dual Probe and HEUS took 15-30 minutes; the examination time with Vscan™ Dual Probe was slightly shorter since less details were observed. Their main diagnoses were compared to investigate the agreement rate as previously described [2]). Artefacts were considered [39-41]. The thorax, pleura and lung were not included and results were published elsewhere [4,6,39,42,43].

The following abdominal organs were evaluated and listed on-site findings as previously described [2]: 1) liver: focal liver lesion detection [44-47] including focal fatty sparing [48,49]; portal vein (flow direction)

![Fig 1. Vscan™ Dual Probe use in scanning the abdomen. Acute biliary pancreatitis is shown (a-c). The gallbladder with stones (a), the bile duct (enlarged) (b), the stone in the common bile duct is assumed (c). A 10 mm lymph node is clearly shown (LN) next to a transmural inflammation in a patient with Crohn’s disease (d).](image-url)
[50-53]; detection of complications after biopsy and treatment procedures [54-58]; diffuse liver disease (liver cirrhosis and fatty liver, defined by the detection of focal fatty sparing) [49,59]; 2) biliary system: detection of gall bladder stones, sludge or neoplasia; measurement of bile duct diameter (normal: <6 mm, after cholecystectomy <10 mm) [60]; cholecystitis; 3) pancreas: detection of focal lesions; diffuse parenchymal disorders with pancreatic duct pathology; 3) spleen: splenomegaly (size); lesion detection; lesion characterization; 4) kidney: detection of hydronephrosis; lesion detection including typical cyst; nephrolithiasis >5 mm; 5) aorta and inferior vena cava: abdominal aortic aneurysm [15,18,23,37,61-64]; inferior vena cava evaluation [28,36,64]; 6) peritoneal cavity: detection of ascites [4,17,23,35]; guiding abdominal paracentesis [57,58,65,66].

For the patients with focal lesions, the largest diameters were measured and the colour Doppler signals (blood flow) were graded within the lesion on the same plane with both the Vscan™ Dual Probe and HEUS as previously described [2]. The vascularity in the lesion was classified into 0-III grades [2,51,53]: grade 0: no vessels; grade I: small vessels, one or two punctiform or short rod-shaped colour flow signals; grade II: medium sized vessels, one main vessel or ≥3 small vessels; grade III: high vascularity, ≥2 medium sized vessels.

Because the size of the window on CDI cannot be changed on Vscan™, larger lesions may not be totally covered by one colour Doppler window. In this case the window was moved from one side to the other for grading the colour flow comprehensively as previously described [2]). For some diffuse diseases of abdominal organs, such as fatty liver, the degree of severity was classified as mild, moderate and severe [49,59,67] depending on sonomorphological results.

In addition, the image quality was evaluated: the image quality of HEUS was classified as excellent. The image quality of the EchoScope Vscan™ Dual Probe was analyzed via display and via PC after copying the images from SD card. They were assessed and classified in three classes: 1: good; 2: sufficient (with noises which did not influence the diagnosis); and 3: insufficient.

**Statistical analysis**

Continuous data were presented as the mean±standard deviation (SD). The measurements achieved from the Vscan™ Dual Probe and HEUS were compared with paired Student’s t test, and also with the Pearson’s correlation test. Wilcoxon rank sum test was used to compare the difference between the grade of colour flow from the Vscan™ Dual Probe and HEUS and also the score of image quality, Spearman’s correlation test was applied to analyze their correlations. p-values <0.05 were considered significant. Tests and calculations were carried out using SPSS package, version 19.0 (SPSS Inc., Chicago, IL, USA).

**Results**

In 221 patients one or more focal lesions were found; 31 patients showed diffuse parenchymal disorders; in 20 patients ascites could be displayed and 25 patients were investigated after performing a liver biopsy. Finally, 45 patients had no pathological ultrasound findings in examination performed with both ultrasound systems.

**Image quality**

The image quality of the pocket device was considered as being good or sufficient in 265/300 (88%) patients in comparison with the image quality of Logiq E9 as our defined standard of excellence.

The detection rate of the EchoScope for abdominal focal lesions was 172/221 (78%) in comparison to the gold standard. The higher frequency transducer of the Dual Probe was tested in all and helpful in 35/300 (12%). In addition, the image quality was not sufficient in three patients with appendicitis and 15 patients with peridiverticulitis.

