

## Running water sound technique in contrast-based voiding cystourethrogram: A case–control study

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### ARTICLE INFO

#### Article history:

Received 8 January 2018

Received in revised form

7 March 2018

Accepted 18 March 2018

Available online 3 April 2018

#### Keywords:

Radiography

Fluoroscopy

Contrast studies

VCUG

Water sound

### ABSTRACT

**Background:** An intervention that can reduce the patient void time during a voiding cystourethrogram (VCUG) procedure can reduce the total radiation dose to the patient. This is because a delay in voiding leads to a high number of intermittent screenings to monitor if voiding occurs. This study assessed the impact of running-water sound (RWS) upon patients' voiding parameters and fluoroscopy screening times during VCUG examinations among children and adults.

**Materials and methods:** A case–control study involving 252 patients was undertaken which consisted two groups (control and test) of adults and children. The test groups underwent VCUG with RWS technique while the control groups underwent the procedure normally. T-test was used to compare the study parameters between the two groups and a *p-value* less than 0.05 was interpreted as significant.

**Results:** The mean screening times (s) for children who underwent VCUG with and without RWS were  $17.15 \pm 2.5s$  and  $30.61 \pm 5.1s$  respectively ( $p = 0.0024$ ). For adults, the RWS technique recorded a mean screening time of  $37.36 \pm 4.4s$  while the non-RWS procedures recorded  $49.80 \pm 5.2s$  ( $p = 0.001$ ). The participants who received RWS intervention also felt the urge to void earlier than those who received no RWS intervention. The differences were also statistically significant for both children and adults.

**Conclusion:** The study being one of the first in this subject area indicates that the application of RWS technique induces early urge of iodinated-contrast voiding, and reduces voiding and fluoroscopy screening times during VCUG among children and adults. This simple technique can potentially enhance current practice.

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### Introduction

Voiding cystourethrogram (VCUG) or Micturating cystourethrogram (MCUG) is a dynamic radiological procedure used mainly to assess the urinary tract, especially the bladder and the urethra after the administration of intravesical contrast agent.<sup>1</sup> VCUG examinations contribute to between 30 and 50% of all fluoroscopy guided examinations performed in children.<sup>2</sup> Despite the ongoing advances in imaging, voiding cystourethrogram is still commonly performed predominantly in children,<sup>2</sup> and adults in some countries like Ghana. It serves as an adjunct to urodynamic evaluation in videourodynamics.<sup>3</sup> In this procedure, the patient's bladder is filled with a radiological contrast agent and then allowed to void<sup>4</sup> on the examination table. Unfortunately, this procedure creates distress in some patients and occasionally staff.<sup>4</sup> While pathologies have been found to cause voiding obstructions,<sup>5</sup> there

are also some anxiety-provoking psychological factors which inhibit voiding<sup>6</sup> while on the examination table. For the latter, some patients our hospital has attended to, have related their inability to void on the examination table to “lack of will” to do so in places not naturally made for such purposes and hence prolonging voiding in some cases. Others have also indicated losing the sense to initiate voiding on examination tables despite their urge to micturate. Herd<sup>4</sup> has also found severe distress among 61% of patients undergoing VCUG. This distress has been connected to the voiding of urine in a socially abnormal situation, hence, emphasising the psychological impact that anxiousness has on this procedure. Zelikovsky et al.<sup>6</sup> have argued that developing effective interventions to reduce patients' distress and encouraging voiding during medical events such as VCUG is important.

In an attempt to find a better option to overcome some of the challenges encountered, such as the aforementioned during VCUG, Goodman and colleagues<sup>7</sup> investigated the effect of warm and cold contrast during VCUG and found no significant difference between

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the two groups with regards to screening time, volume of contrast instilled or number of attempts at voiding. Notwithstanding, there was a statistically significant difference in distress levels, with more children crying during instillation of cold contrast medium than warm. However, the study did not consider the psychological stimuli that could affect voiding. Kwon et al.<sup>8</sup> have also attempted to investigate the effect of the sound of water (running water sound [RWS]) on voiding during uroflometric assessment and found that RWS could affect uroflometric dynamics. However, the study focused on only adults and also failed to address the effect of RWS on contrast agent voiding. This missing information is very important for the radiology department.

To further explore ways of improving VCUG practice and overcome the delay in voiding this study was therefore undertaken with the rationale to investigate the effect of RWS upon patients' urge to void their bladder, voiding times/volume and the fluoroscopy screening times during contrast-based VCUG examinations among children and adults.

