Cancer control and the preservation of neurovascular tissue: how to meet competing goals during robotic radical prostatectomy

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OBJECTIVE

To present early functional and oncological data for the athermal trizonal nerve-sparing technique of robotic radical prostatectomy (RP), that addresses the concerns about deviations from the principles of open RP and revisits the anatomical foundations of this surgery from the robotic perspective.

RESULTS

The athermal technique addresses concerns about the use of thermal energy and bulldog clamps during nerve sparing, and emphasizes the importance of the trizonal neural architecture. We analysed the surgical outcomes of 215 consecutive patients from January 2005. The operative duration was 120–240 min and the mean blood loss was 150 mL. In patients potent before RP the potency rate at 1 year after bilateral nerve-sparing was 87%. The overall surgical margin rate was 6.5% and positive margin rates for organ-confined cancer were 4.7%.

CONCLUSION

We describe the athermal technique of robotic RP and introduce the concept of trizonal nerve preservation. The immediate oncological and sexual outcomes were encouraging.
INTRODUCTION

Surgery for prostate cancer (radical prostatectomy, RP) is challenging, with the competing goals of cancer control and maintenance of erection. The surgeon’s ability to develop a precise plane between the nerves and the prostatic capsule is hampered in RP because it is difficult to recognize microscopic invasion of neurovascular tissue by the cancer. These challenges are amplified in robotic surgery, where there is no tactile feedback. Several experts in prostate cancer have voiced concerns about deviating from the principles of open RP during robotic surgery, e.g. about the use of thermal energy during nerve sparing, and the inability to examine the specimen before completing the surgery.

The present study was designed to address these concerns, and included the following broad aims: (i) to revisit the anatomical foundations and to create a neurovascular map related to the steps of robotic RP; (ii) to abstain from using electrocautery and/or bulldog clamps on the neurovascular tissue; (iii) to devise strategies for deciding during robotic RP about the excision of nerve bundles; (iv) to standardise the steps of robotic RP based on the anatomical studies; and (v) to collect data on the oncological and functional outcomes.

To meet these goals, we present the athermal trizonal (AT) nerve-sparing technique of robotic RP [1]. This new technique is unique in several important ways. In particular, it addresses concerns about the use of thermal energy and bulldog clamps during nerve sparing, it incorporates steps to preserve and handle the trizonal neural structures, and it presents a simplified manoeuvre to identify the bladder neck.

PATIENTS AND METHODS

This study was conducted by the Cornell Institute of Robotic Surgery (New York, NY) in close collaboration with the Institute of Urology at the University of Innsbruck in Austria.

The anatomical data for this study were obtained using 10 fresh and two fixed cadaveric dissections at the two institutions. For the cadaver studies, we selected male cadavers, aged >40 years, with no previous pelvic or urethral surgery. Cadavers were frozen <12–36 h after death and stored at −20 °C until dissection. No macroscopic tumours were evident in the abdominal and pelvic regions of these cadavers. The cadavers were dissected using a high-power operating microscope, and they were documented using still and video cameras.

For the studies on patients, the Cornell robotic team visited Innsbruck to perform and standardize the AT technique in 15 patients. The Cornell team then performed 215 consecutive modified AT robotic RPs at the New York centre (between 1 January 2005 and 31 December 2005); all procedures were recorded digitally in three dimensions.

Baseline demographic data were collected prospectively before RP and included age, race, body mass index, serum PSA level, prostate volume, Gleason score, TNM clinical staging, comorbidities, the IPSS and International Index Composite and the IIEF) and were followed at 1, 3, 6 and 12 months after RP.

RESULTS

Relevant neurovascular tissue around the prostate can be grouped into three broad zones: the proximal neurovascular plate (PNP), the predominant neurovascular bundle (PNVB), and accessory neural pathways (ANP) [1]; Fig. 1 shows these regions.

The PNP is an integrating centre for the processing and relay of er ectogenic neural signals; it is lateral to the bladder neck and seminal vesicle, and is closely intermingled with the branches of the inferior vesical vessels. As a result, it can be damaged during posterolateral incision of the bladder neck, lateral dissection of the seminal vesicle and/or mass clipping or cautery of prostatic pedicles.

