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Urinary volume assessment: comparison of the performance of Mobissom® portable bladder ultrasound equipment with tabletop equipment

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Abstract

This study aimed to compare the performance of Mobissom® portable bladder ultrasound equipment with tabletop ultrasound equipment to assess bladder urine volume. 192 images of 16 adult patients who underwent the exam were analyzed. The bladder volumes obtained by the portable equipment were archived in the form of an image and, later, compared with the ultrasound report of the evaluation performed by a tabletop ultrasound device. The results obtained were compared using the paired t test and the differences were graphically distributed using the Bland & Altmann method. In the overall result, there were no significant differences between the two devices. It is concluded that the equipment, despite the limitation in the visualization of other organs, is easy to use and relevant for bedside assessment.

Keywords: Validation study. Ultrasound. Urinary bladder.

INTRODUCTION

Urinary retention (UR) is characterized by the impossibility of bladder emptying, due to several clinical situations. It can be classified as acute, as in patients who present the condition in the postoperative period, or chronic, in patients with a neurogenic bladder. When approached too late, in cases of acute urinary retention, it can lead to an injury to the detrusor muscle, in addition to other iatrogenics, and prolonged hospital stay[1,2].

The risk of injury is even greater in patients who are unable to verbalize the pain, as they

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are anesthetized, in comatose states, in patients with spinal cord injury, with neurodegenerative diseases, or even in those who are unable to communicate[3,4].

The diagnosis of UR is made during the abdominal examination, through inspection, palpation, and percussion of the suprapubic area. It is estimated that when the bladder is palpable in the umbilical scar, the volume of urine inside it is greater than 500 ml[5]. In cases of obese patients and in those with low bladder capacity, physical examination may not make an early diagnosis of UR, requiring the use of ultrasound of the lower abdomen.

The images obtained by the ultrasound (US) equipment are formed from the creation of mechanical waves, emitted through a transducer, which return as echoes when they affect interfaces with different acoustic impedances, related to tissue characteristics. In the bladder, the different acoustic impedance of the urine, in relation to the walls of the organ, allows the estimation of its volume[6]. Studies show that, for bladder volumes of 100 to 500 ml, the analysis of the volume by means of US allows for calculations with variations between 10% and 20% of the actual bladder volume[7].

Although the gold standard for the validation of ultrasound equipment regarding the measurement of urinary volume should be considered as the comparison of the urine volume estimated by the equipment with the volume of urine drained by urinary catheterization, many studies have shown that the effectiveness of the ultrasound equipment makes it a reliable parameter[1]. The use of ultrasound to assess urinary bladder volume has been consolidated since some researchers[8] have demonstrated that images obtained of sufficient quality were adequate for this purpose. In addition, with technological developments, such as portable equipment, which is increasingly flexible, easy to handle and reliable, has been used to assess bladder volume[9].

Portable equipment available on the market so far has a high degree of reliability and specificity. When applied with appropriate clinical protocols, they can perform the early diagnosis of UR[2,4]. The most used treatment for UR is the use of urinary catheterization. Urinary catheterization is an invasive procedure that, when performed without proficiency, can cause urethral trauma and urinary tract infection[10]. Thus, it should be performed only when necessary, properly, and by competent professionals.

With regards to the use of portable ultrasound equipment at the bedside, it is observed that the advance in the development of software with greater precision and better performance, in smaller devices, has facilitated its entry into health services. Easy-to-handle equipment is sought for, which can be used by trained professionals, such as doctors and nurses, with the objective of supporting, training, and ensuring the care provided to the patient in various procedures, as in the case in question, in performing urinary catheterization. However, the use of equipment at the bedside to assess urinary volume is still not common in Brazil. More complete equipment is sought for, with high diagnostic accuracy, reduced costs, and more accessibility, for a greater scope of applicability and patient safety[11,12].

Therefore, this study aimed to compare the performance of the Mobissom® portable bladder ultrasound equipment with a tabletop ultrasound equipment to assess the urinary volume of the bladder.

METHODOLOGY

This was a descriptive study. For data collection, 16 adult patients were randomly selected, that were conscious, oriented, and previously scheduled for an ultrasound evaluation of the total abdomen with a Toshiba Xario 100® tabletop ultrasound device. Patients under 18 years of age and pregnant women were excluded from the sample.

