

## COMMUNICATION

# Anatomy of the vesicovaginal fascia and its relation to branches of the inferior hypogastric plexus

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**Abstract**

The inferior hypogastric plexus (IHP) lies in the extraperitoneal pelvis, and supplies branches to pelvic and perineal viscera. In men, the rectoprostatic fascia (Denonvillier's fascia) forms a distinct double fascial layer between the seminal glands and the rectum. The hypogastric nerve projections to the prostate and seminal glands run anterior to this. An analogous fascial layer in women between the vagina and cervix posteriorly and the urinary bladder anteriorly has recently been described. The purpose of this study was to examine the anatomy of the vesicovaginal fascia (VVF) and to determine its relationship to the anterior branches of the IHP. This dissection study examined the fascial layers between the posterior urinary bladder and anterior vagina/cervix (VVF) in 15 female embalmed cadavers and three fresh specimens. Anterior branches of the IHP were identified and followed distally. The relationship between these nerve projections and the VVF was examined. In 16 dissection, the VVF was identified as a complete fascial plane extending beneath the vesicouterine pouch to the neck of the bladder inferiorly and to the endopelvic fascia laterally. Anterior projections from the hypogastric nerves and IHP maintained an extraperitoneal course passing anteriorly to the VVF towards the urinary bladder. The VVF is a distinct fascial structure and projections of the hypogastric nerves pass anterior to this. This may have implications for nerve sparing hysterectomy.

**KEYWORDS**

Denonvilliers' fascia, hypogastric nerves, hysterectomy, rectoprostatic fascia, vesicovaginal fascia

## 1 | INTRODUCTION

The pelvic autonomic nervous system comprises the superior and inferior hypogastric plexuses (IHP). The superior hypogastric plexus represents the pelvic extension of the abdominal sympathetic system. It is formed from the aortic and inferior mesenteric plexuses and divides into the left and right hypogastric nerves. The IHP is a mixed (sympathetic and parasympathetic) ganglionated plexus. It is a site of

convergence of preganglionic and visceral afferent axons projecting in the hypogastric nerves and pelvic splanchnic nerves, and postganglionic vasoconstrictor axons from the sacral sympathetic chain. The IHP lies in the extraperitoneal plane of the pelvis and supplies branches to the pelvic viscera as well as erectile and glandular structures in the perineum. Pelvic surgery carries a risk of injuring these autonomic nerves, which may lead to bowel, urinary bladder, or sexual dysfunction post-operatively.

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In males, the rectoprostatic fascia (Denonvilliers' fascia) forms a distinct double fascial layer between the seminal glands and the rectum. The hypogastric nerve projections to the prostate and seminal glands run in the plane anterior to the rectoprostatic fascia and dissection anterior to this fascial layer is associated with a higher rate of sexual dysfunction (specifically ejaculatory dysfunction) due to injury to these nerves (Heald et al., 2004; Lee & Kim, 2018; Lindsey & Mortensen, 2002).

Ghareeb et al. (2018) performed detailed dissections of the rectoprostatic fascia and hypothesized that embryologically analogous fascial planes would be present in females. They described a fascial layer between the anterior aspect of the vagina and cervix and the base of the urinary bladder which extended supero-anteriorly from the posterior urinary bladder neck along the superior surface of the urinary bladder. Our study examined the anatomical relationship of this fascial layer (vesicovaginal fascia [VVF]) and the anterior nerve projections from the IHP. We postulated that these nerve branches would run anterior to the VVF (analogous to the relations of the nerve fibers to the rectoprostatic fascia in men).

Therefore, the purpose of this study was to examine the anatomy of the VVF to determine whether the findings of Ghareeb et al. (2018) can be replicated, and to investigate the relationship between this fascial plane and the anterior branches of the IHP.

## 2 | MATERIALS AND METHODS

This dissection study examined the vesicovaginal space in 15 female embalmed donor cadavers and three fresh frozen donors aged between 59 and 102 years at the time of death. Donors with evidence of prior pelvic surgery or significant pelvic pathology were excluded from the study. The anatomical embalming fluid used in the embalming process contained <2w/w% formaldehyde. Donor bodies used in this project were obtained from the Donor Body Programs at the University of Melbourne and the University of Adelaide. All donors had consented to the use of their body for educational and research purposes. This project has human research ethics approval from Ray Last Laboratories at Adelaide University, the Human Ethics committees at Deakin University (Ethics ID:DS03528) and The University of Melbourne (Ethics ID: 14667).

