Laparoscopic radical prostatectomy with real-time laparoscopic and transrectal ultrasound: preservation of the neurovascular bundles


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Abstract
Radical prostatectomy continues to be the standard treatment for managing localized prostate cancer, in both its open and robotic-assisted modalities. The two techniques have demonstrated similar urinary incontinence and erectile dysfunction rates. Even though laparoscopy offers benefits similar to robotics because it is a minimally invasive procedure, the incontinence and dysfunction rates are still higher than those of the two modalities first mentioned. There is very little available information on the usefulness of real-time transrectal ultrasound of the prostate in the intraoperative identification of the neurovascular bundle and none to the authors’ knowledge on the simultaneous use of laparoscopic ultrasound for the same purpose. This article describes the technical aspect of and our institutional experience in the simultaneous use of laparoscopic intracorporeal ultrasound and transrectal ultrasound of the prostate during laparoscopic radical prostatectomy.
Prostatectomy radical laparoscópica con ultrasonido transrectal y laparoscópico en tiempo real; preservación de los paquetes neurovasculares

Methods

Five patients with clinically localized prostate cancer were evaluated within the time frame of January 2012 to July 2012. They belonged to a population of patients from 50 to 72 years of age and were all classified within a low risk group, having stage T1cN0M0 disease (table 1). All patients underwent pre, intra, and postoperative transrectal ultrasonography. The machine used was a BK Medical Pro Focus Ultraview® 2200 ultrasound with an endfire triplane transducer at a frequency of 12Hz. In addition, intraoperative ultrasound was done with a 4-way flexible laparoscopic transducer at a frequency of 10Hz.

With the patient under general anesthesia and in the modified Trendelenburg lithotomy position, a transperitoneal approach was established with 5 ports. The Hasson technique was used, aided by a traditional laparoscopic kit with dissection and cutting equipment, optical equipment with a 35° lens, ultrasonic energy, an electric knife, cold knife, hemostatic control with titanium staples, Hem-o-lok® clips, and 4-0 polygactin suture with an RB-1 needle.

The surgical team was in the usual position for laparoscopic prostatectomy, with the surgeon on the left side and the assistants on the right. The ultrasonographer was in the center between the legs of the patient (fig. 1).

Three 11 mm and two 5 mm trocars were used. Once peritoneal access was achieved the procedure was begun by entering the anterior peritoneum medial to the mid umbilical ligature. Access to the plane between the prevesical fat and the peritoneum was then attained, exposing the bilateral endopelvic fascia and beginning the lateral to medial reflection of the endopelvic fascia. Next, the inverted “U” dissection of the bladder neck was begun and the prostate was raised with a metal dilator, completing the dissection up to separating the bladder neck from the base of the prostate. Both vas deferens were dissected and cut, achieving hemostatic control with the application of the titanium staples. Seminal vesicle dissection was completed and dissection of the posterior prostate surface of the Denovilliers’ fascia was begun, proceeding to the identification and dissection of the neurovascular bundles with the aid of laparoscopic and transrectal ultrasound, distinguishing the vascular flow of each side.

Transrectal ultrasound was predetermined at a frequency of 12Hz, with gray scale and Doppler color function, for the
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The purpose of identifying the presence of prostatic nodules, protrusion of the mid prostatic lobe, and localization of the vas deferens, the seminal vesicles, and the prostatic apex. Doppler function gain was adjusted to the continuous mode to reduce image artifacts. The Doppler function repetition frequency was set between 500 and 1,000 and the laparoscopic transducer was predetermined at a frequency of 10 Hz.

The vascular flows were first monitored in transverse views, locating the vascular bundles from the distal apex to the tip of the seminal vesicles, following each bundle longitudinally, simultaneously alternating the laparoscopic transducer which attempted a parallel alignment of the vessels (figs. 2 and 3).

Transrectal ultrasound was used for continuous monitoring during the careful blunt dissection of the vascular bundles, enabling the tip of the laparoscopic scissors to be located (observed as a hyperechoic zone with the posterior projection of an acoustic shadow). The sectioning and ligature of the lateral pedicles with metal pins was performed under real-time guidance.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
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<tbody>
<tr>
<td>Patients (total)</td>
<td>5</td>
</tr>
<tr>
<td>Age (mean)</td>
<td>61 (50-72)</td>
</tr>
<tr>
<td>Clinical stage</td>
<td>T1c (100%)</td>
</tr>
<tr>
<td>Gleason score value</td>
<td>6 (3+3)</td>
</tr>
<tr>
<td>Initial PSA</td>
<td>4-10 ng/dL</td>
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<tr>
<td>Mean surgery duration</td>
<td>4 hours</td>
</tr>
<tr>
<td>Intraoperative hemorrhage (mean)</td>
<td>410 cc</td>
</tr>
</tbody>
</table>

PSA: prostate-specific antigen.

Figure 1 Location of the ultrasound equipment and the ultrasoundographer during the surgical procedure.

Figure 2 Four-way laparoscopic transducer.

Figure 3 Four-way laparoscopic transducer and monitoring position parallel to the neurovascular bundle.
staples was then supervised until the Doppler flow showed there was adequate bilateral pulsing blood flow. During these steps the use of thermal, electrocautery, or ultrasonic energy was eliminated.