Data collection instruments

To evaluate the urinary volume measured in the bladder, the Toshiba Xario 100 ® tabletop ultrasound equipment and the Mobissom® portable ultrasound equipment were used. The analysis using the Toshiba Xario 100® device was performed with a convex transducer with a frequency of 3.5MHz, which was connected to the tabletop equipment. For data reliability, the equipment was previously analyzed and validated by a competent company. The determination of the bladder volume by this device was obtained by performing anatomical sections of the bladder (sagittal and transverse).

The portable equipment has a 3.5 to 5 MHz convex transducer, responsible for the formation of 12 images of the urinary bladder, which allows for the automatic analysis of the vesical volume. Its function is restricted to the assessment of bladder volume. The transducer is attached to the equipment, which facilitates handling during the ultrasound examination. To use it, a mobile internet connection to other equipment (tablets and smartphones) is required. An application provided by the company must be installed on the respective equipment. The application allows the images captured by the equipment to be archived, which was used to collect data for this study.

The urinary volume estimation was performed automatically by the equipment and reaffirmed, based on the multiplication of the anteroposterior (AP) and latero-lateral (LL) diameters in the transverse plane, superior-inferior (SI) in the sagittal plane and the constant 0.52, thus, obtaining the result in ml.

Study development

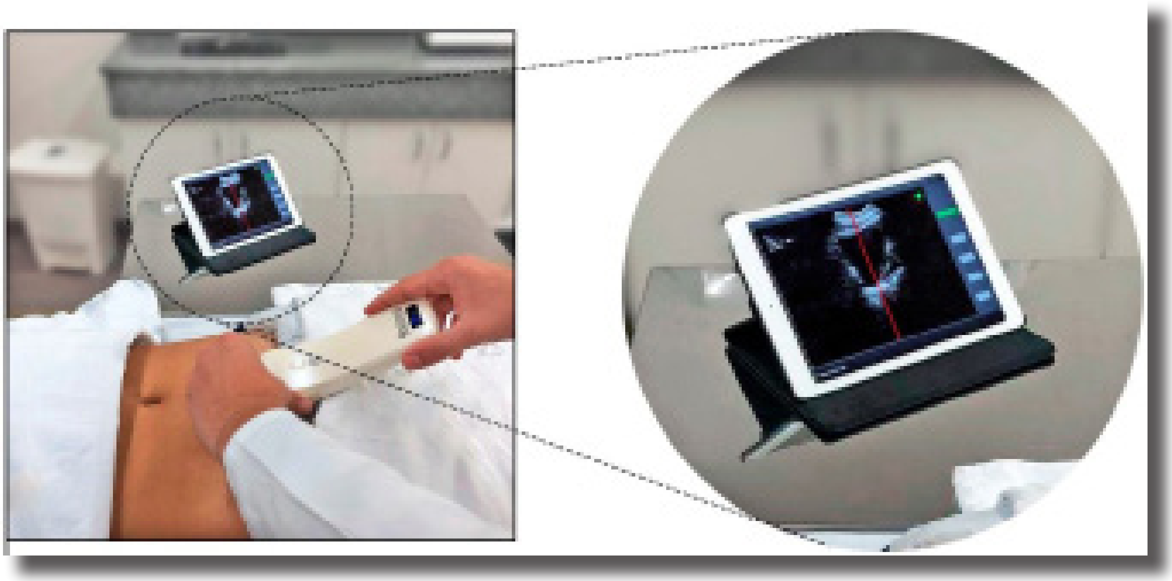
All assessments were accompanied by the researchers and a radiologist with experience in ultrasound assessment.

Patients were instructed to ingest fluid and avoid urination before the evaluation, allowing for an analysis of pre-voiding bladder volume. The examination was performed with patients in the supine position.

To measure the volume of urine in the urinary bladder, the following steps were performed:

a) After positioning the patient and protecting their privacy, the examination with the table-top device began. After the application of the conductive gel, the equipment transducer was positioned in the patient's suprapubic region until a broad bladder image was obtained. Subsequently, the volume was estimated based on the largest measurements obtained, in the sagittal and transverse sections, of the bladder of each patient. Without the knowledge of the researchers, the volume obtained was recorded by the sonographer for the construction of the sonographic report.

b) With the patient in the supine position, the measurement of the bladder volume was performed with the Mobissom ® portable device. After application of the conductive gel, the equipment was positioned in the suprapubic region of the patients until an ample vesical image was obtained, automatically pointed out by the equipment's display with a red stripe (Figure 1). In order to assess the practicality of the equipment and its use at the bedside by trained health professionals, the assessment using the portable equipment was initially performed by non-ultrasound researchers and immediately followed by supervised and corroborated by the sonographer.



