Reducing uncertainty for vesico-urethral sonography in women

J. Beco

Abstract

The author endeavours to detail the technical modalities which can be used to avoid uncertainty in urodynamic sonography, and to obtain easily reproducible quality imaging. The 5 major techniques (transparietal, transperineal, introital, endovaginal and endorectal) are compared. The artifacts generated are described. A choice between these different techniques is performed as a function of the methodological advantages specific to each of them and the clinical applications contemplated by the sonographer. The characteristics of the “ideal” equipment are defined to help the sonographer-to-be to choose his or her equipment with full awareness of the facts (characteristics of the probe, emission frequency, settings by the sonographer, automatic image freeze during coughing). The methodology is described in detail and widely illustrated: position of the patient, choice of the section plane, choice of the reference system, location of the urethra, and definition of the vesical neck, maintenance of the probe position during effort or free movement, degree of vesical fullness, choice of the parameters. Some difficulties can be linked to the patient’s anatomical characteristics (vaginal scar, short or narrow vagina, twisted urethra,...); ways to avoid them are briefly described.

Key-words: Ultrasound — Urodynamics — Urinary incontinence.

I. Introduction

In 1977, the initial study on the use of sonography in the evaluation of continence disorders in women was published by Schaaps and Lambotte (25). Using a transparietal technique, these authors observed that the angle formed by the posterior vesico-vaginal wall and the horizontal is more open in continent patients than in patients presenting urinary stress incontinence (50° versus 12°). It was only after 1985, with the development of endocavitary probes, that urodynamic sonography began its expansion. Today, the prevalence of this technique is such that any urodynamic department with adequate equipment and a competent sonographer should be able to do without X-rays for the vast majority of check-ups. The absence of irradiation and the perfect visualisation of soft tissues are the main advantages sonography has over radiology. Its critics will, however, argue that endocavitary sonography distorts vesico-urethral anatomy and that the technique is significantly more operator-dependant than radiology. The goal of this article is to specify the technical modalities which can be used to avoid uncertainty in sonography and to obtain easily reproducible, high quality imaging.

II. The uncertainty linked to the type of approach and to the choice of equipment

1. Introduction pathways

When choosing among the 5 available techniques (transparietal, transperineal, introital, vaginal, endorectal), the sonographer’s decision will

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depend on the type of application and the specific methodological advantages of each approach (Table 1a and 1b) (5). Sadly enough, it will also depend on the cost and the availability of the material.

Currently, the reference technique remains linear vaginal sonography at 5 or 7.5 MHz (transducer introduced and placed into the vagina) (Fig. 1a). In fact, this technique is the only one which can be used in all applications itemised to this day (2, 3, 4, 7, 24) (except for measuring the posterior urethral-vesical angle and doppler) and has been validated by a study of the artifacts and the inter- and intra-observer repeatability of the parameters (5, 8, 12). It offers optimal comfort both to the sonographer and to the patient, while allowing easy simultaneous urodynamic exploration (1, 6).

The endorectal pathway (transducer introduced in the rectum) (Fig. 1b) supplies information equivalent to that provided by linear vaginal sonography, but is less comfortable for the patient. It is sometimes made difficult by the presence of gas or faeces between the anterior rectal wall and the transducer, notably during effort induced by coughing or by Valsava’s manoeuvre (10, 21).

The introital sectorial technique (sectorial probe placed under the distal 1/4th of the urethra; at the level of the vaginal introitus) (Fig. 1c), frequently referred to in literature (17, 19), requires that the operator maintain the sono graphic probe in examination position; this significantly reduces the comfort of the operator, so simultaneous manometry becomes rather tricky. The total urethral length can not be measured with this technique because the distal 1/4th of the urethra is not visualised. The artifacts induced by the sectorial probe seem to compromise the effectiveness of this method (see artifacts). If the probe slides from the introitus to the vagina, the artifacts increase even more.

The transperineal technique (transducer placed on the vulva) (Fig. 1d), is very similar to introital sonography with probably less artifacts (11, 18, 23).