The PNVB is the classical bundle that carries neuronal impulses to cavernous tissue; it varies in shape and size from the proximal to distal end, and in 65% of cases the PNVB has a medial extension behind the prostate.

The ANP lie within the layers of levator fascia and/or lateral pelvic fascia on the anterolateral or posterior aspect of the prostate. In 35% of cases the ANP form a plexus near the apex. This plexus might serve as a neural pathway for both cavernous tissue and the urethral sphincter.

The prostatic capsule is surrounded by prostatic fascia, lateral pelvic fascia, levator fascia, and finally levator muscles (Fig. 2). Interposed between the prostatic fascia and lateral pelvic fascia are the neurovascular

FIG. 1. The trizonal neural architecture around the prostate comprising the PNP, the PNVB and the ANP. Fresh cadaveric dissection.
tissue and the periprostatic venous plexus, which travel distally to supply the sphincter, urethra and cavernous tissue. These neural fibres usually travel close to the vessels, but occasionally they can travel independently on the surface of the prostate, or laterally on the rectum. Some of these vessels are also subcapsular for a short distance before dipping into the prostatic tissue. Accordingly, excessive blunt dissection of these vessels can create an artificial transcapsular plane, resulting in a capsular incision. Proper nerve-sparing should leave an intact capsule, preferably covered by a ‘safety layer’ of prostatic fascia (and some veins). During aggressive nerve-sparing, a plane is developed deep into the prostatic fascia and veins, which provides maximum chances for potency, but also increases the risk of capsular incision.

**STANDARDIZATION OF TECHNIQUE**

The following modifications in technique were tailored to several factors: specifically, our understanding of trizonal neural architecture, the effect of thermal energy on neural tissue [2], compensatory manoeuvres necessary to operate in a visually rich three-dimensional platform, and the authors’ patient selection protocol for nerve-sparing and wide excision.

The approach can be transperitoneal or extraperitoneal. The retropubic space is developed and the anterior surface of the prostate, endopelvic fascia, apex, and prostato vesical junction are de-fatted. Important landmarks, e.g. puboprostatic ligaments, the arcus tendineus and the prostato vesical junction, are identified.

We sharply incise the endopelvic fascia, leaving the condensed lateral tendon (arcus tendineus) intact. Dissection is kept to a minimum, and a plane is developed either within the lateral pelvic fascia or within the levator fascia. The incision is limited to the proximal third of the prostate, with the distal limit at the sickle-shaped extension of the puboprostatic ligaments (Fig. 3). We avoid over-zealous dissection at all cost, especially avoiding the PNP and periprostatic plexus. The distal plane of dissection must be extended sufficiently to allow for the secure placement of the dorsal venous suture.

**Disconnection of bladder from prostate; ‘the bladder neck pinch’**

In the original description of the bladder neck dissection, surgeons were encouraged to start in the distinct lateral plane demarcated by fat between the bladder and prostate [3]. Unfortunately, such an approach could place at risk the PNP, and vessels of the prostatic pedicle. To prevent this, we use the bimanual bladder-neck pinch technique [4]. A back-bleeding suture is placed on the anterior surface of the prostate and, for traction, a superficial suture is placed on the bladder. Next, robotic forceps and scissors trap the prostate on both sides and pull on the Foley catheter with gentle distal traction, proximally and medially, until the junction of prostate can be identified, with a collapsed bladder. The anterior bladder neck is then incised until the Foley catheter is seen; the catheter is then delivered from the bladder and, finally, the posterior bladder neck is incised (Fig. 4a,b). We take every precaution to preserve the anatomical bladder neck as far as possible, and to avoid injury to the ureteric orifices. The retrotrigonal layer, which is now exposed, is cut to reveal the vasa and the seminal vesicles [5]. Electrocautery is avoided from this point onwards.

