Cadaveric dissection for the rectal surgeon

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The benefits of total mesorectal excision are due to the complete excision of the mesorectum with preservation of the pelvic autonomic nerve plexuses, the hypogastric nerves and nervi erigentes. Several important structures are incompletely seen at operation, and cadaveric dissection of an intact lower trunk and a sagittally hemisected pelvis is a valuable exercise in demonstrating them. A method for dissection is described which illustrates the key anatomical points.

Key words: Autonomic nervous system – Rectal neoplasms – Dissection – Human – Rectum – Sacrum

Over the last few years there has been increasing interest in and a certain amount of debate over total mesorectal excision (TME) in the management of rectal carcinoma. The key to the operation is the complete excision of the mesorectal package with preservation, where possible, of the hypogastric nerves, nervi erigentes and the inferior hypogastric plexuses and their branches. The nerves can serve as markers for the limits of resection, and their conservation minimises postoperative sexual and urinary dysfunction. The surgical technique is described in detail elsewhere.¹²

The pelvic autonomic nerves are often incompletely seen at operation, and the attainment of the correct plane between them and the mesorectum depends on a good knowledge of pelvic anatomy. This has been elucidated in detail over the last 70 years, and there are good descriptions of the autonomic nerves of the pelvis,⁷⁸ the vessels⁷ and the fascial planes.⁵⁹ We aim to simplify a confusing terminology, and describe a technique for cadaveric dissection of the pelvis that demonstrates the important anatomical points.

Patients and Methods

One intact male cadaver, and six half pelvis, one female and five male, were used for dissections of varying depth. Each cadaver was initially preserved by injection of embalming fluid into the femoral artery. The half pelvis extended from the lowermost intervertebral disc to upper femur and were sectioned sagittally in the midline. The specimens in Figures 1, 2 and 5–7 were immersed in 100% alcohol for 2 weeks to soften the tissues, in particular the fatty component, then rinsed.

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Figure 1 (A,B) Nerves around the inferior mesenteric artery

Figure 2 (A,B) The superior hypogastric plexus.
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Figure 3 (A, B) Superficial dissection of the retrorectal space.

Figure 4 Deeper dissection of the retrorectal space.

Figure 5 Window through the rectal lumen onto the inferior hypogastric plexus.

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Figure 6 (A, B) Lateral rectal ligament branches and the bundle to the corpora cavernosa.

Figure 7 (A, B) Neurovascular bundle to the corpora cavernosa, with a section cut from the prostate. The arrow points to the posterior part of the plexus.
and maintained in formalin-free, alcohol-rich fluid. In our experience, this makes it easier to tease out the nerves but makes the fascial planes more difficult to identify.

Results

As an aid to understanding the anatomy of the pelvis, dissection of a sagittal hemisection has several advantages compared with the surgical approach. It provides good access, allows orientation by sacral segment, and shows the retrorectal space well. However, the superior hypogastric plexus and planes at the pelvic brim are best demonstrated in an intact trunk.

**Intact trunk**

In Figure 1, removal of the anterior abdominal wall, the small bowel and mesentery and the proximal colon reveals the aorta and the origin of the inferior mesenteric artery. Between superior and inferior mesenteric arteries the abdominal aortic plexus is found by stripping off the peritoneum. It lies in the subperitoneal connective tissue and consists of thin bundles of nerves lying on either side of the aorta. These are sympathetic fibres arising from the thoracolumbar centre between T_{10} and L_{2}. The nerves course around the inferior mesenteric artery to form the inferior mesenteric plexus, continuing into the superior hypogastric plexus just below the aortic bifurcation. Traction anteriorly on the inferior mesenteric artery tents these fragile nerves, and shows how easily they might be damaged in a 'flush tie'. Dissection of the connective tissue that surrounds the superior hypogastric plexus and inferior mesenteric artery at the pelvic brim shows the proximity of these two structures. The surgical plane must be just posterior to the artery to avoid damage to the nerves.