Researchers' image file.

Figure 1 – Positioning the transducer and centering the bladder. Bauru, 2020.

Before application to patients, the portable ultrasound equipment was previously tested in a simulated environment. At this stage, the non-radiologist researchers were trained to use the portable equipment by the radiologist researcher.

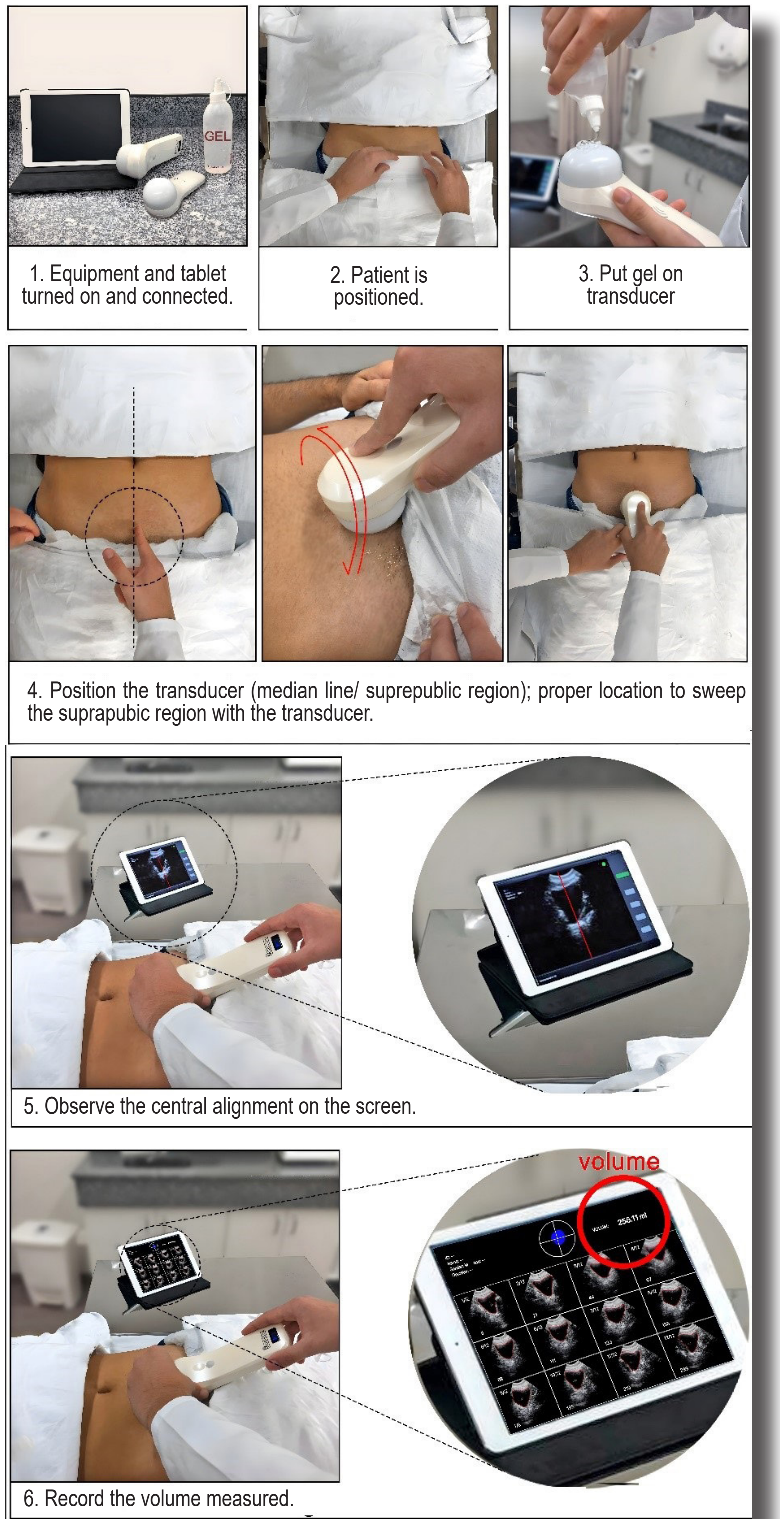
In this test, it was possible to observe that, for the correct formation of the images, it is necessary to position the transducer in the suprapubic region, on the midline, with a medium amount of gel, and pay attention to the vesical image formed in the center of the image frame. The steps for using portable equipment are shown in Figure 2.

