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UROLOGY - ORIGINAL PAPER

A urologic stethoscope? Urologist performed sonography using a pocket-size ultrasound device in the point-of-care setting

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Abstract
Purpose Ultrasound is commonly used in urology. Technical advances with reduced size and cost led to diffusion of small ultrasound devices to many clinical settings. Even so, most ultrasound studies are performed by non-urologists. We aimed to evaluate the utility of a pocket-size ultrasound device (Vscan™ GE Healthcare) and the quality of urologist performed study.
Methods Three consecutive studies were performed: (1) a urologist using the pocket ultrasound, (2) a sonographist using the pocket ultrasound, and (3) a sonographist using a standard ultrasound device. Thirty-six patients were evaluated with a basic urologic ultrasound study. An excepted deviation between studies was preset for numeric parameters and *t* test performed. Ordinal parameters were analyzed using Cohen's kappa coefficient.
Results Kidney length, renal pelvis length, renal cyst diameter, post-void residual and prostate volume (transabdominal) differences were found to be insignificant when comparing a urologist pocket ultrasound study to a sonographist standard ultrasound study ($P = 0.15$; $P = 0.21$; $P = 0.81$; $P = 0.32$; $P = 0.07$, respectively). Hydronpehrosis evaluation (none, mild, moderate and severe) and the presence of ureteral jet signs conferred a high inter-observer agreement when comparing the above studies using the Cohen's kappa coefficient ($K = 0.63$; $K = 0.62$, respectively).
Conclusions Urologist performed pocket ultrasound study is valid in evaluating the upper and lower urinary tract and is practical in many clinical scenarios. The urologic stethoscope is now becoming a reality within reach.

Keywords Point-of-care ultrasound scanning (POCUS) · Urinary tract evaluation · Urologic stethoscope · Urologist performed ultrasound

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Introduction

Over the last half century, ultrasonography (US) became an integral part of many fields in medicine. The ongoing technological advancements manifested by improved performance along with decrease in device size and reduced costs has led to rapid diffusion of ultrasound devices to medical wards, emergency rooms, ICU's and outpatient clinics. This phenomena has brought along the need for adopting point-of-care ultrasound scanning (POCUS) skills. Several disciplines have long ago undergone this change. Gynecologists are long familiar with this modality [1, 2] and have incorporated a self-preformed sonographic evaluation as an integral part of their physical examination. Cardiologists routinely perform echocardiography. Other disciplines have started to recognize the value of POCUS [3, 4].

Sonographic evaluation of the urinary tract is routinely preformed in a vast spectrum of clinical scenarios such as lower urinary tract symptoms (LUTS), renal colic, voiding dysfunction, pediatric patients and many more. Transrectal US for the evaluation of pelvic abnormalities and for guidance of prostate biopsies is almost solely performed by urologists. Leonard et al. reported back in 1987 that a urologist preformed basic US study is cost-effective, useful and therefor recommended [5]. Others have reported similar findings [6–10]. Even so, most of urologic US studies are still commonly performed by radiologists. The vision of the bedside sonographic "Urologic stethoscope" seems now reality with the availability of small-sized US devices.

We aimed to evaluate the utility and performance of a handheld\pocket US device (HHD) compared to a standard US device (SD) while also comparing the quality of a urologist performed HHD sonographic study with that of a trained sonographist.

Materials and methods

We prospectively examined 36 patients admitted to our ward for various reasons. The study protocol was approved by our institution's ethics committee and conducted according to its guidelines.

After obtaining informed consent, three consecutive standard urologic US evaluations were performed, per a preset examination protocol, accordingly:

1. A urology resident (with at least 1 year of routine urologic sonography experience) using the HHD (study 1).
2. A sonographist (with at least 10 years of experience) using the HHD (study 2)
3. A sonographist using a standard (SD) ultrasound workstation (study 3).

The studies were performed consecutively within 1 h.

The following parameters were obtained in each study: kidney length, hydronephrosis (subjective evaluation classified as none, mild, moderate and severe), renal pelvis width, number of renal cysts, diameter of largest cyst, presence of ureteral jet signs, prostate volume (transabdominal) and post-void bladder volume.

