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The progress of dorsal vascular complex control strategy in radical prostatectomy

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Abstract

Radical prostatectomy has undergone a development from open to laparoscopic surgery to a surgical robotic approach. With improved surgical equipment and the continuous development of surgical techniques, various surgical strategies for controlling the dorsal vascular complex (DVC) during RP have been investigated, which affect intraoperative blood loss, postoperative tumour control and postoperative urinary and sexual function. The present narrative review summarizes the latest anatomical information about the prostatic apex and DVC and then describes the three types of DVC control. More detailed anatomy of the DVC is required and the optimal DVC control under different situations needs further research.

Keywords

Radical prostatectomy, dorsal vascular complex, blood loss, positive margin, urinary control

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Introduction

Radical prostatectomy (RP) is one of the main treatment modalities for localized prostate cancer after a comprehensive consideration of the patient's life expectancy and health status. As one of the key steps during RP, the efficient control of the dorsal vascular complex (DVC) has emerged in a variety of ways without recommendations from international guidelines (e.g. European Association of Urology guidelines)

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because of the lack of any comparative (prospective and retrospective) studies.[1] Initially, sutures of the DVC were used to control intraoperative blood loss and to ensure surgical safety.[2] However, with the deepening of the anatomical study of the prostatic apex and DVC, researchers found that the DVC not only contains venous vessels, but also contains nerve and muscle fibres.[3] The function of the DVC requires further investigation. At present, urologists consider not only the control of blood loss, but also the recovery of quality of life in patients, such as postoperative urinary control function and sexual function, when managing the DVC. This current narrative review of the published literature summarizes the research progress made with regard to the DVC control strategy, which plays an important role in intraoperative blood loss, functional and oncological outcomes.

Literature search

A search of the electronic databases PubMed®, EMBASE and Cochrane Central Register of Controlled Trials was undertaken using various combinations of the Medical Subject Headings (MeSH) for 'prostatic neoplasms', 'prostatectomy', 'anatomy', as well as the non-MeSH terms 'radical prostatectomy', 'prostate cancer surgery', 'dorsal vascular complex', 'dorsal vein complex', 'outcome' and 'function'. Studies were indexed between 1 January 1970 and 31 October 2021. There was no limitation on the publication language. Following the literature search, all duplicates were excluded and the retrieved publications were subject to initial assessment of the title or abstract. To ensure comprehensive coverage, references from included studies, review articles, editorials, commentaries and conference publications were reviewed and cross-referenced. The computerized search was executed by two investigators independently (Y.W. and X.C.). Any discrepancy was resolved by consensus, with the participation of a third investigator (Q.X.).

Evidence summary

Anatomy of the DVC

The DVC is located between the puboprostatic ligaments on both sides, the deep surface of the visceral intrapelvic fascia and the outside of the prostatic capsule. The superficial layer of the DVC is the superficial prostatic vein, which can be divided into four variants: a single superficial vein, a superficial vein with left and right branches, a superficial vein with multiple fine branches and the presence of no superficial veins.[4] The first of these variants is the most common, accounting for approximately 60%.[4] The deep layer of the DVC is the prostatic venous plexus and there is communication between the two at the apex of the prostate.[3] The DVC collects venous blood from the dorsal penile vein, internal pudendal vein and obturator vein distally, communicating with the vesico-prostatic venous plexus on both sides.[3] In addition, two small arteries and some fibrous connective tissue are often symmetrically observed in the DVC, but the source of the small arteries is not clear at present. Therefore, the DVC has a rich blood supply and is closely associated with the control of bleeding during surgery on the DVC.

At present, RP mostly focuses on the preservation of the posterolateral neurovascular bundle of the prostate. Previous research demonstrated that nerve fibres were distributed all around the prostatic fascia, with the density of the nerve distribution changing continuously from the base to the apex of the prostate; and there was also a considerable number of nerve fibres in the anterior and anterolateral aspects of the prostate.[5,6] In the prostatic apex and membranous urethral plane, the periprostatic nerves aggregate into two groups, the ventral corpus cavernosum plexus and the dorsal corpus cavernosum plexus, whose function remains unclear, and this part of the nerve is often injured when controlling the DVC and dividing the prostatic apex.[5,6]

It is now believed that the DVC not only contains veins, but also contains small arteries, nerve plexus and external urethral sphincter fibres;[7] and affiliated smooth muscles, which were shown to overlap the DVC with the urethral sphincter.[8] Therefore, a standard suture of the DVC has the potential to injure the urethral sphincter.[9] In conclusion, the control of the DVC is not only associated with intraoperative blood loss, but also to injury of the urethral sphincter and nerve plexus.