**Dissection of vas deferens and seminal vesicles**

Anatomically, the vas and seminal vesicles are enclosed by the retrotrigonal layer anteriorly, neurovascular tissue and prostatic pedicle laterally, rectum and Denovilliers’ fascia posteriorly, trigone and bladder base superiorly, and prostatic base inferiorly. Both the vas and seminal vesicles have their own sheaths and blood supply. We begin the dissection by opening the retrotrigonal layer and exposing the...
anterior surface of the vasa. We next develop
a plane within the sheath and isolate the vasa
proximally, where they are relatively separate
from the seminal vesicles. The vasa are
then grasped, and surrounding vessels are
controlled with 5-mm surgical clips. The
proximal vasa are clipped with haemostatic
clips and divided.

The seminal vesicle sheath surrounds the
vesicles and most of the vessels travel
through the sheath. We thus commence
the dissection by developing the relatively
avascular medial plane and extracting the
vesicles from this sheath. As we come close
to the tip, we bunch together, as a pedicle,
the seminal vesicular blood supply, and
control it with a 5-mm locking clip. To
protect the PNP and vessels lying laterally,
we do this part of the dissection athermally.
Thus we develop small pedicles and control
them with 5-mm surgical clips, or suture
them close to the surface of the seminal
vesicle. Both the seminal vesicles and vasa are
lifted up to expose the posterior surface of the
prostate.

Separation of the prostate from the rectum

In our anatomical dissections we identified
communicating nerve fibres that cross over to
the other side at various levels through the
layers of Denonvilliers’ fascia. These fibres
form a distal plexus behind the apex and
membranous urethra [1] (Fig. 5). We leave
behind a partial thickness of Denonvilliers’
fascia over the rectum in low-risk patients
who are candidates for nerve sparing. This
has not compromised the margin positive
rate in these patients. However, we always
excise the entire fascia in patients who are
not candidates for nerve sparing, have an
abnormal DRE, or whose biopsy shows high-
volume cancer (more than two positive cores
or >22% cancer in each core), a Gleason sum
of 7, or apical cancers.

Control of the prostatic pedicles

The prostatic pedicle includes arteries
and veins entering the prostate, and is
intermixed with the PNP. There are two
distinct components to the prostatic pedicle:
(i) the medial component, which supplies
the base of the seminal vesicles and prostate;
and (ii) the lateral component, which enters
the prostate at its base on the posterior
lateral aspect. The lateral component is the
predominant pedicle, the shape, thickness and
width of which vary, based on the anatomical
variations and size of the prostate.

Traction on the vas and seminal vesicles
causes prostatic pedicles to become more
prominent. When the prostate is lifted
upwards, the medial pedicle is identified
and kept close to the prostate with a clip. We
then focus on the lateral pedicles. Starting
medially, we develop two to four small
pedicles close to the prostate (and control
them with 5-mm clips). This exposes the
undersurface of the prostate and gently
separates the PNP from the dissection
zone. A slight contralateral traction exposes
the few remaining vessels entering the
prostate, which are then clipped and cut
(Fig. 6).

Release of the NVB

When the prostate is freed from the vascular
pedicle it becomes more mobile and can be
rotated to expose the neurovascular triangle.
The neurovascular triangle is a potential
avascular triangle bounded posteriorly by
Denonvilliers’ fascia, laterally by the levator
fascia, and medially by the prostatic capsule
covered by prostatic fascia [6]. Once this
triangular space springs open, the rest of
the dissection becomes very elegant, and is
achieved simply by pushing the prostate away
from the NVBs. Doing so athermally, with
clips, preserves the tissue’s texture, and
prevents coagulation and desiccation.

The extent of the cancer dictates the
positioning of the plane relative to the
prostate. We develop a very close plane
(just on the prostatic capsule) for aggressive
nerve-sparing (intrafascial) (Fig. 7). However,
most typically, we develop a close plane
(outside the prostatic fascia but within the
lateral pelvic fascia) for safe nerve-sparing
(interfascial) (Fig. 8), and in some situations
we develop a plane far from the prostate
(removing a few medial layers of lateral pelvic
fascia on the specimen), allowing for only
partial or incremental nerve-sparing.