In order to isolate the operator from the device performance, we separately compared the urologist performed HHD study to the sonographist performed HHD study (1 vs. 2) and the sonographist performed HHD study to the sonographist performed SD study (2 vs. 3). In addition, we compared the urologist performed HHD study to the sonographist performed SD study (1 vs. 3).

The ultrasound used were: HHD—Vscan™(GE Healthcare). SD—GE Volusion 730/Logic Q8 (GE Healthcare)

Statistics

A preset clinically excepted deviation of the quantitative parameters was defined for each parameter. These excepted deviations were set to a magnitude that would represent negligible differences of no clinical significance. These were analyzed using a t test to determine the significance of deviation. P value was based on a significance level of 0.05. Ordinal parameters were analyzed using the Cohen's kappa coefficient. Analysis was carried out using SPSS version 20.

Results

Of the 36 patients examined, 30 were men and 6 were women. Mean age was 56.5 years (range 19–81). Mean BMI (body mass index) was 27.6 (SD 5.3). Quantitative parameters are displayed in Table 1.

The upper urinary tract was evaluated in 71 kidneys examined of 36 patients (one patient had a prior nephrectomy). Mean kidney lengths are given Table 1. We set an acceptable deviation of 13 mm between studies. When comparing urologist performed HHD (study 1) to a sonographist performed SD (study 3) mean difference was 15.4 mm which was insignificant for the preset deviation ($\alpha = 0.15$). Urologist performed HHD (study 1) compared to the sonographist HHD performed (study 2) showed a mean difference of 11.4 mm that was insignificant ($\alpha = 0.19$). Comparison between sonographist performed HHD (study 2) and SD (study 3) revealed a mean difference of 10.2 mm ($\alpha = 0.43$). We evaluated hydronephrosis as none, mild, moderate or severe. We compared the observations using the Cohen's kappa coefficient. Ordinal parameters are summarized in Table 2. The comparisons made showed substantial agreement for subjective hydronephrosis ($\kappa = 0.63$, $\kappa = 0.61$, $k = 0.79$ for urologist HHD versus sonographist SD and urologist HHD versus sonographist HHD and sonographist HHD versus sonographist SD, respectively). Renal pelvis diameter was measured only when the pelvis was found to be dilated ($n = 13$). We allowed a deviation of 3 mm between studies. When comparing urologist HHD to sonographist SD (studies 1 vs. 3) mean difference was 4.7 mm, insignificant for our deviation ($\alpha = 0.21$). Urologist HHD versus sonographist HHD (studies 1 vs. 2) and sonographist HHD versus sonographist SD (studies 2 vs. 3) comparisons showed insignificant mean differences of 3.2 and 2.9 mm, respectively ($\alpha = 0.86$; $\alpha = 0.86$, respectively). We also compared the number of renal cysts identified by each examiner using the Cohen's kappa coefficient. Slight agreement was observed comparing urologist HHD to sonographist SD (studies 1 vs. 3) ($\kappa = 0.12$), urologist HHD versus sonographist HHD (studies 1 vs. 2) revealed moderate agreement ($\kappa = 0.55$), whereas sonographist HHD versus sonographist SD (studies 2 vs. 3) revealed substantial agreement ($k = 0.66$) for number of renal cysts.

Measuring the diameter of the largest cyst, a deviation of 3 mm was permitted. Mean differences were 3.2, 6.6, 4.2 for urologist HHD versus sonographist SD (studies 1 vs. 3);

Table 1 Quantitative parameters summary

Parameter	*N*	Urologist + HHD mean (sd)	Sonographist + HHD mean (sd)	Sonographist + SD mean (sd)	Preset permitted differences between studies compared	Urologist + HHD versus Sonographist + SD mean difference (*P* value)	Urologist + HHD versus Sonographist + HHD mean difference (*P* value)	Sonographist + HHD versus t Sonographist + SD mean difference (*P* value)
Kidney length (cm)	71	10.6 (1.7)	11 (1.3)	11.8 (1.4)	1.3	1.54 (0.15)	1.14 (0.19)	1.02 (0.43)
Renal pelvis length (when dilated, mm)	13	15.6 (6.6)	15.3 (6.1)	13.7 (6.8)	3	4.7 (0.21)	3.2 (0.86)	2.9 (0.86)
Renal cyst diameter (mm)	10	36.2 (19)	32.9 (17)	26.9 (17)	3	3.2 (0.81)	6.6 (0.06)	4.2 (0.12)
Post-void residual (cc)	26	39.5 (45)	33.7 (37)	41.8 (47)	10	14.4 (0.32)	14.8 (0.29)	14.4 (0.29)
Prostate volume (cc)	25	43.7 (38)	38.3 (47)	39.3 (41)	13	21 (0.07)	23.9 (0.11)	11.1 (0.46)