## Method

This case–control study was undertaken from April 2014 to December, 2016. Ethical approval was gained from the Ethics and Review Committee of the teaching hospital where the study was conducted. The teaching hospital is the biggest tertiary referral hospital in Ghana and an average of 1234 VCUG cases are performed a year. These cases are performed for both children and adults and their frequencies are in a ratio of 3 to 1 respectively. In this hospital, radiologists are mainly responsible for VCUG examinations; however, some of the cases are undertaken by radiographers with the necessary training.

Adult patients who were referred for VCUG at the study site were approached about the study during the examination booking process. They were told of their rights, the risks and benefits and then invited to participate. In the case of the children, their parents/guardians were contacted because all were accompanied by close relations.

The inclusion criteria focused on male children aged 4 years and above and adults (not above 80 years) referred to the radiology departments for a contrast voiding cystourethrogram. The age range was chosen because they were considered very cooperative and suitable of communicating their urge feelings effectively during the procedure. Males were the study participants because the procedure is very common among males than females in the study's setting. For example, out of the above mentioned yearly performed VCUG cases, only 67 were females. Meanwhile, patients with hearing impairment, urethral stricture, trauma, calculi, recent history of lower urinary tract (LUT) surgery, any congenital LUT anomaly, any history of malignancy or other neurological or neurodegenerative diseases affecting bladder function were excluded as suggested by Kwon et al.<sup>8</sup> All patients who had been prescribed alpha-blockers or anti-muscarinic agents in the last 3 months were also excluded. The assessment of the qualified participants was achieved with the use of the patients' medical folder. The researcher together with a radiologist reviewed the patients' folder. All those who met the study criteria consented to participate in the study. For patients below 18 years consent for participation was sought from their parents while individual consent was sought from the adults.

A STATA software version 13 for estimating sample size for hypothesis testing was used to determine the sample sizes for both test sample and control groups for the children category. The same approach was used for the adult categories. STATA Command “*sampsi 0 2, sd(4) a(0.05) p(0.80)*” was employed where the 0.2 represents the effective value that is desirable to detect a difference

in response. This value was chosen based upon Kwon et al.<sup>8</sup> study. The *sd(4)* represents the standard deviation identified from the pilot study (undertaken to first assess the feasibility of the study). The pilot study used 5 patients in each group (test and control) as trial samples and found the average standard deviation to be 4. The *a* (0.05) represents 95% confidence level while the *p* (0.80) represents the power at 80%. From the STATA command, 126 samples (63 for control and another 63 for the test) were used for the children category. Similar numbers were used in the adult category. The characteristics of the samples (control and test) in terms of age and clinical indications were similar. This was ensured by conveniently recruiting participants of matched characteristics in each of the study groups during the case-booking process. Those who agreed to participate in study were booked on days the researcher, the radiologist (who agreed to participate in the study by conducting the procedure) and the assisting radiographers were on duty. To ensure the control and the test groups were similar, comparative statistical tests (*T-test*) were performed. The outcomes are presented in the results section.

In each category, one group went through the normal process of VCUG while the other group received RWS during the VCUG procedure. However, all participants were blinded to what was being investigated. A tap attached to a barrel filled with water and placed close to the patient's head position was opened into a bowl to produce the RWS (Fig. 1).

The VCUG examinations were undertaken at one fluoroscopy unit by one radiologist with 10 years experience in VCUG. Prior to the procedures, patients were asked to empty their bladder. A control image was then taken prior to instilling contrast media and aseptic bladder catheterisation was then performed. Each catheter was secured by the use of the catheter balloon. Iodinated contrast agent (typically of contrast to a saline ratio of 1:1), of room temperature, was administered by gravity drip. The volume of contrast used for each patient was calculated using the ABC-formula [(Age × 30)/2],<sup>9</sup> but not exceeding 300 ml. The water tap was opened immediately once the contrast started filling the bladder in patients whom the running RWS effect was being tested. Patients were told to inform the performing radiologist once they feel the urge to urinate. Urge time, fluoroscopic (screening) time, voiding time and voided volume were recorded in the two groups. In this study, the urge time was defined as the period at which contrast was introduced into the bladder and a patient started feeling the urge to micturate while the screening time was defined as the period at which radiation was used for the procedure. The voiding time was also defined as the time period between the contrast introduction and voiding while the voided volume represents the volume of contrast voided.