Menon et al. [7] elegantly described the extent
of the preserved fascia and enclosed nerves
(Veil of Aphrodite). They recommend that the
incision be quite anterior, to handle those
distal nerves that deviate anteriorly while
destined to continue as cavernous nerves
beyond the pelvic hiatus. Thus in the trizonal
approach we incorporate this recommended
anterior incision. In addition, in patients with

FIG. 5. Posterior dissection; separation of
the prostate from the rectum; the distal apical
plexus is formed posteriorly from cross-communicating
fibres from the NVBs. LA, levator ani.

FIG. 6. Dissection of left NVB.

FIG. 7. Aggressive (intrafascial) nerve-sparing at
the left apex, showing the plane developed on the
prostatic capsule.

FIG. 8. Interfascial nerve-sparing at the right apex,
showing the plane developed between the prostatic
fascia and lateral pelvic fascia.
low-risk cancer, we preserve the retroapical plexus by leaving a distal layer of superficial Denonvilliers’ fascia. These two modifications maximize the preservation of accessory nerves responsible for sexual function. Our AT approach minimizes damage to all three neural zones including the PNP, the PNVB and the ANP.

In robotic surgery, NVBs are usually released antegradely. However in patients with large prostates (>100 g) or wide prostatic pedicles, we initially release the NVBs retrogradely, up to the pedicles. We then release the NVBs antegradely until the prostate is only attached to the body by a clearly defined and controlled pedicle, at which point the prostate is released.

With the prostate freed all around, we embark on distal dissection of the apex. Apical dissection is the most critical step in robotic RP, affecting the apical margin rate, continence and sexual function. There are significant anatomical variations in prostatic apical shape, and in its relationship to the distal sphincter complex, nerves and urethra. Variations in shape can significantly affect the level of membranous urethral transection. Unrecognized variations could either result in apical positive margins or loss of significant urethral length. Our continence preservation technique and associated results were described previously [8].

Examining the RP specimen during RP aids in deciding how to handle the NVB. In three kinds of patients we remove the specimen immediately after apical transection, i.e. those with high-grade cancers, with a preoperative endorectal MRI report of suspicious capsular penetration, and those who have poorly developed planes between the prostatic and lateral pelvic fascia. In all other cases we remove and examine the specimen after the anastomosis. Intraoperative frozen sections are taken of suspicious areas, and if these, or findings on palpation, suggest involvement of the NVB with cancer, we place clips on the NVBs near the base and at the apex, excising them widely.

Table 1 summarizes some of the outcomes in 215 consecutive patients undergoing robotic RP by one surgeon (A.T.) between January and December 2005. The mean age of the patients was 60 years, the operative duration was 120–240 min, the mean blood loss was 150 mL, and 3% required a blood transfusion after RP. The mean haemoglobin and haematocrit at discharge were 13 g/dL and 38%, respectively; the mean (range) duration of catheterization was 7 (4–14) days.

The serum PSA level was <10 ng/mL in 92.5% of patients; 72.6% had a Gleason score of 6 and 4.7% of ≥8 (=47% had a Gleason score of ≤6). There was capsular invasion in 36 patients (17%), perineural invasion in 104 (48%), and high-grade prostatic intraepithelial neoplasia in 55 (26%). Surgical margins were positive in 14 patients (6.5%) and there were 16 positive margins. There was PSA recurrence in 7% of patients overall. In all, 182 patients (85%) had bilateral nerve-sparing using the AT technique, 24 (11%) had incremental nerve-sparing and another nine (4%) had wide excision. Of patients aged <70 years who were potent before RP (Sexual Health in Men score >22) and who had bilateral nerve-sparing surgery, 87% (89/102) were potent at 1 year after RP.

**DISCUSSION**

We describe the AT robotic technique of RP and introduce the concept of trizonal nerve preservation. The early functional and oncological outcome data are encouraging.

**CONFLICT OF INTEREST**

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REFERENCES

1. Tewari A, Takenaka A, Mtui E et al. The proximal neurovascular plate and the tri-zonal neural architecture around the prostate gland: importance in the athermal robotic technique of nerve-sparing prostatectomy. BJU Int 2006; 98: 183–7


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Abbreviations: RP, radical prostatectomy; PNP, proximal neurovascular plate; (P)NVB, (predominant) neurovascular bundle; ANP, accessory neural pathways; AT, athermal trizonal; IIEF, International Index of Erectile Function.