sd standard deviation, *HHD* handheld device, *SD* standard device

urologist HHD versus sonographist HHD (studies 1 vs. 2) and sonographist HHD versus sonographist SD (studies 2 vs. 3), respectively. All of the above differences were found insignificant ($\alpha = 0.81$; $\alpha = 0.06$; $\alpha = 0.12$, respectively).

Examples of the imaging quality depicted by the HHD are shown in Figs. 1, 2 and 3.

The lower urinary tract was evaluated through post-void residual (PVR), prostate volume (transabdominal) and ureteral orifice urine projections ("jet signs"). We calculated prostate and bladder volume using the ellipsoid formula (anterior-posterior diameter × length × width × $\pi/6$).

When evaluating PVR we allowed a 10 cc deviation. We evaluated 26 bladders (8 patients carried an indwelling catheter making this measurement irrelevant, 1 underwent a cysto-prostatectomy and 1 data missing). Urologist HHD versus sonographist SD (studies 1 vs. 3) revealed a mean difference of 14.4 cc insignificant for the permitted deviation ($\alpha = 0.32$). The other two comparisons showed insignificant mean differences of 14.8 and 14.4 cc for urologist HHD versus sonographist HHD (studies 1 vs. 2) and sonographist HHD versus sonographist SD (studies 2 vs. 3) ($\alpha = 0.29$; $\alpha = 0.29$, respectively).

Transabdominal prostate volume was evaluated in 25 patients (i.e., 6 women, 1 post-cysto-prostatectomy, 4 not evaluated-excluded). Deviation permitted was 13 cc. Urologist HHD versus sonographist SD (studies 1 vs. 3) comparison showed a mean difference of 24 cc insignificant for the deviation set ($\alpha = 0.07$). Comparing the other studies showed mean differences of 23.9 and 11.1 cc for urologist HHD versus sonographist HHD (studies 1 vs. 2) and sonographist HHD versus sonographist SD (studies 2 vs. 3), respectively ($\alpha = 0.11$; $\alpha = 0.46$, respectively).

Finally, we evaluated inter-observer and intra-observer agreement for ureteral orifice jet signs. Substantial agreement was observed when comparing urologist HHD and sonographist SD (studies 1 vs. 3) ($\kappa = 0.62$) and sonographist HHD versus sonographist SD (studies 2 vs. 3) ($k = 0.69$), whereas urologist HHD versus sonographist HHD (studies 1 vs. 2) revealed moderate agreement ($\kappa = 0.42$).

Discussion

The utility of handheld US devices has been reported in several medical professions, mainly in point-of-care setting. These included cardiologists, internists, gynecologists and emergency physicians [11–14]. Data regarding urinary evaluation with a handheld US device are little. Studies including full sonographic evaluation of the urinary tract using such a device have not been reported. Comparative evaluation of urologist versus sonographists sonographic capabilities has been reported in obtaining percutaneous

Table 2 Ordinal parameters summary

Parameter	*N*	Urologist HHD versus Sonographist SD (*k*)	Urologist HHD versus Sonographist HHD (*k*)	Songraphist HHD versus Sonographist SD (*k*)
Hydronephrosis evaluation (none, mild, moderate, severe)	71	0.63	0.61	0.79
Number of renal cysts	15	0.12	0.55	0.66
Jet signs	68	0.62	0.42	0.69