**Scanning for focal lesion**

In 221 patients, 221 focal lesions were assessed by HEUS in different locations: liver, n=101; gallbladder, n=21; pancreas, n=13; spleen, n=7; kidney, n=30; abdomen, n=9; aorta, n=7; portal vein, n=2; common bile duct, n=1; colon, n=12; lymph nodes, n=12. EchoScopy was unable to detect the known lesions in 12 patients due to insufficient image quality (four deeply located focal liver lesions, one patient with appendicitis, 2 with diverticulitis and five patients with Crohns disease). Taken together, the detection rate of EchoScopy for abdominal focal lesion was 172/221 (78%). The mean diameter of the focal lesions measured with HEUS and EchoScopy were 3.7±2.6 cm and 3.6±2.4 cm, respectively (not statistically significant (p=0.11). CDI was performed in all patients with focal lesions identified both ultrasound systems; 193/221 (88%) of lesions had the same CDI grades on both HEUS and EchoScopy.

**Scanning for diffuse disease**

Diffuse diseases were diagnosed in 19 patients using HEUS (fatty liver, n=8; liver cirrhosis, n=5; bowel wall thickening, n=3; hydronephrosis, n=3). The diagnosis with EchoScopy and HEUS were in agreement in 18/19 (94.7%) patients. Only one patient with mild fatty liver disease using HEUS was misdiagnosed as a normal finding on EchoScopy.
Abdominal paracentesis and assessing complications after intervention

EchoScopy was used for performing abdominal paracentesis, especially to determine the best localization site for puncture in six patients with ascites. HEUS and EchoScopy had a total (100%, 6/6) agreement for the localization. The depth of the fluid at the positioning point on HEUS and EchoScopy was 4.03±1.51 cm and 4.08±1.52 cm, respectively. For six patients with unclear liver tumors who underwent liver biopsy, both US devices showed that there was no hemorrhage or other complication.

Discussions

So far small sized handheld devices have been mainly studied in cardiology (echocardiography) [4,6,33,35,68], vascular indications mainly focusing on abdominal aorta aneurysm [15,18,23,37,61-63] and in the setting of Focused Assessment with Sonography for Trauma (FAST) [4,17,23,35,69-71]. Studies on the use of abdominal diseases are sparse [2,22,72-74] and except one [2] mainly focus on case reports [72] and acute cholecystitis patients [74].

The present study analyses the value of a new dual probe ultrasound pocket device in screening abdominal organs compared with a HEUS system (feasibility study). In slight contrast to the recently published study with examinations of HEUS before echoscopy the results in this study were slightly worse for EchoScopy, explained by the different setting of HEUS before EchoScopy versus EchoScopy before HEUS.

The main results can be summarized as follows: 1) the image quality of EchoScopy was good in comparison to the excellent image quality of HEUS in examining most abdominal diseases; 2) EchoScopy has an impact for detecting abdominal diseases in certain indications; 3) EchoScopy is not intended to rule out abdominal diseases in detail; 4) Vscan™ dual Probe measurements are reliable; 5) EchoScopy has an impact in the localization of the puncture site for paracentesis and assessing complications of intervention.

EchoScopy using Vscan™ is hitherto the smallest available handheld device which fits into the pocket of a white coat. In spite of its small size, the image quality is sufficient in many clinical settings. To rule out abdominal diseases is not possible [2,7,72,73]. The results are in accordance with other applications, e.g., echocardiography [4,6,16,17,19,23,24,28,30,32,33,35,75-78]. A reason might be that the quality and the frequency of a probe strongly affect the depth and resolution of the image. Due to the fact that the penetration and frequency of the Vscan™ probe is limited compared to the wider range of HEUS, it determines that the Vscan™, has some deficiencies in scanning superficially and very deep located organs and structures. One major limitation for most available US equipment is to achieve a good image quality in obese patients. Therefore, it is not surprising that Vscan™ is no exception.