Data processing and analysis

The ultrasound images obtained were separated, identified, and associated with the patients. The voiding bladder volumes obtained by the portable equipment were archived in the form of an image and later compared with the ultrasound report of the evaluation performed by the tabletop device. The results obtained were compared using the paired t test and the differences were graphically distributed using the Bland & Altmann method to analyze the level of agreement of the means measured by the two devices in the entire volume range analyzed. The results were presented in the form of figures and tables and discussed according to the literature on the subject.

Ethical considerations

This study was authorized by the Ethics Committee of the Hospital for Rehabilitation of Craniofacial Anomalies of the University of São Paulo – HRAC/USP, opinion: 3.611.671. After explanation of the study objectives by the researchers, the patients' acceptance of participation was formalized through an Informed Consent Form.



Researchers' image file

Figure 2 – Steps for positioning the portable ultrasound equipment. Bauru, 2020.

RESULTS

A total of 192 images referring to urinary bladder volumes of 16 patients were evaluated, including 15 male and one female. The mean age was 57.4 years, with a minimum of 27 years and a maximum of 88 years. Figure 3 shows the subjects evaluated according to sex, age, reason for the examination, body mass index (BMI), and bladder volumes measured by both ultrasound equipment used.

Patient	Sex	Age	Exam reason	BMI	US1 Volume ml*	US2 Volume ml **	Difference%
1	M	44	Routine	26.5	305	290.0	5.3%+
2	M	51	Routine	25.7	560	538.1	4.1% -
3	M	49	Diagnostic Investigation	26.0	381	369.8	3.0% -
4	M	88	Macroscopic Hematuria	22.0	448	459.5	2.6% +
5	M	73	Benign prostatic hyperplasia	25.1	261	271.7	4.1% +
6	M	65	Benign prostatic hyperplasia	36.7	270	279.0	3.3% +
7	M	67	Benign prostatic hyperplasia	25.3	340	334.0	1.8% -
8	M	64	Benign prostatic hyperplasia	26.3	124	110.2	12.5% -
9	M	82	Benign prostatic hyperplasia	31.9	251	239.6	4.7% -
10	M	68	Benign prostatic hyperplasia	28.9	256	256.1	0.0% +
11	M	61	Benign prostatic hyperplasia	25.4	127	110.7	14.7% -
12	M	58	Hypogonadism	34.6	270	282.0	4.4% +
13	M	34	Recurrent urinary tract infection	24.8	283	302.1	6.7% +
14	F	37	Renal lithiasis	25.7	237	207.0	14.5% -
15	M	51	Infravesical Obstruction	27.8	502	767.5	52.9% +
16	M	27	Urethritis	30.1	224	220.8	1.4% -

*Toshiba Xario 100® Tabletop Ultrasound Equipment. **Mobissom® portable ultrasound equipment.

Figure 3 – Subjects evaluated according to sex, age, reason for the examination, body mass index (BMI), and measured bladder volumes. Bauru, 2020.

It was possible to observe normal distribution of the sample (Kolmogorov Smirnov test). Thus, the results of the volumes obtained by the two ultrasound devices were compared using the paired t test, as shown in Table 1. This table describes the measurements obtained by the two devices and compares the means obtained. On average, there was no statistically significant difference between volumes (p = 0.481), which can be seen in Table 1.

Table 1 – Description of measurements obtained by the two devices and comparison of means by a paired t test. Bauru, 2020.

Measurement	Average	Standard deviation	Minimum	Maximum	p
Toshiba	302.44	120.3	124.0	560.0	**0.481**
Mobissom	314.9	162.7	110.2	767.5	
Difference	12.45	68.91	-29.9	265.5	
Difference %	1.1%	15.1%	-12.8%	52.9%	
Absol. Dif. %	8.1%	12.5%	0.0%	52.9%	

The bladder volumes obtained were further distributed using the Bland & Altman method, shown in Figure 4. The result is the average of the volume measured by the Mobissom® portable ultrasound equipment plus the volume measured by the Toshiba Xario 100® ultrasound equipment (X axis), in relation to the difference in volume measured by both equipment (Y axis).