Transparietal sonography (probe placed on the hypogastrium) (Fig. 1e), is only useful for measuring the residue after micturition (14).

Table 1a. — Choice of the type of sonography: according to their methodological advantages

<table>
<thead>
<tr>
<th></th>
<th>Vaginal</th>
<th>Rectal</th>
<th>Introital</th>
<th>Perineal</th>
<th>Parietal</th>
</tr>
</thead>
<tbody>
<tr>
<td>High frequency</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td>+</td>
<td>—</td>
</tr>
<tr>
<td>Patient comfort</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Operator comfort</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Horizontal easy</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
<td>—</td>
<td>+</td>
</tr>
<tr>
<td>Simultaneous urodynamics</td>
<td>+++</td>
<td>+++</td>
<td>—</td>
<td>?</td>
<td>+++</td>
</tr>
<tr>
<td>Artifacts absent or mastered</td>
<td>++</td>
<td>+++</td>
<td>?</td>
<td>+++</td>
<td>?</td>
</tr>
<tr>
<td>Repeatability</td>
<td>+++</td>
<td>+++</td>
<td>?</td>
<td>+++</td>
<td>?</td>
</tr>
<tr>
<td>Pluridisciplinary use of the probe</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
</tr>
</tbody>
</table>

Table 1b. — Choice of the type of sonography: according to their possibilities

<table>
<thead>
<tr>
<th></th>
<th>Vaginal</th>
<th>Rectal</th>
<th>Introital</th>
<th>Perineal</th>
<th>Abdominal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study of the sphincteric zone</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>—</td>
</tr>
<tr>
<td>Position neck and urethra</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>++</td>
<td>—</td>
</tr>
<tr>
<td>Posterior urethrovessical angle</td>
<td>—</td>
<td>—</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Neck descent</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>—</td>
</tr>
<tr>
<td>Urethral instability</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>—</td>
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<tr>
<td>Miction</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>—</td>
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<tr>
<td>Residue</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+++</td>
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<tr>
<td>Echo-guided EMG</td>
<td>+++</td>
<td>++</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Synthetic strip visualisation</td>
<td>+++</td>
<td>++</td>
<td>+</td>
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<td>—</td>
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</tbody>
</table>
The intra-urethral technique (rotating probe introduced in the urethra within a catheter) has not shown any real clinical utility to this day (16).

2. **Artifacts**

The most effective techniques are usually the most invasive, and thus those most likely to generate artifacts.

Providing that a strict methodology is used, endovaginal linear sonography provokes constant or non-critical artifacts (5, 8). At rest, a 43% decrease in the angle between the intra-urethral cotton swab and the horizontal can be observed. The tilting of this cotton swab during coughing effort is reduced by 33%. The maximal urethral gain (increase of the closure pressure during an effort of voluntary squeezing) is increased by 12 cm H\(_2\)O. These three artifacts have no clinical impact since they are identical for any patient or operator. This is probably due to the fact that the linear probe is placed in the vagina and on an external support without exerting a voluntary pressure on the urethra. It is also for this reason that no modification in the closing pressure or in the functional length has been observed. A very tight and not very compliant vagina could however provoke a slight increase of the closing pressure
(of 5 cm H₂O if the distance between the sono-
graphic probe and the pubic arcuate ligament is
less than 14 mm). As we were able to observe by
transpapetral (abdominal) sonography, the poste-
rior urethro-vesical angle was strongly increased
by the presence of the probe in examination
position (Fig. 2a). This artifact also exists, but to a
lesser degree, if the probe is placed in the rectum
(Fig. 2b). While for some, the posterior urethro-
vesical angle plays a vital role, we no longer
measure it, because it does not present any utility
for us. Besides a tight and not very compliant
vagina, a short vagina (often after surgery), imped-
ing the access of the vesical neck without a major
thrust on the probe, is an element which signifi-
cantly aggravates the artifacts. In this case, as
soon as the thrust on the probe begins, the urethra
is pulled by the posterior wall of the bladder
towards the patient's cephalic pole.