In addition, continuous transrectal ultrasound was used during the posterior dissection of the bladder neck, in freeing the rectal wall, and in the dissection of the prostatic apex.

**Results**

The presence of vascular bundles could be demonstrated in all the patients and the prostatic characteristics and periprostatic structures were defined.

This ultrasound equipment employs 2 sophisticated transducers that make it possible to dynamically alternate the transrectal and abdominal images so that the
ultrasonographer and surgeon can select the best angle, thus avoiding interference and noise.

Figure 4 shows the vascular flow of the neurovascular bundle in a sagittal plane, with the transrectal transducer aligned parallel to the bundle.

Figure 5 shows the image projected by the laparoscopic transducer with the presence of the vascular flow of the same pedicle.

Figure 3 shows the position of the laparoscopic transducer in relation to the neurovascular pedicle.

The continuous blood flow was documented with the Doppler function, carefully controlling the nontraumatic dissection of the neurovascular bundles and the subsequent sparing of the nerves, always in the absence of thermal, electric, or ultrasonic energy. Figures 6 and 7 show the bilateral blood flow in both neurovascular bundles after the sectioning of the lateral pedicles and their ligature with metal staples.

The real-time transrectal navigation and monitoring facilitated dissection through visualizing the tip of the laparoscopic scissors, seen as a small hyperechoic zone with the projection of a posterior acoustic shadow outside the prostatic capsule (fig. 8).

Discussion

The use of laparoscopic transrectal ultrasound made it possible to adequately locate the larger vascular structures of the vascular bundles, which in turn enabled the close location of the nerve structures to be inferred. In addition, it greatly facilitated the identification of the periprostatic structures such as the vas deferens, the seminal vesicles, and the posterior surface of the prostate in relation to the rectum, thus aiding in the dissection of and approach to each anatomic plane, always being able to visualize the flow of the vascular structures.

This type of technique, as described in studies reporting on hypoechogenic lesions suggestive of cancer, even in regions where there could be extracapsular disease, helps the surgeon perform a larger dissection in order to obtain disease-free surgical margins. Some studies have also estimated that transrectal ultrasound of the prostate has a positive predictive value of 74% for extracapsular disease.1,2

Through the use of this technique, the oncologic success of the procedure can be improved by performing an anatomic intervention directed in real-time at 2 or 3 different planes, in turn minimizing the damage to the periprostatic structures mainly in the region of the neurovascular bundles and the urethra. This counterbalances the effect of the absence of tactile perception always attenuated and criticized in laparoscopic surgery compared with open surgery, making laparoscopic surgery a safe technique that offers the same success rates that the open and robotic-assisted techniques have in relation to urinary incontinence and erectile dysfunction.

It is important to mention that in our case series, the procedure was only carried out on patients with clinically localized disease that had stage T1cN0M0 disease, and that this technique can also be performed on patients with more advanced or high risk oncologic disease (elevated PSA, higher Gleason scores, or the presence of prostatic nodules) and will offer the benefit of realizing a more extensive dissection directed in real-time through laparoscopy and ultrasonography that is sufficient for obtaining negative surgical margins.2,3

A limitation of the transrectal and laparoscopic ultrasound image is the interference caused by gas, bone and metallic structures, and active hemorrhage. These were causes that conditioned noise in the ultrasound signal, which can lead to an inadequate interpretation of the results or a lack of identification of other structures. We observed this mainly when the perirectal fat was dissected, because there was gas between the Denovilliers’ fascia, causing poor structure visualization.

Some disadvantages of the procedure are the fact that the cost of the ultrasound technique is higher and that the learning curve is acquired by the ultrasonographer intraoperatively mainly with the laparoscopic transducer, because there are presently no similar studies with this transducer.

The ultrasonographic and physical parameters to evaluate have yet to be standardized and some of the important ones to mention are: 1) the length and thickness of the neurovascular bundle, 2) the vascular resistance of each vessel of the neurovascular bundle, 3) the calculation of the distance between the periprostatic hypoechogenic zones in relation to the surgeon’s dissection margin, 4) the amount of hemorrhage permissible in the procedure to avoid the noise signal during measurements, and 5) defining the population of patients in whom the procedure would be beneficial.

Furthermore, the reproducibility and interpretation capacity of the study should be considered, based on each ultrasonographer, in regard to the intraoperative navigation, the comparison with the postoperative definitive result of the previously defined hypoechogenic areas, and with the pre and postoperative histopathologic results.

A larger number of studies with experimental designs are necessary for determining the short, mid, and long-term results in relation to the rates of urinary incontinence, erectile dysfunction, and oncologic control compared with open surgery, robotic-assisted surgery, and traditional laparoscopic surgery.

Conclusions

It was concluded that this is an accessible and easy-to-perform technique that favors better prostatic dissection and the sparing of the neurovascular bundles, thus enabling an improved technical performance by the surgical team. It can also be applied in the different techniques of open surgery and robotic-assisted surgery. This technique cannot yet be defined as the best, given that not enough prospective, controlled, and randomized studies have been conducted and there are still many parameters to be determined for its adequate performance and standardization. In addition, this technique increases the cost of both the procedure and the logistic employment of material and personnel.
Conflict of interest

The authors declare that there is no conflict of interest.

Financial disclosure

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References