The urge and voided times were evaluated with a digital stopwatch. The screening time and the voided volume were also assessed with fluoroscopy timer and a calibrated receiver respectively. These assessments and readings were undertaken separately by two assisting radiographers with 5 and 9 years experiences in VCUG. These same radiographers took the measurements and the inter rater agreement for all measurements were assessed with kappa and found to be very good prior to accepting the results (kappa co-efficient = 0.91). A Shimadzu, overhead-tube pulsed fluoroscopy equipment with last image hold, (*FLEXAVISION, Kyoto, Japan*), was used to monitor the micturating process. The pulse rate used was 3.0 fps for all study groups and the exposure factor selected was by automatic exposure control (AEC) system incorporated in the machine.

Descriptive statistics were used to analyse the demographics while *T-test* was used to compare the voiding parameters among the test and the control groups for the children and the adult category. This test tool was used because the data were randomly

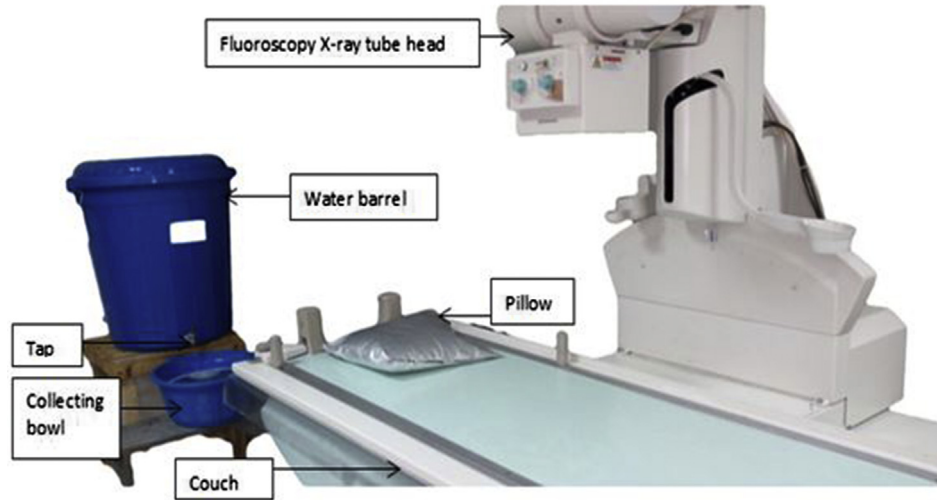


Figure 1. A diagram showing the room set up for the RWS examinations.

distributed. The *T*-test analyses were two-tailed and *p*-value of less than 0.05 was interpreted as significant.

**Results**

The study participants comprised children and adults whose ages ranged from 4 to 80 years. For the children's category, the majority 56 (44.44%) were 4–9 years while the majority 30 (24%) were 18–25 years old for the adult category. Several indications were also presented by the participants. In the adult category, the majority 36 (28.57%) presented with lower urinary tract symptoms (LUTS) while 45 (35.71%) presented with Enuresis among for the children category. Details of the age distribution and the indications presented for the procedure are shown in Figs. 2 and 3 and Tables 1 and 2. The mean urge time, voiding time, radiation screening time and the voided volumes of the procedures “with RWS” and “without RWS” for the children's category are presented in Table 3 while that of the adult category are presented in Table 4. Comparative statistical tests (*T*-test) performed to assess the similarity of the test and control groups showed they did not differ significantly. Regarding the indications, a *p*-value of less than 0.05 ( $p = 0.978$ ) was observed in the children (control and test) groups while a *p*-value of less than 0.05 ( $p = 0.965$ ) was observed in the adult groups. With respect to the age characteristics, a *p*-value of less than 0.05

( $p = 0.977$ ) was observed in the children's groups while a *p*-value of less than 0.05 ( $p = 0.912$ ) was observed in the adult groups.

**Discussion**

This study is one of the first studies to investigate the impact of running water sound on voiding, urge and fluoroscopy screening times for VCUG examinations among children and adults. It is also the first to suggest a clinical set-up for the RWS. The results show that the application of RWS technique in VCUG examinations can improve some of the procedure dynamics and parameters statistically. In particular, the screening, the urging and the voiding times were reduced significantly with the use of the RWS technique compared with VCUG undertaken without the application of the RWS technique. The findings and that of Kwon et al.<sup>8</sup> suggest that RWS influences both urine and iodinated contrast agent voiding. It also confirms Fernbach, Feinstein & Schmidt's<sup>10</sup> observation that the RWS provokes voiding in children.

