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REVIEW ARTICLE

Prophylaxis and management of perioperative hemorrhage in retropubic radical prostatectomy

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Abstract

Retropubic radical prostatectomy (RRP) has commonly been performed for localized prostate cancer. In the past decade, with the development of laparoscopic and robotic techniques, laparoscopic radical prostatectomy (LRP) or robotic-assisted LRP has been widely used due to its less invasive nature along with its shorter recovery, reduced blood loss, and improved visualization of the operative region compared to open techniques. Severe hemorrhage following prostatectomy is relatively rare (0.5% to 1.6%), but it is a serious complication. Here, we summarize circumstances in which perioperative severe hemorrhage can develop and interventions needed to achieve hemostasis.

Keywords： cancer; prostate; prostatectomy; hemorrhage; management

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Prostate cancer is one of the most common malignancies of the urinary tract. Based on incidence and mortality data from several agencies, the American Cancer Society estimates that 233 000 new prostate cancer cases and 29 480 mortalities from prostate cancer are projected to occur in the United States each year [1]. Treatment of metastatic prostate cancer mostly requires castration therapy alone or in combination with other treatments, such as chemotherapy and targeted gene therapy [2–3]. Nevertheless, radical prostatectomy (RP) has commonly been performed using an open retropubic approach for localized prostate cancer. However, in the past decade, with the development of laparoscopic and robotic techniques, laparoscopic radical prostatectomy (LRP) or robotic-assisted LRP (RALRP) has become widely accepted given its reduced invasiveness, shorter recovery, reduced blood loss, and improved visualization of the operative region compared to open techniques [4–5]. Although the recent advent of laparoscopic radical prostatectomy, with or without robotic assistance, has significantly reduced intra-operative blood loss, hematoma may still develop after surgery. Severe hemorrhage following prostatectomy is relatively rare (0.5% to 1.6% [6–7]), but it is a serious complication.

Severe hemorrhage following radical prostatectomy was first described by Foss in 1923 [8]. The incidence of intraoperative and post-operative hemorrhage have decreased since Reiner and Walsh [9] described the anatomy of the dorsal venous complex (DVC) and a method for early hemorrhage control during radical prostatectomy. Hemorrhage following radical prostatectomy is mainly of venous origin, while arterial hemorrhage is uncommon. Meanwhile, several studies have been performed to identify methods that improve hemorrhage control.

Improvement in the knowledge of anatomy and advanced laparoscopic techniques for reduced hemorrhage

Improvement in the knowledge of prostate anatomy and advances in laparoscopic techniques have improved operational results and reduced hemorrhage. These results are closely related to the identification of a multilayered periprostatic fascia and blood supply. Furthermore, vascularization of the prostate mainly comes from prostate arterial supply, DVC, and neurovascular bundle (NVB). Recognition of this blood supply is important for effectivecontrol of blood loss.

Depending on the dissection plane chosen, intrafascial, interfascial, and extrafascial dissection methods have been described. Intrafascial dissection is considered a

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dissection that follows a plane on the pseudocapsule, remaining internal to the prostatic fascia at the antero- and posterolateral aspects of the prostate and anterior to the posterior prostatic fascia/seminal vesicles fascia (PPF/SVF). The intrafascial approach allows a whole-thickness preservation of the NVB and reduces hemorrhage from the NVB. An interfascial dissection of the NVB is considered a dissection within the thickness or between the leaves of the periprostatic fascia and includes incremental nerve sparing. An extrafascial dissection is a dissection conducted lateral to the levatorani fascia and posterior to the PPF/SVF. In this case, the NVB will be completely resected.