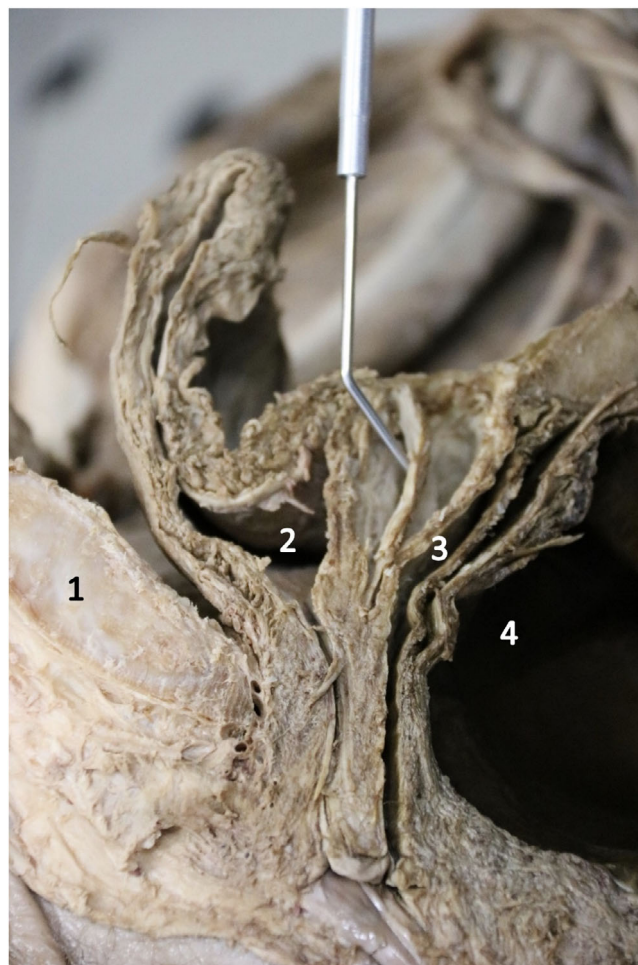
The dissections were performed by a colorectal surgeon (D. Stupart) and two anatomists experienced in dissection procedures (C. Briggs and K. Pickles). The initial dissection was performed on a hemisected pelvis and in this case, each half of the vesicovaginal region was explored laterally from the midline. Seventeen subsequent dissections were performed on whole pelvis commencing at the base of the vesicouterine pouch. The fascia of the vesicovaginal region was explored by dividing the peritoneum at the lowermost point of the vesicouterine pouch and dissecting inferiorly against the anterior aspect of the cervix of the uterus and vagina. A distinct fascial layer was able to be identified in this manner. Returning to the lowermost point of the vesicouterine pouch, a second dissection was subsequently performed anterior to this fascial layer and posterior to the

base of the urinary bladder. The dissections extended inferiorly towards the urinary bladder neck and laterally to the endopelvic fascia of the lateral pelvic walls.

Once the fascial layers were identified, the left and right hypogastric nerves were located on the posterior wall of the pelvis and their path traced distally to the IHP. The relationships of the branches of the hypogastric nerve and anterior projections of the IHP to the exposed fascial planes were examined and documented. Tissue samples were obtained during two of the dissections. These were preserved in paraffin for detailed histological analysis at a later stage.