Linear endorectal sonography does not pro-
voke any modification in the closing pressure or in
the functional length (22). The urethral angulation
(the cotton swab's incline) is not modified but, as
mentioned above, we observed that the posterior
urethro-vesical angle is opened by the probe. The
artifacts induced by a sectorial probe in introital
position were studied by Wise et al. (28). These
authors have shown that this type of approach
provokes a 57% average increase of the closing
pressure with a 35% increase in the functional
length. Moreover, they noted a 19% decrease in
the posterior urethro-vesical angle and a rise of the
vesical neck. These artifacts are linked to the
"impaction" of the urethra into the bladder and to
its flattening on the pubic symphysis (Fig. 3).
However, they can vary as a function of the
operator. To obtain quality imaging, the sectorial
probe requires an excellent contact between its
small emission surface and the structure to be
studied. This contact implies pressure by the
operator, which must be as slight as possible in
order not to provoke artifacts. Introital sonography

Fig. 2. — Opening of the posterior urethro-vesical angle by the linear probe. A = the introduction of the endovaginal linear probe
beyond the vesical neck provokes a distortion of the posterior vesical wall (---). The posterior urethro-vesical angle is opened by the
sonographic probe. B = the distortion of the posterior vesical wall also exists if the linear probe is used by the endorectal pathway
(R). The arching is however situated a bit more at the back than the arching induced by the endovaginal probe (V).
must ideally be performed by maintaining the probe continuously on the verge of “switching off” (minimal pressure on the probe), at introitus level and in the ideal section plane both at rest and during effort. This represents a technical exploit, that is not within reach of the first sonographer who comes along!! The artifacts induced under these ideal conditions should thus be less significant than those described by the Anglo-Saxon team, which is obviously not made up of “sonography fans”.

No study investigated the possible artifacts which could be induced by transperineal sonography.

3. Specifications for “ideal” equipment

Imaging quality depends on the choice of equipment. To be able to choose with full knowledge of the facts, this chapter have summarised a “specification sheet” based on our experience, defining the ideal equipment (Table 2).

a. Probe characteristics: the linear probe used in the vagina or rectum (Fig. 4), must have the smallest diameter or thickness possible (max. 10 mm). The length of the probe’s emitting section must be 4.5 to 5 cm to allow complete visualisation of the urethra from the meatus to the vesical neck (especially to measure the total urethral length). The non-emanating extremity of the probe should be as short as possible (max. 2-3 mm), to reduce as much as possible its impact on the posterior wall of the bladder, limiting the risk of expulsion, with non-visualisation of the neck, when coughing. The sizes of a sectorial probe used through the introitus or of a probe used by the transperineal pathway do not influence the results of the examination.

Fig. 3. — Artifacts induced by introital sonography. A = without the sectorial probe; B = introital sectorial probe in place:
— the urethra is compressed on the arcuate pubic ligament;
— it is “impacted” in the bladder.
---- = anatomy without the sectorial sound. → = modifications induced by the probe.
The handle of the endocavitary probe should include a level so that the operator can hold it horizontally (see the choice of the reference system).

b. The frequency of emission: the higher this frequency, the better the image definition, but at the expense of exploration depth. A 5 MHz frequency is adequate for use by the rectal, vaginal and introital pathway with sufficient definition. With a frequency of 7.5 MHz, the exploration depth could be insufficient in case of rectal use, but the definition is excellent when the vaginal pathway is preferred. The transperineal pathway constrains the sonographer to use a lower emission frequency, because the target is at a distance.

c. Sonography unit characteristics and adjustments are only important for dynamic studies. Ideally, with the enlargement of the image without loss of definition, the sphincter zone should be displayed full screen. This is mainly useful for studying the urethral pulse (2) or the very low amplitude movements characterising urethral instability (7). Optimal measurement of the bladder neck descent during coughing effort necessitates a perfect freeze frame. To obtain this result, the sonographer must supply as many scanning images as possible per second (> or = 20). If this number is too low, and if the neck moves very rapidly during coughing, the freeze frame will be blurred. This will inevitably decrease the visual comfort of the operator and reduce the reliability of the measurement. The adjustment of the device is also determinant. One single focal plane (adapted to the exploration level) must be chosen. The use of 2 focal planes (or more) at the same time reduces the number of images per second. Another important feature of some recent devices is their “correlation system” allowing a more or less complete fusion of the last 2 images to obtain a more stable, more “polished” image, and thus more pleasant to look at. This system must be disactivated to obtain a clear image when blocking the sonographic sequence during coughing. The raw imaging obtained is less attractive, but it is closer to the actual dynamics (the same adjustments are used in echocardiography). However, to accentuate tissular contrasts on a static image, the correlation percentage must be as high as possible.