Prostate arterial supply is as follows. The most frequent origin of the prostate arteries is from the internal pudendal artery, which is an extension of the internal iliac artery after it contributes branches to the obturator artery, the vesical arteries, and the superior and inferior gluteal arteries. The common gluteal-pudendal trunk is the next most frequent origin, and less frequently, the prostate arteries arise from a branch of the obturator artery or the inferior gluteal artery. Usually, there is only one common trunk per side, but there are numerous anastomoses with terminal branches of the internal pudendal arteries, contralateral prostate arteries, and superior vesical arteries. After branching, the artery has a tortuous course that travels obliquely downward towards the posterior and inferior part of the bladder and provides several inferior vesical arteries. It terminates with numerous prostate branches, often after a bifurcation, thereby resulting in two main pedicles. The posterior pedicle surrounds the seminal vesicles and deferential ducts before reaching the prostate base, while the anterior pedicle surrounds the lateral border of the prostate before ultimately running to the prostate apex as an anterior capsular prostate branch. The prostate arteries give rise to numerous perforating branches to the prostate. Furthermore, there is considerable inter- and intra-individual variability in the vascular anatomy.

DVC often contains small arteries that originate from the inferior vesical artery and dorsal vein complex or Santorini's plexus, which drains blood from the penile veins together with the urethral and lateral pelvic veins. Distal to the prostate apex, the DVC is separated from the urethral sphincter by the sphincter's fascia. At the apex, the DVC may be split by the PV/PPLs into medial and lateral components. The DVC then courses superiorly on the ventral aspect of the prostate towards the bladder. In the process, variable anastomotic branches are generated that travel towards the bladder and lateral prostate veins. Ventrally, the DVC is covered by extensions of the visceral endopelvic fascia and the detrusor apron. At the prostatourethral junction, an avascular plane is present between the prostate and the DVC, forming a landmark for DVC control. The pelvic plexus lies within a fibrofatty, flat, rectangular, sagittally oriented plate between the bladder and the rectum. Meanwhile, at the prostate apex and the urethra, the NVB is separated into two distinct groups: the cavernous nerves and corpus spongiosum nerves as well as contains many prostate artery branches.

Laparoscopic radical prostatectomy for localized prostate cancer offers several advantages, including enhanced visibility during surgery and the creation of a pneumoperitoneum that reduces blood loss in comparison to the corresponding open procedures. Ligation and transection of the deep DVC remains among the most challenging aspects; however, safe and secure completion of this procedure is important to minimize the blood loss. Furthermore, a V-lock thread is used to facilitate the completion of this procedure. The liberal use of bipolar coagulation for hemostasis could stop bleeding at some spots of the DVC. Ligation may sometimes prove difficult, particularly in obese patients with a short and broad DVC, a large prostate gland, and a narrow pelvis. The presence of prominent pubic tubercles may further increase this difficulty. Subsequently, bleeding from the DVC may be controlled without suture ligation through a combination of a modest pneumoperitoneum with pinpoint coagulation of one or two small arteries that are consistently found in the superficial layer of the complex. Precise, even-level transection is possible under direct vision with no more than modest blood loss. A Z-shaped stitch is then applied to the entire transected stump of the DVC. This procedure is simple and easily performed, even by those with limited experience.

RALP offers many benefits that reduce the difficulty involved in performing complex laparoscopic urologic procedures, particularly for non-laparoscopic surgeons. Therefore, its application might already yield a real advantage by shortening learning curves compared to conventional laparoscopy. Open RP has a higher estimated blood loss and subsequently results in a greater need for transfusion than does LRP and RALRP. Pneumoperitoneum laparoscopy and tight hemostatic control allows for the early identification and meticulous ligation of vessels as well as produces a tampon effect that reduces blood loss from the prostatic venous sinuses. The mean blood loss during RALP was significantly lower than in open RP (200 mL vs. 800 mL; $P < 0.001$), and blood loss and transfusion rates were significantly lower in those patients who underwent LRP. The laparoscopic/robotic-assisted prostatectomy group could reach a 77% decreased risk of perioperative transfusion and considerably decreased incidence of perioperative transfusion compared to open RP [4].