## 3 | RESULTS

In the 18 dissections performed, a distinct fascial plane (the VVF) was identified extending inferiorly below the peritoneum of the vesicouterine pouch to the neck of the urinary bladder (Figure 1). In each of these dissections, this was a distinct fascial layer that was able to be separated from the posterior aspect of the urinary bladder and the anterior vaginal wall. In 16 dissections, this fascial layer extended



**FIGURE 1** Right hemisected pelvis dissection with probe indicating vesicovaginal fascia below peritoneum of vesicouterine pouch. One pubic bone; two bladder; three vagina; four rectum

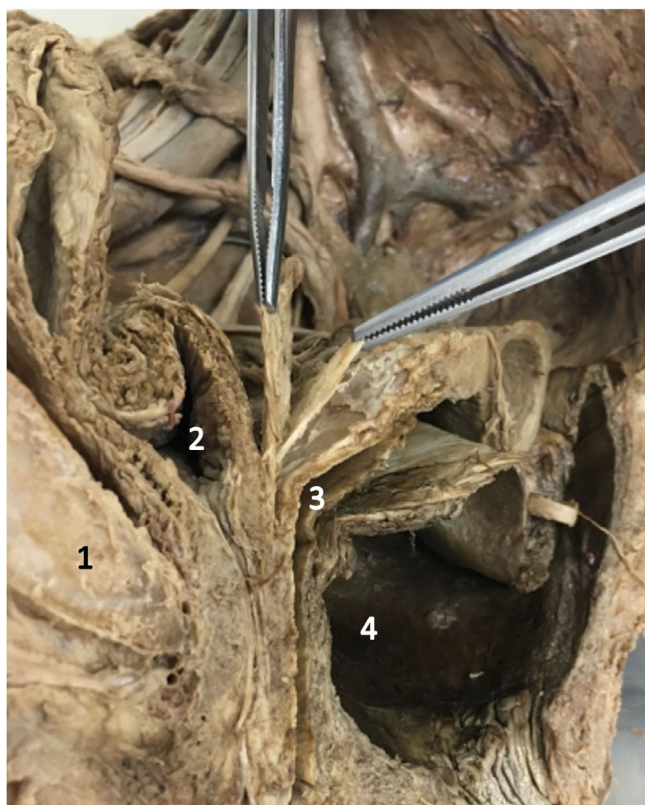
transversely to blend with the endopelvic fascia of the lateral pelvic walls bilaterally. Superiorly the VVF appeared continuous with the inferior aspect of the peritoneum at the base of the vesicouterine pouch.

In three dissections, (two embalmed, one fresh tissue) a double fascial layer was demonstrated within this region. In these three dissections the separate fascial layers were detached from the urinary bladder anteriorly and cervix/vagina posteriorly (Figures 2 and 3). A clear plane was apparent between these two layers with no neurovascular structures visible passing between these two layers of fascia.

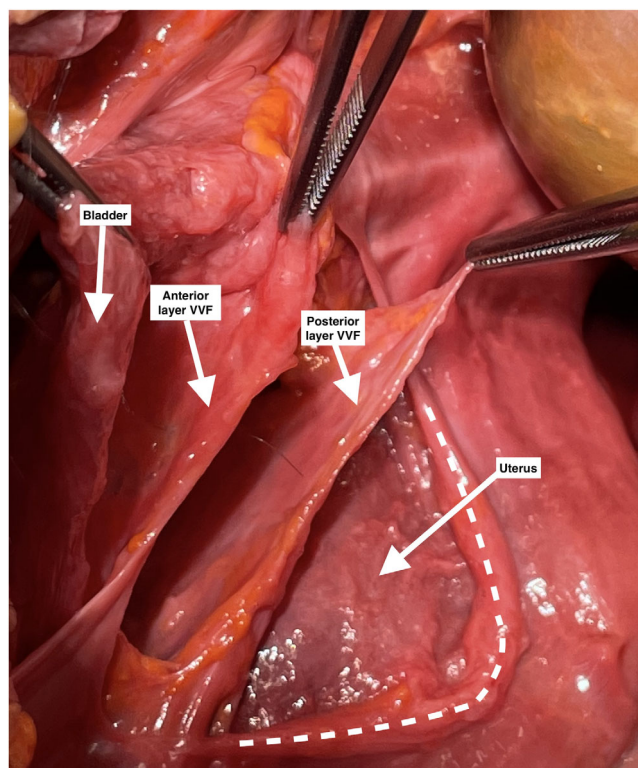
Of the 18 dissections performed, there were two in which the VVF was not identified across the entire width of the vesicovaginal region. In one instance, tissue was excised from the left vesicovaginal region en bloc with part of the urinary bladder and uterus for histological examination, preventing the delineation of the entire fascial layer. In the second instance, the fascial layer was identified on the right, but was fused with the anterior vagina in the midline and unable to be distinguished on the left side.