In Figure 2 the superior hypogastric plexus is identified at the pelvic brim. Traction anteriorly on the rectum now creates a retrorectal space filled with loose areolar tissue, easily broken down by careful blunt dissection with a finger. On enlarging this space, the hypogastric nerves are usually more adherent to the visceral fascia covering the mesorectum than the pelvic sidewall, and lie anterior to the retrorectal space. Dissection inside the plane of the nerves as in TME is still relatively easy but in the cadaver requires sharp rather than blunt dissection. At this stage it is easy to see how the hypogastric nerves may be cut by surgical dissection at the pelvic brim unless they are seen and preserved. Opening the retrorectal space distally, the nervi erigentes (the sacral parasympathetics arising from sacral roots S_{2}, S_{3}, and S_{4}) may be seen crossing it, and it may be possible to demonstrate a middle rectal artery arising superior and anterior to them. These two structures are easier to find if the reader has already dissected a sagittally hemisected pelvis, as described below.

**Sagittally hemisected pelvis**

As shown in Figure 3, gentle traction anteriorly on the rectum again produces a space between the pelvic sidewall and mesorectum, the retrorectal space, filled with some loose areolar tissue. Already it is possible to see the hypogastric nerve descending in the visceral fascia as it moves laterally from the superior hypogastric plexus like one limb of a wishbone, 2 cm below and parallel to the ureter. On the left it can be found just deep to the vessels in the sigmoid mesocolon as they descend over the pelvic brim. Freeing the nerve should be left until the dissection is more advanced.

In the midline at the level of S_{2} there is almost always a fascial connection between mesorectum and sacrum, thicker than the loose tissue in the rest of the retrorectal space, and dividing it in the midline into an upper and lower part. This is the rectosacral fascia, which becomes weaker and then disappears laterally after 1–2 cm. The retrorectal space is limited inferiorly by the fusion of parietal and visceral fasciae over the anococcygeal ligament.

Cutting the rectosacral fascia and opening the retrorectal space laterally (Figure 4) reveals the nervi erigentes, with the S_{3} component usually largest. Crossing the space laterally, they are tented up by medial traction on the rectum. They arise from the anterior sacral foraminae, deep to the true parietal fascia that covers the pelvic surfaces of the muscles lining the pelvic cavity. They then run for 3 cm or so anterolaterally beneath the parietal fascia before turning medially to join the inferior hypogastric plexus, which is not yet visible. Here they cross the parietal fascia and the retrorectal space and take with them an ensheathing layer of parietal fascia. The nerve to levator ani may also be seen, arising from S_{2} and S_{3} with the nervi erigentes, but remaining all the time behind the parietal fascia, and running caudally rather than laterally.

In Figure 5, the inferior hypogastric plexus is easily identified by removing a window of rectal wall, and then careful dissection down through the mesorectum at the level of S_{2} to reveal the tough plexus of nerves, running caudally and laterally.

Reflecting the surgical approach, the rectum and Denonvilliers fascia are now stripped from the seminal
vesicles or vagina and uterus, with the initial incision through the peritoneal reflection. In the male cadaver, it is possible to separate the rectum and a smooth layer of Denovillier’s fascia from the seminal vesicles, but at the apex of the prostate Denovillier’s fascia becomes adherent to rectourethralis, and the surgical plane is usually just behind it.

To demonstrate the limits of the rectorectal space, place a finger in the space posteriorly and sweep it circumferentially around the mesorectum. Moving laterally and caudally, the space ends over the anterior branches of the internal iliac artery as they move medially and caudally to supply the pelvic viscera, forming with their ensheathing fascia what Uhlenhuth called the ‘hypogastric root’. It is this ‘root’ that prevents a finger in the rectorectal space from passing anteriorly into the space of Retzius. Medial to the root, lying against the anterior rectum and the seminal vesicles or upper third of the vagina, is the inferior hypogastric plexus. It lies in a plane just medial to the vascular structures.

From above, the hypogastric nerve is freed from mesorectum and pelvic side wall down to the level of the plexus (Figure 6). The nerve is usually plexiform and lies on the fascia that surrounds the ureter and the vessels of the pelvic side wall. The terminology of this fascia is the source of considerable variation and is variously called the presacral fascia, the hypogastric sheath or the ureterohypogastric fascia (Sato and Sato, unpublished). The plexus is revealed as a matted rhomboid structure, of dimensions 4 cm x 2.5 cm, lying almost in the sagittal plane lateral to the rectum. In the male, a useful marker for its mid point is the tip of the seminal vesicle. The nervi erigentes have already been identified and can be further revealed by dissection deep to the parietal fascia. This also reveals the vessels of the pelvic wall, and it is often helpful to remove the thin-walled and variable veins that lie superficial to the sacral plexus. A third, less significant input to the inferior hypogastric plexus is the sacral sympathetic trunk, a continuation of the lumbar sympathetic trunk, lying medial to the anterior sacral foraminae and sometimes giving very thin branches that run to the plexus roughly in parallel with the nervi erigentes.