DVC control methods

Since the blood flow source and control mode of the DVC have been clearly described, both open and laparoscopic RP have started to suture the DVC routinely. At present, the control methods for the DVC during laparoscopic RP vary between different surgical centres, giving rise to various new techniques and surgical skills, all of which are challenging for traditional DVC suture. As a consequence, the DVC control during traditional open retropubic RP is no longer just suturing. The following is a review of the DVC control methods and timings used during open and laparoscopic (including robotic-assisted RP) approaches for RP (Figure 1).

Control of DVC during open surgery

The control of the DVC during open surgery first originated from the classical method of Chute in 1954, which was subsequently improved.[10–12] After opening the pelvic floor fascia, the puboprostatic ligament was transected. The bilateral branches of DVC were sutured together with the pelvic floor fascia on both sides to the midline from the prostatic apex to the junction of the prostate and bladder to better expose the prostatic apex,[10] while an alternative method sutured the DVC upside down to the periosteum of the pubic symphysis to play a suspensory role similar to the puboprostatic ligament, then divided the DVC was divided and the stump was tightly sutured.[11] A previous study sutured both pelvic floor fascia vertically to cover the DVC stump and then sutured to the pubic symphysis, a method that improved postoperative urinary control.[13] Other researchers performed blunt dissection of the space between the urethra and the DVC using their fingers whilst preserving the puboprostatic ligament, followed by the insertion of an 'figure of 8' style suture.[14–16] The use of the fingers rather than instruments prevents the freeing of tissues beneath the DVC. DVC bleeding was also controlled in a simple and safe manner.

With the development of medical consumable industry, some special DVC control devices have been used for open RP. A previous study described the use of a transurethral entry DVC suture device that was sutured to the pubic cartilage.[17] The suture device reduced intraoperative bleeding, avoided the use of excessive electrocoagulation, preserved a long membranous urethra and had some advantages in the recovery of postoperative urinary control.[17] A vascular closure system (LigaSure™) that was used to suture and transect the DVC during modified transperineal RP, followed by suture of the distal end of the DVC, demonstrated a similar operative time and blood loss compared with conventional transperineal RP.[18] In addition, suture-free for the DVC control has also been tried during open surgery. For example, a previous study controlled DVC bleeding used two methods during RP after opening the pubic bone.[19] One method injected 20–40 ml water into the water-filled balloon of a catheter and

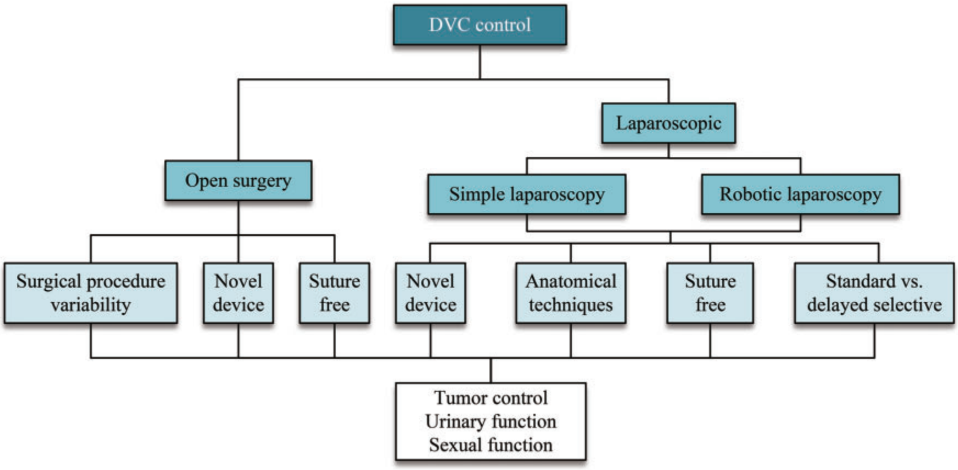

Figure 1. Flow diagram of dorsal vascular complex (DVC) control strategies.

pulled it to the pelvic floor for compression.[19] Another method was to pack medical sponge for compression (details unknown).[19] Unfortunately, suture-free DVC control significantly increased bleeding.[19]

In conclusion, in the era of open surgery, although achieved in different ways, the closure and separation of the DVC can significantly reduce intraoperative bleeding, which is essential to obtain a better visual field during surgy and to achieve better postoperative urinary control function.