After identifying the fascial structures present in the plane between the cervix/vagina and urinary bladder, anterior fiber projections from the IHP were distinguished and their anatomical relationship to the VVF recorded. Projections from the plexus were first traced to the intersection of the uterine artery and ureter. As described by Mauroy et al. (2007) some of these nerve bundles appeared to pass

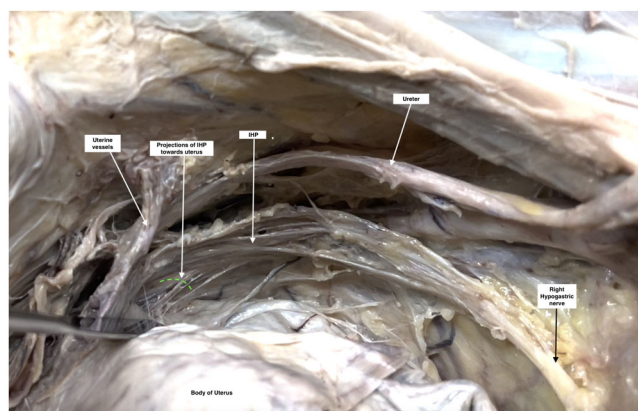
with the uterine artery towards the lateral aspect of the uterus, posterior to the VVF (Figure 4). However, other neurovascular structures were closely associated with the ureter and followed an extraperitoneal course towards the urinary bladder. These bundles passed anterolateral to the attachment of the VVF layer in close relationship to the ureter (Figure 5). This arrangement was visualized bilaterally in 12 of the 18 whole pelvis dissections. In all the remaining six dissections demonstrating the VVF, a similar arrangement was only clearly visualized unilaterally. This was due to a variety of causes including the presence of



**FIGURE 2** Further dissection of fascia shown in Figure 1. Illustrating anterior and posterior layers of vesicovaginal fascia held by forceps. One pubic bone; two bladder; three vagina; four rectum

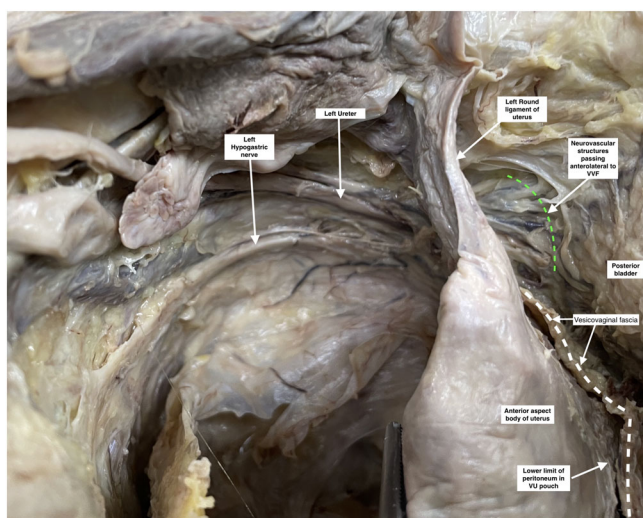


**FIGURE 3** Dissection of fresh frozen tissue showing anterior and posterior layers of vesicovaginal fascia. Dashed line indicates cut edge of peritoneum at base of vesicouterine pouch



**FIGURE 4** Right pelvic wall. Dissection of embalmed tissue illustrating projections of the IHP beneath uterine vessels





**FIGURE 5** Left pelvic wall. Dissection showing neurovasculature passing anterolateral to broad ligament and vesicovaginal fascia (VVF) (dashed line) towards bladder

adhesions, enlargement of pelvic veins, tissue sampling techniques, and refinement of dissection technique throughout the course of the study.

## 4 | DISCUSSION

In this study of 18 female cadavers, the VVF was consistently identified as a distinct and robust fascial structure. In 16 dissections, this layer was found beneath the peritoneum, extending transversely between the posterior aspect of the urinary bladder and urinary bladder trigone, and the anterior wall of the vagina and cervix. This fascial layer extended laterally to blend with the endopelvic fascia. In three dissections, the septum was demonstrated as two distinct layers of fascia which appeared to be continuous with the inferior aspect of the peritoneum of the vesicouterine pouch. In these dissections, the plane between these two layers did not appear to contain neurovascular structures.