Recently, it could be shown that the image quality via EchoScopy display was significantly better than the image quality after transferring and displaying the data via PC. The Vscan™ device is equipped with a 4 GB SD card for the storage of the videos and images, and an image is usually 14-20 KB of size, which is much smaller than images of other ultrasound systems. The small size of the image restricts the resolution, and especially the image quality copied on a PC was of poor quality. There was a significant difference between evaluation on the Vscan™ device and after transferring to a PC (p=0.026). Similar results have also been reported in echocardiography. We did not exam this factor again, since no other results were expected. The Vscan™ full screen echocardiography images on PC were of a lesser quality than those from the HEUS equipment.; However, no difference was found between the image quality on the display of Vscan™ device and that of the high-end ultrasound equipment [19]. However, this issue is not of high importance for most clinical applications, since diagnosis is often made directly when the examination is finished, but may causes problems when reproducibility is required, for example if interhospital transfer is necessary.

The difference in measurements on the same section by the same sonographer between the two US systems was also estimated which is of importance when it comes to normal reference values [52,60,64]. No significant differences were found [2]. Nevertheless the measurements intravaginally obtained by Vscan™ with a designed intravaginal gadget for obstetric and gynecologic lesions were 0.3-0.4 cm lower than those obtained with a high resolution ultrasound device [20], a trend we could observe as well. Although the measurement does not affect the detection of lesion, it may influence the diagnosis of the diseases and predominantly the therapeutic procedures [2]. The agreement for abdominal aorta aneurysm diagnosis was high using these two ultrasound systems [15].

CDI using EchoScopy has been established and has worked well with respect to sensitivity in the abdomen [2]. It was used in echocardiography in the emergency setting including trauma [4,6,16,19,33,71-79]. More details have been recently discussed [2]. The main disadvantages and limitations are the small screen size (the CDI window cannot be changed during Vscan™ exam-
imization to cover the whole area of a larger lesion) and lack of pulse-wave and continuous Doppler to evaluate the blood flow velocities. It has to be pointed out that CDI plays a crucial role in the differential diagnosis of abdominal focal lesions [2,80-84].

The small size of this miniature scanning device allows the physicians to perform US bedside, not only for diagnosis, but also for therapeutic options such as performing abdominal paracentesis or detecting complications after puncture. It is beneficial that the patients do not need to be transferred to the US unit and subsequently it simplifies the diagnostic and therapeutic procedures. According to our experience, Vscan™ can also be used for the puncture of abdominal effusion [2].

Some other studies have shown that the inter-observer agreement was high; both inexperienced and experienced sonographers could produce adequate quality images [18-20]. Another important limitation to this study is that there was no better gold standard than performing an US examination with a HEUS. One additional limitation of this study is that Vscan™ and HEUS examinations were performed by only one physician; therefore, we could not demonstrate the inter-observer variability.

It is expected that the current high frequency probes may facilitate sonographers to examine superficial organs, e.g. thyroid, breast and cervical vessels. In general handheld, battery-powered US devices may be very useful in a variety of clinical settings. Due to the fact that image quality, feasibility, handling and storage options are improving rapidly, Point of Care Ultrasound (POCUS) will achieve a significant importance in outpatient and in-patients’ care, but also in emergency settings. Additional acquisition costs are reasonable.

Conclusion

Our prospective study showed a good feasibility for scanning abdominal diseases with a high detection rate for abdominal pathologies but could not exclude diseases with an appropriate guarantee. Vscan™ Dual Probe does not allow detection very superficially and deep located lesions. We summarized in Table I the limitations for Ecoscopy. The EchoScopy device can be used in the assessment of particular defined abdominal diseases under certain clinical settings with yes/no responses. It can also be used, for performing abdominal paracentesis and the evaluation of complications after an abdominal puncture. Future studies should focus on the point of care value in certain settings, e.g., palliative care and geriatric patients. Taken all results together, the Vscan™ Dual Probe is a good advancement compared to Vscan™ with only one probe. It is very helpful and can be used in many clinical settings. This mini-handheld ultrasound device improves clinical examination in the every-day setting.

Table I. Not recommended abdominal indications for EchoScopy

- Examination of superficially located organs, e.g. intestinum, bowel wall estimation
- Detection of superficial pathological findings
- Indications in oncology
- Estimation of vascularity, e.g., inflammatory bowel diseases
- Difficult examination conditions, e.g. obesity
- Indications beyond the definition of EchoScopy

References

is interchangeable with high-end portable system when performed by experienced examiners. Acta Anaesthesiol Scand 2010;54:1217-1222.


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