A number of nursing and psychology texts and parenting books advise running water in the sink for situations as varied as potty-training toddlers, helping people with paruresis, and patients fresh out of prostate surgery, who all may have trouble getting the waterworks started unassisted.<sup>11</sup> However, the theoretical mechanism behind this has not been fully explained and understood. Nonetheless, it is believed that because the RWS is a sound often

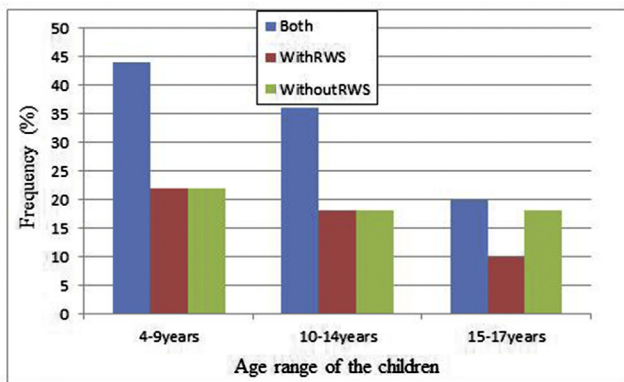


Figure 2. Age characteristics of the children who participated in the study. The diagram shows the control (withoutRWS) and the test (withRWS) groups were matched in terms of clinical presentations.

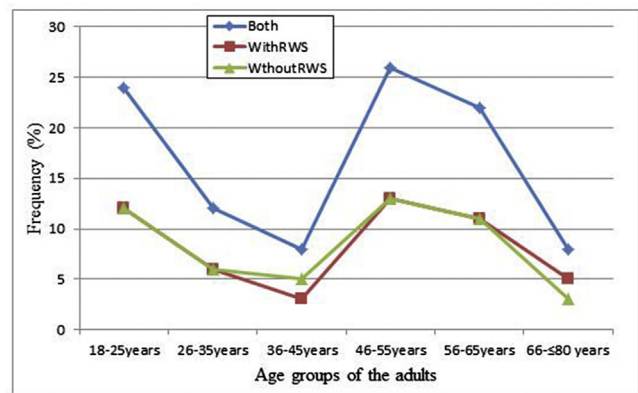


Figure 3. Age characteristics of the adult participants. This shows the control (withoutRWS) and the test (withRWS) groups were matched in terms of age range.

**Table 1**  
Indications presented by children participants.

Indication	Frequency N (%)		
	Control (Without RWS)	Test (With RWS)	Both
Blood in urine	9 (7.14%)	9 (7.14%)	18 (14.28%)
Pain upon urination	8 (6.35%)	7 (5.55%)	15 (11.90%)
Cloudy or pinkish urine	2 (1.59%)	2 (1.59%)	4 (3.18%)
Dribbling of urine	2 (1.59%)	3 (2.38%)	5 (3.97%)
Recurrent urinary tract infection	7 (5.55%)	7 (5.55%)	14 (11.11%)
Suspected bladder diverticulum	6 (4.76%)	6 (4.76%)	12 (9.52%)
Evaluation of vesicoureteral reflux	6 (4.76%)	7 (5.55%)	13 (10.31%)
Enuresis (bedwetting)	23 (18.25%)	22 (17.46%)	45 (35.71%)

**Table 2**  
Indications presented by adult participants.

Indication	Frequency N (%)		
	Control (Without RWS)	Test (With RWS)	Both
Lower urinary tract symptoms	18 (14.29%)	18 (14.29%)	36 (28.58%)
Urinary tract infection	12 (9.52%)	14 (11.11%)	26 (20.63%)
Diabetes	5 (3.97%)	3 (2.38%)	8 (6.35%)
Bladder diverticulum	2 (1.59%)	2 (1.59%)	4 (3.18%)
Pain during micturating	5 (3.97%)	5 (3.97%)	10 (7.94%)
Urine retention	2 (1.59%)	2 (1.59%)	4 (3.18%)
Suspected vesicoureteral reflux	15 (11.90%)	15 (11.90%)	30 (23.80%)
Incontinence	4 (3.18%)	4 (3.18%)	8 (6.35%)

**Table 3**  
Procedure parameters for running water sound and non-running water sound applications in children category.