Finally, the device must allow rapid measurement of angles and distances.

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Table 2. — The “ideal” material

<table>
<thead>
<tr>
<th>Probe:</th>
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<tbody>
<tr>
<td>— linear;</td>
</tr>
<tr>
<td>— &gt;45 mm long;</td>
</tr>
<tr>
<td>— &lt;10 mm thick and wide;</td>
</tr>
<tr>
<td>— non-emitting extremity &lt;3 mm;</td>
</tr>
<tr>
<td>— level in probe handle.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Emission frequency:</th>
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</thead>
<tbody>
<tr>
<td>— 7.5 MHz if endovaginal;</td>
</tr>
<tr>
<td>— 5 MHz if endorectal and endovaginal.</td>
</tr>
</tbody>
</table>

Characteristics of the sonography unit and adjustments:

| — significant enlargement (sphincteric zone in “full screen”); |
| — clear freeze screen during effort: |
| — >20 scanning images/second, |
| — 1 single focal plane, |
| — percentage of “correlation” = 0; |
| — easy measurement of angles and distances. |

Coupling sonography urodynamics: automatic blocking of the image at the peak of vesical pressure generated by coughing.

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Fig. 4. — Characteristics of the “ideal” linear probe. N = level built in the probe handle (easier to keep the probe horizontal).
d. Automatic blocking of the sonographic image (Fig. 5): when the patient performs a maximal coughing effort, the vesical neck moves very rapidly. It is very difficult to block the image manually at the maximum neck descent. The measurement can however be performed later from a videotape displayed in slow motion. This technique is rather tedious and encouraged many teams to measure the neck descent on a Valsava effort rather than on a maximal coughing effort. This practical problem was resolved nicely by coupling sonographic and urodynamic devices using a simple co-axial cable. Thanks to software (Geyre Electronique), the sonographic image is automatically blocked at the maximal vesical pressure peak generated by the coughing effort. A threshold system avoids unwanted blocking of the image for insignificant efforts. This application is probably the only one where the association of urodynamics and sonography is indispensable. This association allows fast and repetitive measurement of neck descent during coughing effort.

III. Methodological uncertainties

The variety of the methodologies presented in the literature leaves the reader potentially interested by urodynamic ultrasonography very perplexed. Who is right? Several quality criteria are

Fig. 5. — Automatic blocking of the sonographic image. PV = vesical pressure; T = time; C = adjustable blocking threshold. A = freeze frame at the vesical pressure peak; B = no freeze frame. 1 = rest; 2 = image not blocked during coughing (does not get over the “C” threshold); 3 = automatic blocking at the vesical pressure peak. L1 = distance arcuate ligament-vesical neck at rest (situation 1); L2 = distance arcuate ligament-vesical neck during maximum coughing effort (situation 3).

Practically: a. measure the maximal coughing effort on the vesical pressure curve; b. adjust the blocking threshold “C” on the urodynamic device to: max. coughing - 10 cm H₂O; c. measuring L1 using sonography; d. make the patient cough beyond the “C” threshold and measure L2; e. neck descent or “sliding” corresponding to L1-L2.
mentioned in this paragraph to offer the future sonographer or the perfectionist sonographer an overview of this literature from a more critical point of view (Table 3).

1. **The position of the patient**

To obtain a repeatable image, the position of the patient must be standardised. Among the different possibilities, the most frequently used is the dorsal position, in lithotomy position (feet level with buttocks). The patient must avoid raising buttocks during the examination (notably during coughing or squeezing effort) to avoid disrupting measurements.