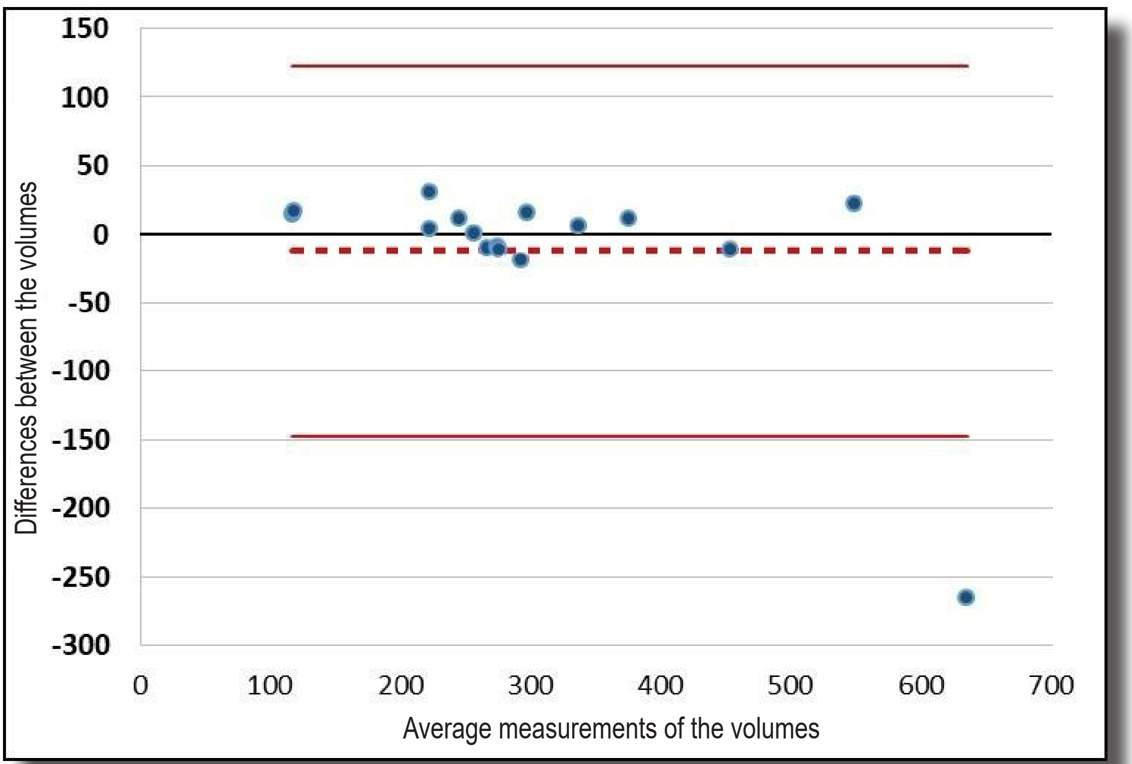


Figure 4 – Distribution of differences by the Bland & Altman method. Bauru, 2020.