The distinct layer of VVF found in our dissections appears consistent with the layer of fascia described and illustrated by Ghareeb et al. (2018). In their study, dissection of five female cadavers exposed a fascial layer extending from the posterior urinary bladder neck to the superior surface of the urinary bladder and it was considered that this fascial layer corresponded to a fascial layer found within the prerectal space of the male. Histological analysis of the tissues within the vesicovaginal region of 10 female cadavers was performed by Hinata et al. (2014). In their study, this tissue was described as the pubocervical fascia rather than the VVF. These histological studies found this tissue to be inconsistent in the midline, but laterally identifiable as a rough fibrous network of thick fiber bundles which did not contain smooth muscle fibers. (Hinata et al., 2014). In a schematic representation of their work, Hinata et al. (2014) illustrated the pubocervical fascia as joining with the rectovaginal septum lateral to the vagina and attaching to the tendinous arch of pelvic fascia on the

lateral pelvic wall. This description of the pubocervical fascia supports the dissection findings of the VVF described in our study.

In another study of this region, Kostov et al. (2020) described the region between the urinary bladder and the vagina as the vesicovaginal space—one of nine avascular spaces in the female pelvis. Considering that two of the dissections in our study found the VVF to be a double layer of fascia, it may be possible that the avascular space described by Kostov et al. (2020) correlates with the apparently avascular plane found between these two layers. Greater clarification for this layered arrangement is needed and will require further histological studies. However, correlating each of these earlier studies with our findings provides good evidence for recognizing the presence of a distinct fascial layer between the urinary bladder and vagina/cervix.

Having determined the presence of the VVF, the second aspect of our dissection study was to examine the relationship of this fascial layer to the surrounding neurological structures. After dissecting out the VVF, we traced the anterior projections of the hypogastric nerves and IHP in relation to this fascial layer. Nerve bundles identified at the point of intersection of the uterine artery and ureter were followed anteriorly. In all 18 dissections, we were able to visualize nerve bundles passing anterior to the VVF and coursing towards the urinary bladder with the ureter on at least one side of the pelvis. In 12 of the dissections, this was demonstrated bilaterally. Posterior to the VVF, nerve bundles passing to the uterus with the uterine artery were observed. In the three dissections where the VVF was found to be formed from two layers, neurovascular structures were not observed passing between these layers.

Several other studies have examined the anatomy of the pelvic nerves in this region; however, they have not described these in relation to the VVF (Baader & Herrmann 2003; Mauroy et al. 2007; Aurore et al., 2020; Diaz-Feijoo et al., 2021). A dissection study by Muallem et al. (2020) examined the relationship of the pelvic autonomic nerves to the fascia of the paracolpium in 19 female pelvis. In their study, the pubocervical fascia was described as synonymous with the endopelvic fascia and detailed as extending from the symphysis pubis to the lateral aspect of the rectum. This study did not examine the fascial layers between the vagina and urinary bladder (VVF) but highlighted the relationship of the endopelvic fascia to the nearby IHP. The importance of the anatomy of this region during nerve sparing radical hysterectomy (RH) procedures has been emphasized by others. (Muallem et al., 2020; Yamaguchi et al., 2011). Yamaguchi et al. (2020) illustrated the proximity of the nerves to the urinary bladder in this region of the female pelvis. Their dissection of seven female pelvis showed nerve branches from the IHP passing to the urinary bladder. Additional branches were visualized extending directly from the hypogastric nerves and running with the ureter to reach the urinary bladder trigone. Therefore, after exploring the anatomy of the VVF and examining the relationship of the hypogastric branches to the VVF we suggest that this fascial layer may be of importance during nerve sparing gynecological procedures.