HHD handheld device, *SD* standard device, *k* Cohen's kappa coefficient

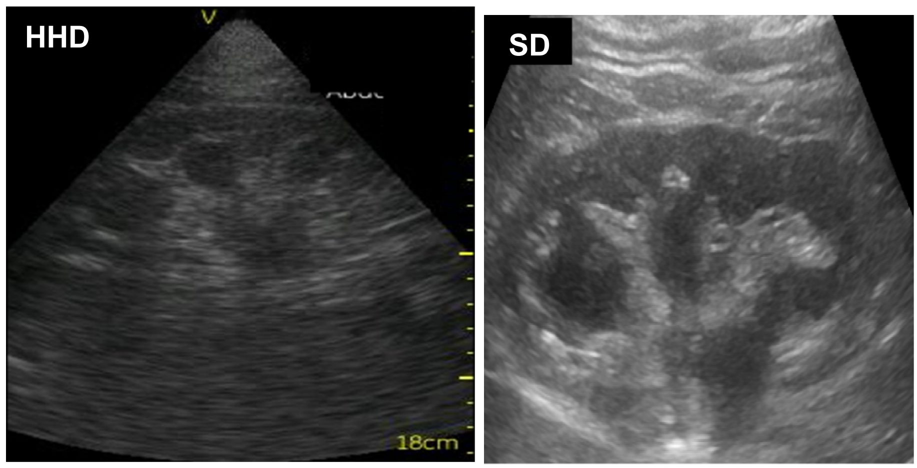

Fig. 1 Hydronephosis imaged by the HHD compared with the SD

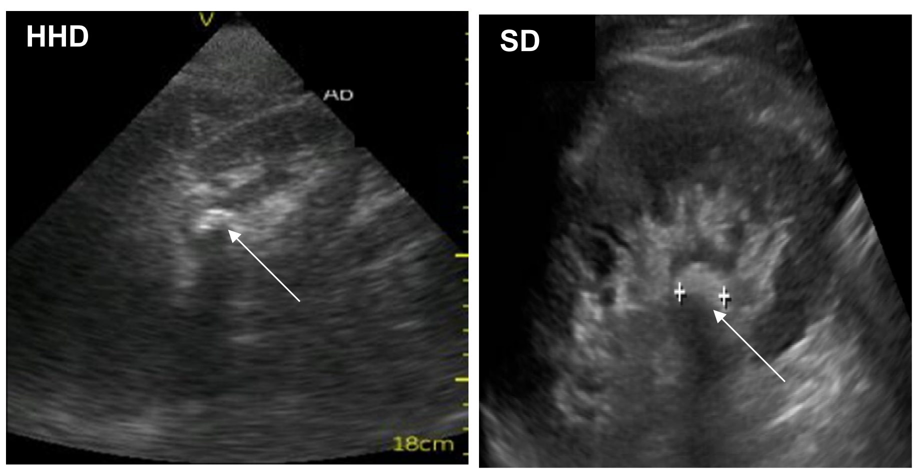

Fig. 2 A stone in the renal pelvis imaged by the HHD compared with the SD

access during nephrolithotripsy [15]. Similar results have been reported in other noninvasive aspects of uroradiology.

We aimed in our study design to address independently the operator (i.e., sonographic capabilities of the urologist) and the device capabilities. This was accomplished through comparing the urologist performed studies to sonographist performed studies using the HHD (studies 1 vs. 2). A second goal was to evaluate the HHD independently of the examiner by comparing studies performed with the HHD to these performed with the SD both by the more experienced sonographist (studies 2 vs. 3). Finally, we addressed the most practical issue to our opinion, which is the utility of the HHD studies in the hands of the urologist. This was accomplished through comparison of the urologist HHD to the sonographist SD studies (studies 1 vs. 3). We chose urology residents and not senior urologists since the use of the HHD at our institution is a common practice and the residents have the greatest experience using it.