Robotic and simple laparoscopic DVC control

Unless specifically noted, the laparoscopic techniques described below do not differentiate between robotic and simple laparoscopes.

Suture of the DVC during laparoscopic RP. Due to anatomical characteristics, it is more difficult to accurately control the needle track during suture of the DVC laparoscopically so as to avoid damage to the vein, urethral sphincter, urethra and prostatic apex. In addition, pelvic deformity, large prostate volume and a wide DVC are unfavourable for suture ligation. Therefore, urologists have tried a variety of technical improvements in the last two decades in order to better suture the DVC. First, they have used new devices. A previous study reported the use of a laparoscopic-assisted suture device (titanium knot placement device), which was first used to ligate the DVC twice before separating it from the surface of the prostatic apex.[20] This treatment was safe, rapid and convenient; and it reduced the learning curve of surgeons performing laparoscopic DVC suture.[20] Two other studies used a vascular sealer to close the DVC with care being taken to avoid injuring the urethra before activating the sealer.[21,22] These two studies found that this treatment was safe and rapid without increasing postoperative positive margins (PSM), urinary incontinence and biochemical recurrence.[21,22] In addition, researchers have treated the DVC with a plasma knife or unidirectional knotless barbed sutures (V-Loc®) instead of conventional polyglactin sutures to sew knotless DVC,[23–24] both of which provided safe and rapid control the DVC. Laparoscopy provides a good view of the surgical field, which helps the surgeon to locate the key anatomical landmarks for DVC suture. Three-dimensional reconstruction of the prostatic apex shows that there is an avascular plane between the junction of the detrusor apron and pubic symphysis and the junction between the prostatic apex and urethra, from which a needle can be inserted from the suture DVC.[4] Previous research described using the fingers to bluntly dissect the space between the urethra and the DVC, possibly entering this plane.[14–16] A groove between the prostatic apex and the membranous urethra was identified during laparoscopic RP, which was the lateral aspect of the avascular area.[25] Sewing the DVC with a blunt needle from this groove could better control the DVC and the authors named this anatomical landmark the 'golden eye'.[25] In addition, some researchers have changed the shape of the DVC to make it easier to suture.[26,27] The DVC was narrowed and compacted by extrusion through the traction of the urethral probe or the temporary clamping of the laparoscopic intestinal clamp, which permitted easier suturing.[26,27]

In conclusion, with the development of medical devices, and by making full use of the good field of vision provided by laparoscopy and the operating advantages of working in a narrow space, urologists are continuously improving the surgical techniques used while ensuring safe control of the DVC during RP. Ultimately, the aim is to provide simple and rapid control of the DVC, as well as better tumour control and postoperative urinary control function.

Suture-free control of the DVC during laparoscopic RP. The necessity for conventional ligation during laparoscopic DVC control remains controversial.[28,29] The method of control used for the DVC largely depends on the surgeon's experience and skills. A previous study reported that they temporarily clamped the DVC with atraumatic grasping forceps through the auxiliary operation hole, maintaining the anterosuperior tension.[30] Next, they lifted the forceps apron, pushed the external urethral transverse sphincter anteriorly and pulled the puboprostatic ligament, maximized the preservation of the sphincter and ligaments, and made the prostatic apex easier to expose.[30] Then they directly divided the DVC and the internal tissue by the grasping forceps.[30] When the prostate was completely freed, the grasping forceps was released, and the DVC stump was elastic retracted.[30] The results showed that this method reduced the operation time and had a lower incidence of postoperative urinary incontinence without significantly increasing intraoperative blood loss.[30] There is also a relatively conservative but more ingenious way of suture-free DVC, which takes advantage of the avascular plane between the ventral capsule and fascia of the prostate,[31] along which the ventral and apical parts of the prostate are separated in the direction of the prostatic venous plexus and neuroplexus. This method uses an intrafascial technique to preserve the DVC.[31] Previous studies evaluated this treatment method and the results demonstrated that it achieved better tumour control and improved the recovery of postoperative urinary control function without significantly increasing intraoperative blood loss.[32–34]

In conclusion, it is safe and feasible to attempt suture-free DVC control for selective patients and this is beneficial to their recovery of postoperative urinary control. Combined with local anatomical characteristics, it may be beneficial for the recovery of postoperative erectile function. However, this method needs to be further validated by randomized controlled trials. Among them, the dissection of the subfascial DVC maximizes the preservation of tissue and reduces thermal damage, which should be a better way.