RH is associated with long-term urinary bladder dysfunction in up to 85% of patients (Danford & Wu, 2017; Ripperda et al., 2017; Zullo et al., 2003). Sexual dysfunction has been reported in up to 65% of

women undergoing RH (Jensen et al., 2004; Serati et al., 2009), although there is a great deal of variation in the published literature, reflecting the multifactorial nature of sexual dysfunction (physical, psychological and social) and a lack of universally accepted or validated tools for assessment of female sexual function (Lonnée-Hoffmann & Pinas, 2014).

During hysterectomy, the IHP is recognized to be at particular risk of injury during transection of the utero-sacral ligament, and during lateral dissection of the upper vagina. In order to reduce this risk, the technique of nerve-sparing RH (NSRH) has been introduced. This technique was first described in Japan by Kobayashi in the 1930's and has been refined and adopted by multiple centres worldwide (Charoenkwan, 2010; Fujii et al., 2007). In the case of simple hysterectomy as performed for benign disease, the lateral (extraperitoneal) dissection of the pelvis is not routinely performed. Even in this setting, however, post-operative sexual and urinary bladder dysfunction has been reported (Lonnée-Hoffmann & Pinas, 2014; Thakar et al., 1997). One possible cause for this is injury to the hypogastric nerve branches to the urinary bladder and external genitalia as they run between the cervix/upper vagina and the urinary bladder. A systematic review and meta-analysis of all studies comparing standard RH with NSRH, focusing on urinary bladder and sexual function, was published by Xue et al. (2016). Only three of the 20 studies included in this meta-analysis were randomized, and only two of the studies measured sexual dysfunction (one of which was randomized). Bearing this caveat of suboptimal quality of evidence in mind, however, the overall finding that there was less urinary bladder and sexual dysfunction in patients who had undergone NSRH compared with standard RH (and importantly with equivalent oncological outcomes) appears to be robust and was a consistent finding across the included studies. Despite these findings, NSRH has not been universally accepted as the standard technique for RH. The procedure is technically demanding, and the NSRH as described by Kobayashi is an extremely radical resection of questionable utility in the current era where the large cervical tumors requiring this type of surgery are usually treated with radiotherapy (Hopkins & Schnettler, 2007).

Proponents of NSRH have described the relevant anatomy of the hypogastric nerves and IHP in females in great detail. Another particularly meticulous dissection and description is by Fujii et al. (2007). The key surgical anatomical details they emphasize include: identifying the hypogastric nerves in the pararectal and paravesical spaces after division of the uterine artery; the close relationship of the deep uterine vein anterior to the pelvic splanchnic nerve branches; the nerve branches from the IHP to the urinary bladder deep to the inferior vesical vein; preservation of the urinary bladder branches of the IHP. They did not, however, provide any detailed anatomical descriptions of the course of the terminal branches of the IHP anterior to the cervix and vagina, or any specific surgical techniques aimed at preserving the nerves at this level.

Our findings suggest that it may be possible to avoid or minimize injury to the anterior branches of the IHP passing towards the urinary bladder by identifying the VVF and deliberately dissecting posterior to it. Histological analysis will assist in further clarifying the layered arrangement of this fascia. Tissue samples have been retained for this

purpose and the results of this analysis will be published on completion of the current studies.

In conclusion, in the 18 dissections performed in this study, the VVF was found to be a distinct fascial structure. Anterior projections of the hypogastric nerves and IHP extending towards the urinary bladder appear to travel anterior to this fascial plane, analogous to the rectoprostatic fascia in males. This may have implications for nerve sparing when performing a hysterectomy.

## ACKNOWLEDGMENTS

The authors sincerely thank those who donated their bodies to science so that anatomical research could be performed. Results from such research can potentially increase mankind's overall knowledge that can then improve patient care. Therefore, these donors and their families deserve our highest gratitude (Iwanaga, J. et al. 2021). We also thank Professor Janet Keast and laboratory staff from the University of Melbourne and Deakin University for their assistance during this project.

Open access publishing facilitated by Deakin University, as part of the Wiley - Deakin University agreement via the Council of Australian University Librarians.

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**How to cite this article:** Stupart, D., Pickles, K., & Briggs, C. (2022). Anatomy of the vesicovaginal fascia and its relation to branches of the inferior hypogastric plexus. *Clinical Anatomy*, 35(7), 855–860. <https://doi.org/10.1002/ca.23858>