The reasons for the choice of the dorsal position are multiple:
- the patient's comfort;
- the operator's comfort, for better measurement repeatability, and reduction of compression artifacts offer better quality imaging;
- simultaneous urodynamic examination is easily performed;
- the descent of the bladder neck is not significantly different when compared with the

![Diagram](image)

**Table 3. — The “ideal” methodology**

<table>
<thead>
<tr>
<th>Position of the patient: dorsal position (lithotomy).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standardised section plane:</td>
</tr>
<tr>
<td>— max. thickness of the arcuate ligament in the symphysial window;</td>
</tr>
<tr>
<td>— intra-urethral catheter;</td>
</tr>
<tr>
<td>— vertical sonographic emission plane.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reference systems:</th>
</tr>
</thead>
<tbody>
<tr>
<td>— either posterior edge arcuate lig. + horizontal plane;</td>
</tr>
<tr>
<td>— or posterior edge arcuate lig. + symphysial axis.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Definition of the neck: junction anterior vesical wall – sphincteric zone (fastening of the urethra on the bladder).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe:</td>
</tr>
<tr>
<td>— introduced maximum 10 mm beyond the neck (if endocavitary);</td>
</tr>
<tr>
<td>— follows the movement of the neck during coughing.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameters:</th>
</tr>
</thead>
<tbody>
<tr>
<td>— repeatable;</td>
</tr>
<tr>
<td>— easy to measure;</td>
</tr>
<tr>
<td>— defining the entire anatomical system.</td>
</tr>
</tbody>
</table>

Artifacts: constant or absent → endorectal or endovaginal.

upright position. For Vierhout et al. (26), the maximum displacement of the bladder neck is measured in dorsal position. Moving from the dorsal position to the sitting position moves the neck down. Since for the 2 positions, the neck is situated at the same level at the maximum effort, its maximum displacement is measured in dorsal position. For Schär et al. (23), the difference between the supine and upright positions were minor in the ultrasound examination, although the funnelling of the bladder neck could be detected better in the upright position.

Some researchers prefer to use the sitting position, since it favours micturition (13).

2. **Choice of the section plane**

To define a section plane, you must use at least one point and one line.

In linear vaginal sonography, the standard sagittal section plane includes (Fig. 6):
- a point: the posterior border of the arcuate pubic ligament, at its thickest (in the symphysial “window”);
- and one line: the intra-urethral catheter in its portion above the symphysis (the perfectly horizontal orientation of the emitting section of the sonographic probe constitutes a second

![Diagram](image)

**Fig. 6. — Standardised section plane. It includes a line: the manometric catheter in its portion above the pubis (arrow) and a point: the posterior edge of the pubic arcuate ligament at its thickest (arrow). The emitting portion of the probe is perfectly horizontal.**
imaginary line confirming the quality of the section).

The arcuate pubic ligament unites the 2 pubic bones at the back. Its posterior border represents the main reference point. In nearly all the studies, it is difficult to distinguish from the symphysis pubica (slightly hyperechogenic line situated further forward) or the pubis (very hyperechogenic line, parasagittal section). It is difficult to visualise it because its echogenicity is equivalent to that of the Retzius space. A small vein (non-echogenic image) often delimits it at the back. It can be located precisely by holding the sonographic probe horizontally and moving it up and down slightly (compression-decompression of the space between the probe and the arcuate ligament). These movements provoke a displacement of soft tissues relative to the arcuate ligament which can then be easily located (Fig. 7). To be perfectly sagittal, the section must go through the zone in which the arcuate ligament is thickest (with some experience, a sonographic cleavage plane between the symphysis and the ligament can be distinguished). If the plane is slightly parasagittal, the arcuate ligament becomes thinner. If it is offset by several millimetres, the point of reference becomes too clear, the section leaves the “sym-

physial” window and goes through the pubic bone, which appears as a clearly hyperechogenic line (Fig. 8). A reference point which appears too clearly on a photographic or video document is the sign of a parasagittal section, which of course reduces the validity of the study presented (example: ref 27). Since the symphysial “window” is narrow (5-6 mm), the localisation error of the reference point is minimal.