Standard versus delayed selective suture of the DVC. Since around 2010, investigators have proposed methods for delaying suture ligation or selective suture ligation of the

DVC.[35] Unlike the conventional method of suturing the DVC before separating the prostatic apex, the general steps of delayed selective suture of the DVC are as follows:[28] (i) when the DVC is treated before transection of the urethra, the pneumoperitoneum pressure should be temporarily increased to approximately 18 mmHg, and the curved scissors should be used to cut superficially from the middle of the DVC; (ii) At this time, 1–2 small arterial pulsatile bleeding may be encountered. The arteriovenous stump should be coagulated with a single pole, and the remaining DVC venous branches may not have significant bleeding due to the effect of pneumoperitoneum pressure during transection; (iii) the urethra is then transected and the prostate is mobilized; (iv) if the DVC is wide, the lateral venous vessels of the DVC are coagulated with bipolar electrocoagulation, and if there is more bleeding from the severed DVC stump, the bleeding point or the entire DVC stump is selectively sutured to avoid suturing to the peripheral tissue; (v) and then the pneumoperitoneum pressure will return to normal. A previous study described the clinical data from 90 patients that underwent this management method and concluded that this method was safe and efficient, with little intraoperative blood loss and good postoperative urinary control function recovery.[35] Other studies retrospectively compared delayed selective suture with conventional suture DVC and found that the former was non-inferior to the latter in terms of operation time, blood loss, PSM, urinary continence and erectile function recovery.[35–37] A prospective randomized controlled trial compared the two methods and showed that delayed selective suture reduced intraoperative blood loss and PSM of the prostatic apex, but increased overall PSM in patients with localized prostate cancer; but there was no difference in postoperative haemoglobin levels, postoperative prostate-specific antigen levels, transfusion rate and postoperative urinary continence.[38]

In addition, there are also technical differences in the way that delayed selective suture of the DVC can be undertaken. For example, two previous studies described cold separation of the prostatic apex and DVC without the use of bipolar electrocoagulation to minimize tissue damage to the urethral peripheral nerves and muscles.[39,40] Another study pulled the catheter balloon by hand during selective suture ligation to better expose the DVC stump and basin and facilitate suture ligation; and the results manifested that this method reduced the dependence on assistants and significantly reduced PSM at the prostatic apex.[41] Temporarily clamping the DVC with a vascular clamp before dividing the DVC, prostatic apex and transecting the urethra, demonstrated a significantly reduced operation time and it may have improved urinary control in the early postoperative period.[42]

There were significant differences in the study results for delayed selective suturing of the DVC during RP. A recent meta-analysis reviewed the safety, recovery of urinary continence function and tumour control outcomes of delayed selective suture DVC in 1822 patients.[43] The results showed that delayed selective suture of the DVC resulted in more intraoperative blood loss, but it did not significantly increase the blood transfusion rate.[43] Delayed selective suture of the DVC reduced the operation time, reduced PSM and improved the postoperative 6-month urinary control rate.[43] However, there was no significant advantage in the postoperative 3-month and 12-month urinary control rates.[43] In conclusion, delayed selective suture of the DVC may reduce the operation time with slightly increased intraoperative blood loss, which can be considered as safe and efficient, but the effect on postoperative tumour control, urinary control function and sexual function remains to be further confirmed by a prospective randomized controlled trial.

Conclusion

With the in-depth study of the local anatomy of the prostate and the development of surgical instruments, the methods for controlling the DVC during RP are developing. Under the premise of ensuring safety, urologists focus on postoperative urinary control and erectile function as much as possible, with the aim of reducing these complications that adversely affect quality of life. However, due to the individual variations and differences in surgical techniques, it is still difficult to choose a golden-standard DVC control method. Similar studies reported contradictory results and there is still a lack of randomized controlled trials with long-term follow-up to evaluate the different DVC control methods. Multiparametric magnetic resonance imaging has demonstrated a good performance in prostate cancer staging and surgical planning.[44] Further research into the local anatomy of the prostate is required, especially with regard to the tracks and function of the nerve branches, which could guide urologists so that they can preserve function after surgery.

Author contributions

All authors contributed to the design of the work, drafted and reviewed the manuscript and approved the final version of the manuscript.

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