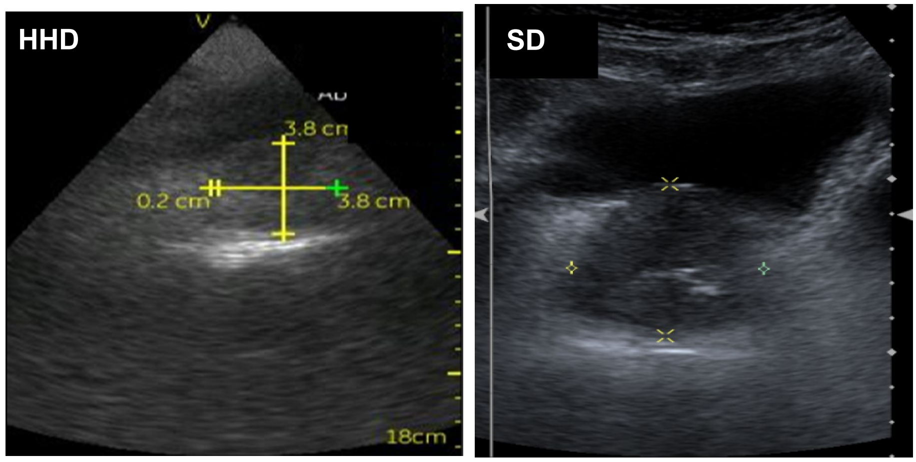

Fig. 3 Prostate imaged (transabdominal) by the HHD compared with the SD

Several parameters evaluated the upper urinary tract. We found no major differences through all comparisons made between operators or devices measuring kidney length, hydronephrosis, renal pelvis width and renal cyst diameter. Others have reported the diagnosis of hydronephrosis using the same HHD (Vscan™; GE) with good results compared to standard evaluation [16]. The evaluation of renal cysts showed slight to moderate inter-observer agreement as evident in Table 2. Even though differences between renal cyst diameters were insignificant, we believe that the HHD is not sufficient for evaluating focal renal lesions. Moreover, though not reported in this study, the authors' experience identifying renal masses with the HHD was not satisfactory and we cannot recommend the use of the HHD at this point. Even so, others have reported different findings regarding renal cysts. Stock et al. [17] reported 79% sensitivity for compressive kidney cysts diagnosis with a handheld device (ACUSON p10™ by Siemens) compared to standard device. In summary, it is evident that the HHD in the hands of urologists is equivalent to the standard study in answering most common day questions regarding the upper tract and therefore valid in basic evaluation of the upper urinary tract.

PVR was evaluated as part of the lower urinary tract. Daurat et al. [18] reported a nurse preformed measurement of the largest bladder diameter using the same HHD (VSCAN™;GE), but this was not compared to other US measurements of this parameter. In our study, PVR measurements showed insignificant differences for the preset deviation. The same applies for transabdominal prostate volume, again making the HHD a very useful decision making tool in the daily common urologic practice. Finally, the inter-observer and intra-observer agreement for ureteral jet signs was moderate to substantial, again contributing to the high utility of HHD in answering the most common urologic questions.

This study is the first to address the utility of an HHD in the hands of urologists performing a thorough urologic sonographic evaluation. Former studies using a HHD have either been in fields other than urology or addressed only few parameters of the urologic US study [11–14, 16, 18]. This study is the first to evaluate a complete urologist preformed US study.

The small number of patients recruited is a major limitation of our study. It should be noted that bladder and kidney lesions were not systemically evaluated in this study, though to our experience bladder lesions can be well demonstrated by the HHD. As sonographic evaluation is highly operator dependent, the results of this study are strongly influenced by the operator skills no matter whether him being a sonographist or a urologist. Another parameter with possible influence on the results is the type of SD used. The study population's high BMI (27.6) highlights our results since our patients were not ideal for sonography.

Larger studies are needed to further evaluate the utility of these miniature US systems and the sonographic capabilities of urologists along with defining the necessary training needed.

Other future interesting insights would be to evaluate the role of the handheld devices in specific urologic populations. Evaluating patients with urolithiasis with a handheld device can be extremely useful and practical given the high recurrence rate of this pathology which warrants constant evaluation.

Another aspect to be evaluated is the use of these devices during surgical procedures. It is the authors' common practice to confirm with the HHD double-pig tail stent placement in the renal pelvis in pregnant women and thus to preclude the use fluorescence.

In our study, urology residents performed the studies. It is much needed to evaluate handheld devices among MD senior urologists.

We believe our results support the utility of the HHD in urology and in the hands of urologists. Our results prove that urologists can perform a thorough sonographic evaluation of the urinary tract in the point-of-care setting with no major limitations.

Conclusions

This study shows that urologist performed US study using a handheld-\pocket-size device is equivalent to a sonographist performed US study using a standard device in most parameters examined. The handheld device can be used in evaluating the upper and lower urinary tract with the exception of renal masses and therefore be of great assistance in a wide variety of the daily urologic practice scenarios. However, it seems that these miniature US systems may answer many questions in our urological daily practice, whether in the emergency room, the ward or the clinic. In the near future, the study can be integrated as a standard part of the urological examination and the vision of a urologic stethoscope will truly become a reality.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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