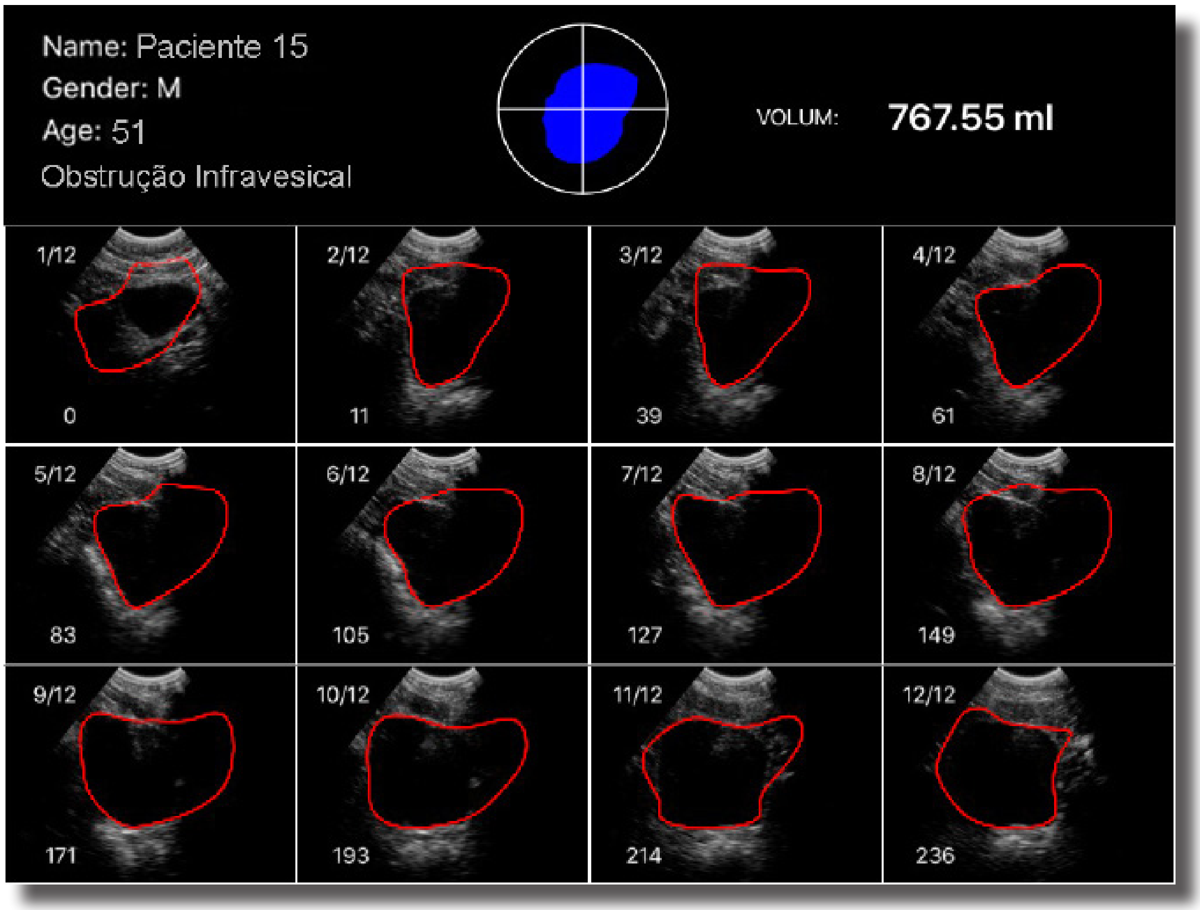


Figure 5 – Bladder volume images obtained by portable ultrasound equipment. Bauru, 2020.

DISCUSSION

More and more, portable ultrasound equipment has become an object of interest and need in medical education. In the USA, recently, bodies that regulate the training of emergency and imaging residents released guidelines for the teaching of medical residency aiming at the proper use of portable ultrasound equipment. In the study that covered the entire American territory, about 90.0% of respondents reported the importance and the increasingly daily use of portable ultrasound equipment in their practices[13,14].

Non-invasive measurement of urinary bladder volume (cyst volumetry) allows for better management of diseases involving the urinary tract. Therefore, the use of portable bladder ultrasound equipment and tabletop ultrasound equipment as non-invasive, reliable, and trustworthy procedures have been considered the gold standard for this activity. The use of a portable bladder ultrasound device is simple and has been highlighted as a fast, safe, non-invasive, painless, and comfortable method for patients. Some studies show that the specificity of the equipment that has been used reaches more than 97.0%[15].

However, some authors have already mentioned limitations such as false results in the presence of urinary volume less than 100 ml or greater than 1000 ml, in use with obese patients, pregnant women, and in the presence of neoplasms, cysts, and other abdominal pathologies. Even so, there is a consensus among researchers that, even with such limitations, the equipment should be used in the indication or not of urinary catheterization[9,16]. Ultrasound equipment commonly used in clinical practice displays important variations in the analysis of bladder volume[17]. Overestimation or underestimation of the actual volume of urine in the urinary bladder will lead the professional to perform or not perform urinary catheterization[18].

In this study, as shown in Figure 3, BMI did not influence the reliability of the assessments and as shown in Table 1 and Figure 4, there was no statistically significant difference between the measurements obtained between the two devices. Each point shown in Figure 4 corresponds to the volume variation presented by a patient and the horizontal distribution of the sample consolidates the fact that the analyzed volume range does not compromise the efficiency of the device. Still in Figure 4, the variation obtained in Patient 15 (Figure 5) is highlighted, which may have influenced the standard deviation, represented by the horizontal lines at the ends of the figure. It is observed that all the variations obtained in each patient, consisting of points, are located close to the center line (measurement average) and within the standard deviation range, with the exception of the volume obtained in Patient 15.