Without an intra-urethral catheter it is very difficult to define the axis of the urethra, and the section plane becomes unreliable.

Since the ideal section plane is known, and is easy to obtain, this contributes to the effectiveness of the method. The same section plane must be utilized when introital, trans-perineal or trans-rectal sonography is used.

3. Choice of the reference system

A complete reference system must include at least a line and a fixed point in a well defined plane (= the section plane described above).

Any other method which does not use a system of this type will neglect most of the information available in the image. So, in the absence of a

Fig. 7. — The arcuate ligament: a. a small vein (black spot) borders it in the background; b. a translation movement of the probe upwards allows very clear visualisation of its outlines, by making the pre-urethral soft tissues glide with respect to the arcuate ligament.
fixed reference point (neck descent compared to itself), the validity of the study must be seriously questioned (example: ref. 10). It is an error to believe that the patient and the probe remain totally immobile during a coughing effort. Moreover, the use of one single fixed point (without a reference line) is not sufficient to define the position of the neck and of the urethra on 2 axes in space (example: ref. 15).

On a patient installed in dorsal position, the ideal fixed reference point is on the posterior border of the arcuate pubic ligament. Two lines can be used: the horizontal and the axis of the symphysis.

The horizontal is defined by the plane of the sonographic probe (lower edge of the image) for a vaginal or rectal sonography using a linear probe positioned in a perfectly horizontal plane (a level

Fig. 8. — Images obtained as a function of the section plane. 1 = ideal section plane: cuts through the arcuate ligament (LA) at its thickest. A small vein (V) borders it in the background. The arcuate ligament presents the same echogenicity as the Retzius space and is thus poorly visible. It is doubled in the foreground by a discreetly echogenic line corresponding to the interface with the pubic symphysis (PS) = interpubic fibro-cartilage. 2 = lesser quality section plane: the arcuate ligament is less thick but no hyperechogenic line is visible. The section plane remains within the “symphysial window”. The error is minimal, 3 = bad quality section plane: a very clear hyperechogenic line appears on the screen; significant attenuation of the echoes is visible behind this line. It corresponds to the posterior edge of the pubis. The section plane is clearly parasagittal; the validity of the measurements performed under these conditions must seriously be questioned.
built into the probe handle could verify this horizontal plane (Fig. 9a).

The guideline used for echoguiding a biopsy can be used as reference if a sectorial introital probe is kept horizontal (or at a constant slope relative to a horizontal plane) during the entire examination, using the level built into the housing. If the sectorial probe doesn’t have a built-in level, a "sonographic" level (9) can be improvised using the balloon of a Foley catheter half filled with liquid, half with air (Fig. 9b).

The axis of the symphysis (Fig. 10) is situated equidistant from the upper and lower sides of this symphysis; it goes through the posterior edge of the arcuate ligament. While this reference line seems ideal, because it is independent from the movements of the patient, it presents two disadvantages:

— the line does not appear on the screen and must thus be traced by the sonographer;
— it includes the posterior edge of the arcuate ligament; this implies that, to obtain an ortho-

Fig. 9. — Reference systems including the posterior wall of the arcuate ligament and a horizontal plane. A. Linear endorectal or endovaginal probe: the probe is maintained in a perfectly horizontal position (patient installed in dorsal position with the feet level with the buttocks). The reference system includes the posterior wall of the arcuate ligament (1) and the horizontal plane represented by the lower border of the image (2). This last plane corresponds to the position of the sonographic probe. An orthogonal system is obtained (axes x and y perpendicular). B. Sectorial introital probe: Above: the line used as guide for a possible puncture (2) represents the horizontal plane on the screen if the sonographic probe is maintained at a predefined slope with the horizontal plane (as a function of the characteristics of the equipment). Bottom: the horizontal is visible on the screen using a “sonographic” level obtained by filling a Foley probe balloon half with air, half with water.
gonal system, a line perpendicular to the axis of the symphysis, going through this posterior edge, must absolutely be traced. This absence of direct visualisation will inevitably hinder the measurement of the different parameters.