Laterally, the inferior hypogastric plexus is tethered by virtue of its origin within the fascia on the side wall of the pelvis. Medially it is tethered by its branches. The more cranial, posterior portion of the plexus is the more mobile part, lying against the mesorectum and tethered to it by the lateral rectal ‘ligament’.

The lateral ‘ligament’ lies between the mesorectum and the inferior hypogastric plexus. It consists of the rectal branches from the plexus, connective tissue and in approximately 25% of patients one or more vessels. If sharp dissection is used with minimal tension in the surgical plane inside the plexus, nothing as substantial as a ligament is cut. However, traction medially on the rectum tents the plexus inwards, producing a ‘ligament’ and showing how easy it is to ‘cut the top off’ the plexus during TME.

Continuing this dissection more caudally shows the inferior hypogastric plexus fanning out to supply the viscera (Figure 7). In the male, its most posterior and caudal part continues as the nerve supply to the corpora cavernosa, running in the groove between rectum and prostate in a neurovascular bundle. This bundle lies 1.5–3 mm posterolateral to the prostate capsule and continues distally to the apex of the prostate to enter the deep perineal pouch posterolateral to the membranous urethra. It is easy to see how it could be damaged in both radical prostatectomy and in rectal surgery. Cutting a transverse section from the prostate, initially within its capsule, re-inforces the impression of a bundle and clarifies its position. Mundy has written a detailed description of the plexus and its branches in the female pelvis.

Laterally, the connective tissue between inferior hypogastric plexus and pelvic wall can be removed starting in the angle between hypogastric nerve and nervi erigentes. The resulting space is free of any major structures and the posterior part of the plexus is now free but for the nerve fibres leading to it (see large pink arrow, Figure 7). At operation, therefore, there are two virtually bloodless planes: one medial to the plexus and one lateral to it. It is in the lateral plane that many Japanese surgeons perform nerve-preserving pelvic lymphadenectomy for rectal cancer.

Exploration of the branches of the internal iliac artery shows the internal pudendal artery running down towards the greater sciatic notch, and perhaps a middle rectal artery arising from it, around 2 cm anterior and cranial to the origin of the nervi erigentes. This will then run near to or through a distal part of the plexus, and almost tangentially to the rectum for around 5 cm, before entering it with nerve branches. It may be possible to find further vessels supplying the rectum more distally and anteriorly, near levator ani.

Cutting the lateral ligament and removing the rectum as in TME is not usually necessary, and leaves a less informative specimen for reference.

Discussion

Dissection of the autonomic nerves of the pelvis demonstrates several anatomical relationships that may not be
well seen during TME until they have been recognised and understood by cadaveric dissection.

1. The sympathetic fibres that run to the superior hypogastric plexus lie in the subperitoneal connective tissue on each side of the aorta. They are closely related to the inferior mesenteric artery, and tented by anterior traction on it.

2. As the hypogastric nerve descends from the superior hypogastric plexus it may be adherent to the visceral fascia over the mesorectum. Unless it is seen and protected, it is vulnerable during surgical dissection in the retrorectal space at and below the pelvic brim.

3. In the midline posteriorly, the surgical plane is the almost bloodless retrorectal space. Crossing it is the rectosacral fascia, which must be cut to avoid 'coning' into the mesorectum.

4. The nervi erigentes cross the retrorectal space laterally, and together with the inferior hypogastric plexus, are tented by medial traction on the rectum. These structures are thus vulnerable during sharp dissection in the surgical plane.

5. Where the inferior hypogastric plexus is related to the mesorectum, there are two potentially bloodless planes around it: the surgical plane between rectum and plexus, and a plane between plexus and lateral pelvic wall.

6. In the male, the neurovascular bundle to corpora cavernosa runs close to the rectum and prostate, and is vulnerable in both anterior resection and radical prostatectomy.

The dissection described above is painstaking, but it is possible to dissect a trunk in 2–3 h, and a sagittally sectioned pelvis in 4–10 h. It enables the surgeon performing TME to appreciate the anatomy of the operation, and it leaves an informative specimen.

Acknowledgements

The authors thank Mr Colin Binch at the Department of Human Morphology, University of Nottingham, and Mr John Davies at the School of Biological Sciences, University of Manchester, for their help in preparing the specimens.

References