Recent studies that aimed to analyze the performance of devices already used in the American scenario to assess bladder volume[17,19], although they used the volume of urine drained by urinary catheterization as the gold standard for comparison with the volume measured by the ultrasound equipment, demonstrate together with the results found in this study that BMI is a component that must be observed with care in obtaining the analysis measures. However, other studies showed that, when compared to the use of tabletop ultrasound equipment, portable bladder ultrasound equipment found less congruent results in patients who had obesity, an indwelling urinary catheter, and the presence of ascites. However, the authors reinforce its importance as an easily accessible, bedside method that assists in patient safety, especially for analysis of kidney function restoration and removal or replacement due to obstruction of indwelling urinary catheters. Such findings were corroborated by other researchers who compared electrical bioimpedance tomography with the use of tabletop ultrasound equipment and portable bladder ultrasound equipment. Among the three equipment, the portable ultrasound equipment was the one that showed the greatest incongruity of information[20].

Ultrasonography is an examiner-dependent assessment, which may also have influenced the examination of Patient[15]. In this sense, clinical experience and periodic updating of the professional examiner are essential for the quality of the procedure[16,21]. In this matter, it is also worth noting that since the portable bladder ultrasound equipment for measuring the volume of urine from the bladder, aims to support bedside procedures, with an emphasis on whether or not to perform urinary catheterization, which puts it directly in contact with medical and nursing professionals, it is essential that the equipment be intuitive, robust, and easy to handle.

Echogenicity is related to the ability of different structures to reflect waves from ultrasound equipment, generating echoes. The term anechoic is used when there is an absence of echoes, which is usually observed in liquid media such as urine. The observation of the 12 bladder images obtained by the portable ultrasound equipment to calculate the final bladder volume of patient 15 allowed us to observe that, unlike the other patients, the area delimited by the red line (Figure 5) for the bladder volume considerably exceeds the anechoic limits, related to the presence of fluid (urine) in the patient's bladder and may have caused the discrepancy between the volumes measured by both devices. This type of variation may result from operator-dependent factors, such as inadequate positioning of the transducer in the suprapubic region or the involuntary displacement of the performer or the patient while scanning the device, and/or factors related to anatomical variation between the patients[22,23,24].

Although the Mobissom® equipment has technology that helps in identifying the bladder, it is necessary for the operator to correctly position the device in order to visually identify the best incidence of the bladder, as shown in Figure 2, to correctly obtain the urinary volume.

Correct handling of the transducer ensures a right angle of incidence of the ultrasound beam in relation to the area of interest. This will often identify whether the perceived echo in the image is true or not. Artifacts can be classified as the display of information that does not exactly print the true image of the analyzed area. In them, the images can be displaced, be erroneous, or superficial and must be observed so that false interpretations can be avoided.

Reverberation is a type of artifact where the production of echoes is false and caused by two or more reflectors in the sound path and depends on the penetrating power of the beam and the sensitivity of the transducer in obese patients. Thus, the most suitable measures for analyzing the reliability of the equipment to be used could be the waist-hip ratio associated with BMI[22,24].

In ultrasound equipment, the transducer is a device that generates mechanical (sound) energy from electrical excitation. The choice of transducer defines the ultrasound frequency that will be used in the exam and is directly related to the characteristics and thickness of the piezoelectric crystals used in its construction. The smaller the thickness, the higher the frequency produced. Depending on the frequency at which a transducer is set, the penetration of sound into tissues occurs in a limited way. The two pieces of equipment used had convex transducers, therefore, they did not influence the results[24,25].

Although 192 images were evaluated, the number of patients evaluated, the lack of control of measurements and the waist-hip ratio can be considered limiting factors. Also included here are the lack of using a urinary catheterization to corroborate the data found, despite the validation of the measurement of the table equipment.

CONCLUSION

The portable ultrasound equipment Mobissom®, did not demonstrate significant differences in the performance of the results obtained in the measurement of urine volume from the bladder when compared to the table equipment. Being small, which facilitates its use at the bedside, the portable equipment can support health team professionals in making decisions related to whether or not to perform urinary catheterization, the objective for which it is intended.

To better clarify the gaps presented by this research, new studies, with a greater number of patients in the sample, with different anatomical characteristics, and that compare different performances between evaluators and equipment will need to be carried out.

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