We prefer using a horizontal plane and the posterior edge of the arcuate ligament in linear vaginal sonography.

4. Location of the urethra and definition of the neck

A thin supple manometric fluid-filled catheter is preferable to locate the urethra because it is not very uncomfortable for the patient and allows simultaneous pressure measurements without rigidifying the urethra like a cotton swab (Fig. 11). A cotton swab, by straightening the urethra, significantly modifies the angle between the urethra above the symphysis and the horizontal plane. The catheter must be visualised over its entire length in its portion above the symphysis to confirm the quality of its section plane. In the absence of an intra-urethral catheter, the position of the neck and especially the axis of the urethra are difficult to individualise. This is especially true during coughing effort. The vesical neck is, under these circumstances, often confused with the vesical base in a parasagittal plane and the section plane then becomes unreliable (ex.: ref. 17).

The vesical neck must be located using purely anatomical elements (Fig. 12). Using the cotton

Fig. 10. — Reference system including the axis of the symphysis (2) and its perpendicular lowered to the level of the posterior edge of the arcuate ligament (1).

Fig. 11. — Locating the urethra. Left: the urethra is located with the help of a thin manometric catheter which does not rigidify it. A = urethro-horizontal angle. Right: the urethra is located with a cotton swab. This cotton swabs makes it artificially straight. The angle B measured under these conditions no longer corresponds to the initial angle (A).
ball of the cotton swab, a small chain or the balloon of the Foley catheter to define the neck, is implicitly admitting that the imaging obtained is insufficient to identify it (these are often studies performed using transperineal sonography) (ex.: ref. 11).

When soft tissues are perfectly visualised, a sonographic neck is easily defined. This sonographic neck corresponds to the junction between the front vesical wall and the sphincteric wall (urethral fixation on the bladder) (6). This excellent definition of the neck is one of the main advantages of sonography over a radiographic image. In case of cervical incompetence with funnel-shaped bladder, it is nearly impossible to locate the neck in radiology (Fig. 13). Its position is then often confused with the extremity of the incompetent cervix or roughly estimated in the continuity of the vesical wall. This location error then becomes more significant when the coughing effort aggravates cervical incompetence. Sonography can thus be used, even during coughing, to perfectly locate the implantation of the urethra on the bladder and thus to measure cervical incompetence. More, the ultrasound images a thin cut through the female pelvis, while X-ray assessment scans all layers of the pelvic region. In measuring the posterior urethrovesical angle or in locating the bladder neck, lateral layers also influence the result. This could enhance the error in the definition of the bladder neck using X-ray (23).

5. Fixed probe or mobile probe
during coughing?

During a coughing effort, the sonographic probe (linear endocavitary, or sectorial introital)

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Fig. 12. — Locating the vesical neck. 1. Location based on purely anatomical elements: junction between the sphincteric zone and the anterior vesical wall. 2. Located by the cotton tip of a cotton swab. 3. Located by a small chain. 4. Located by the Foley catheter balloon.
must follow the movement of the vesical cervix (Fig. 14). If the probe is maintained firmly in place, the imaging will indeed be easier to interpret (the pubic symphysis will remain almost at the same place on the image) but the descent will be strongly decreased (examples: ref. 10, 15). In this case, the probe will perform the equivalent of a Bonney test.

Fig. 13. — Sonography locates the vesical neck more accurately than X-rays. A. Vesical neck located by sonography: junction between the sphincteric zone and the anterior vesical wall. This reference point is very clear. B. The vesical neck is very difficult to locate on X-rays. This difficulty increases during an effort (funnel-shaped bladder) and in case of incompetent cervix.