Procedure parameters	With RWS	Without RWS	<i>p-value</i>
	Mean	Mean	
Urge time (s)	20.12 ± 5.1	30.9 ± 4	0.012
Voiding time (s)	22.14 ± 1.8	45.50 ± 4.1	0.001
Screening time (s)	17.15 ± 2.5	30.61 ± 5.1	0.0024
Voided Volume (ml)	80.17 ± 13.0	85.1 ± 1.1	0.712

**Table 4**  
Procedure parameters for running water sound and non-running water sound applications in adult category.

Procedure parameters	With RWS	Without RWS	<i>p-value</i>
	Mean	Mean	
Urge time (s)	29.36 ± 3.8	36.9 ± 6.1	0.003
Voiding time (s)	37.67 ± 1.8	47.80 ± 1.6	0.001
Screening time (s)	37.36 ± 4.4	49.80 ± 5.2	0.001
Voided Volume (ml)	279.67 ± 14.0	281.87 ± 71.3	0.640

heard during micturating in the bathroom, it physiologically induces stimuli for voiding. According to Ellsworth et al.<sup>12</sup> and Largo et al.<sup>13</sup> this phenomenon might be explained by the mechanism of parasympathetic acceleration and pavlovian conditioning, in view of the central and peripheral neural responsive system of the bladder detrusor muscle and urethral sphincter. Kwon et al.,<sup>8</sup> further indicated that RWS might enhance the parasympathetic tone, which powers the detrusor muscle, and relax the resistant tone of the urethral sphincter.

The outcome of this study as observed among a wide-ranging age categories of patients with varying indications, may help to improve the VCUG work-ups among a number of male patients who are 4 years and above. In particular, it may help those who lose the sense to initiate micturating on examination tables because of psychological anxiousness.<sup>6,14,15</sup>

Moreover, the X-rays associated with VCUG can induce stochastic and hereditary effects.<sup>2,16</sup> This is because the irradiated field during the investigation contains many of the most radiosensitive organs and tissues.<sup>1</sup> Hence, the International Commission on Radiological Protection (ICRP) has suggested that the doses associated with every justified medical examination must be optimised<sup>17–19</sup> by ensuring that they are as low as reasonably achievable, taking into account social and economic factors.<sup>17</sup> This principle is known in the UK as the ALARP principle.<sup>20</sup> The observed reduction in the screening time, with the use of the RWS technique as compared with procedures without the RWS technique is significant in reducing radiation to patients. This is because a short screening time reduces radiation dose<sup>10,21,22</sup> as a delay in voiding leads to a high number of intermittent screenings to monitor if voiding is occurring. Therefore, this simple technique of RWS can potentially enhance current practice and may serve as a potential dose optimisation tool in VCUG procedures. In particular, among children (such as the study participants) who often undertake such procedures and have higher risks of developing radiation-induced cancer than adults.

Practically, the RWS technique set-up (Fig. 1) is less expensive as what is needed is a tank/barrel with a simple tap and a collecting bowl or sink. Alternatively, a modified version comprising a running tap and a sink at a distance where the patient can hear the sound can also be used in the imaging room.

A major limitation of this study however is that children under four years old were excluded since they could not be very cooperative to immediately inform the performing practitioner of their urge to urinate. Therefore, the findings could not be generalised to include these children. Also, factors such as weight, height and BMI, which could possibly impact on patients' voiding as well as on fluoroscopy screening times, were not taken into consideration and therefore the recommendations suggested should take these factors into consideration when implementing them. Moreover, due to the lack of DAP reading systems on the fluoroscopy used, the dose parameters were not recorded and considered in the study.

## Conclusion

This study is one of the first studies to investigate the impact of running water sound on voiding, urge and fluoroscopy screening times for VCUG examinations among children and adults. It is also the first to suggest a clinical set-up for the RWS. The results show that the application of RWS technique can be helpful in inducing early urge of iodinated contrast voiding among the study participants. The technique also reduced voiding times significantly, during contrast-based VCUG. This technique may help patients who lose the sense to initiate micturating on examination tables because of psychological anxiousness or distress. In addition, radiation dose optimisation is paramount in radiography and this study shows a simple technique to enhance current practice and reduce doses in VCUG which is a common paediatric examination.

## Conflict of interest

None

## Acknowledgement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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