Fig. 14. — To measure the neck descent during an effort, the linear endovaginal or endorectal probe moves freely in the horizontal plane. A = mobile probe: the neck descent is only slightly influenced. B = fixed probe: the neck descends much less. Measurement is indeed easier but it is no longer reliable.
IV. Patient uncertainties

Some technical difficulties can be induced by the patient’s anatomy. A vaginal scar can hinder the passage of ultrasounds and decrease the quality of the image. A short or narrow vagina, an intact hymen, or a major prolapse pushing the extremity of the vaginal probe beyond the vesical neck necessitate choosing endorectal, introital or transperineal sonography.

A laterally deviated or twisted urethra (often after surgery) is an obstacle to obtain a classical sagittal section plane. In this case, one should try to locate the catheter at the level of the vesical neck in a plane as close as possible to the sagittal plane.

V. Conclusions

The critics of urodynamic sonography, often afraid of its innovative image and its apparent complexity, criticise its impact on anatomy, its
price and its absence of standardisation. By judiciously choosing appropriate equipment, and by using irrefutable methodology, it is possible for any clinician interested by this technique to perform effective and repeatable examinations, thus responding to these ill-founded criticisms. Understanding the uncertainties of urodynamic sonography is a major step which must be well managed to be able to build personal experience in this technique. Sonography expresses figures obtained by manometry, but its language, like any other, requires thoughtful training. Once the responsible clinician knows the artifacts which can be generated, the way he can control them and the different types of sonographic approaches possible, he will be able to use sonography as the ideal morphologic complement to perform urodynamic assessment.

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Résumé

L’auteur tente de préciser les modalités techniques permettant d’éviter les aléas de l’écographie urodynamique et d’obtenir une imagerie de qualité, aisément reproducible. Les 5 techniques principales (transpariéale, transpérinéale, introitale, endovaginale et endorectale) sont comparées. Les artefacts générés sont décrits. Un choix entre ces différentes techniques est réalisé en fonction des avantages méthodologiques propres à chacune d’elles et des applications cliniques envisagées par l’échographiste. Les caractéristiques du matériel ‘idéal’ sont définies pour aider le futur échographiste à choisir son matériel en connaissance de cause (caractéristiques de la sonde, fréquence d’émission, réglage de l’échographe, blocage automatique de l’image à la toux). La méthodologie est décrite en détail et amplement illustrée : position de la patiente, choix du plan de coupe, choix du système de référence, repérage de l’urètre et définition du col vésical, maintien de la sonde à l’effort ou non, degré de remplissage vésical, choix des paramètres. Certaines difficultés peuvent être liées aux caractéristiques anatomiques de la patiente (cicatrice vaginale, vagin court ou étroit, urètre tordu,...); la manière de les éviter est décrite succinctement.

Samenvatting

De auteur probeert de technische omstandigheden te verduidelijken waaronder de wisselvalligheid van de urodynamische echographe kan worden vermeden en waaronder kwaliteitssafbeeldingen mogelijk zijn die zich gemakkelijk laten reproduceren. De vijf belangrijkste technieken (transpariëtaal, transperineaal, introitaal, endovaginaal en endopectaal) worden vergeleken. De bewerkstelligde artefacten worden beschreven. Afhankelijk van de methodologische voordelen die eigen zijn aan iedere techniek en afhankelijk van de klinische toepassingen die door de echo-onderzoeker worden beoogd, wordt een keuze gemaakt tussen deze verschillende technieken. De kenmerken van de „ideale” apparatuur worden bepaald om de aankomende echo-onderzoeker te helpen zijn apparatuur met kennis van zaken te kiezen (kenmerken van de sonde, emissiefrequentie, instelling van de echograaf, automatische bevriezing van het beeld bij hoesten). De methodologie wordt omstandig beschreven en rijkelijk geïllustreerd : positie van de patiënté, keuze van het snijvlak, keuze van het referentiesysteem, lokalisatie van de urethra en bepaling van de blaashals, vasthouden van de sonde met of zonder inspanning, mate van blaaussvulling, keuze van de parameters. Bepaalde moeilijkheden kunnen in verband worden gebracht met de anatomische kenmerken van de patiënté (vaginaal litteken, korte of nauwe vagina, verdreide urethra enz.); de manier om deze moeilijkheden te vermijden wordt in het kort beschreven.

Zusammenfassung

References