Prophylactic management of

hemorrhage

Maintaining low central venous pressure reduces the estimated blood loss compared to both conventional fluid management and normovolemic hemodilution in patients undergoing radical retropubicprostatectomy. However, there was no difference in allogeneic blood transfusion between the two groups. The multivariate model showed that the estimated blood loss (mean ± SD) was significantly lower with low central venous pressure (706 mL ± 362 mL) compared to acute normovolemic hemodilution (1103 mL ± 635 mL) and conventional (1051 mL ± 714 mL) groups (P = 0.0134) [10]. Conversely, it is possible that thoracic epidural analgesia (TEA) may influence intraoperative blood loss in RRP. Baumunk *et al* [11] observed 235 patients and monitored their blood loss, infusion rates, and anesthesiological parameters, which were analyzed using regression models and analyses of variance. In doing so, they did not find that TEA had a direct impact on intraoperative blood loss and transfusion rates in RRP. Further randomized clinical trials are needed to evaluate the impact on blood loss of the different anesthetic procedures presented alone or in combination. Meanwhile, Strang *et al* [12] reported that controlled hypotension (MAP 60–70 mmHg) consisting of thoracic epidural anesthesia and restrictive fluid management is a safe for minimizing blood loss. The 25° Trendelenburg position supports the multimodal treatment of controlled hypotension. Therefore, some measures of anesthesia may help reduce intraoperative blood loss.

Optimal control of the dorsal vein complex can help control and prevent early hemorrhage. If DVC is not controlled properly, bleeding may occur during the apical dissection. Suture ligation is the most common technique used for dorsal vein control. Furthermore, the size of DVC may affect venous control. García-Segui *et al* [13] developed a DVC narrowing technique for use during laparoscopic radical prostatectomy to simplify the suturing of the DVC. This technique involves a surgeon inserting a metallic urethral sound into the urethra while the surgical assistant's hand maintains pressure on the distal tip of the device in a posterior direction. This pressure is applied while the ligature stitch is passing through the venous plexus. However, the estimated blood loss from this technique was found to be not significantly different compared to patients treated using aconventional ligature. Cristini *et al* [14] described a safe and easily reproducible technique to control the Santorini plexus during radical retropubic prostatectomy. This technique involves the index finger, which is used not only to localize the catheter inside the urethra, but also to develop the right plane between the Santorini plexus and the urethra. This is performed using a gentle bilateral digital dissection through the lateral aspects of the periprostatic fascia, which were eventually breached by the fingers. In doing so, the correct plane was identified just above the urethra. The Santorini plexus was then easily ligated and divided. The maneuver was successful in 95% of patients. The mean (range) blood loss was 620 mL (100–1500 mL). Furthermore, this technique facilitated the process of finding the right plane just above the urethra, thereby allowing the formation of good hemostasis in the surgical field and proper apical dissection. Furthermore, some authors have recommended using an endovascular stapler to control DVC. Recently, athermal division and selective suture ligation technique has been reported for DVC control. Tüfek *et al* [15] described a new technique using a bulldog clamp to control the DVC during robot-assisted radical prostatectomy. The control of the DVC with a bulldog clamp allowed a bloodless field with precise apical dissection and provided preservation of the maximal urethral length while avoiding injury to the sphincter.

Management of intraoperative hemorrhage

Compression of the retropubic space with tissue-to-tissue contact leads to rapid resolution in cases of venous hemorrhage in the course of RRP. Bipolar electrocoagulation and hem-o-lock can effectively prevent the loss of blood from the dissection surfaces and arterial hemorrhage from branches of the internal iliac artery.

Management of postoperative hemorrhage

A meticulous technique can minimize the risk of postoperativehematoma formation and severe postoperative bleeding after RRP. Furthermore, hemodynamic instability may necessitate open surgical exploration and be associated with considerable morbidity. Tasci *et al* [16] reported that a total of five among 317 (1.6%) patients experienced serious postoperative bleeding requiring postoperative transfusion. Hemorrhages like these most often develop in the prostatic bed between the bladder and the rectum. In this location, a sizeable blood clot may cause pain, tenesmus, and discharge through the anastomosis into the bladder, resulting in hematuria, often with troublesome clots. Most patients experiencing this complication were successfully treated with conservative management; however, arterial hemorrhage following prostatectomy still required emergent invasive treatment.

Transarterial embolization (TAE) for arterial hemorrhage following radical prostatectomy is a safe and minimally invasive treatment compared with surgical intervention. Hiroshige *et al* [17] reviewed 12 patients who were reported to have developed a post-operative hemorrhage. Three patients underwent open RP, four underwent RALRP, and five underwent LRP. Eleven cases underwent bilateral or unilateral nerve sparing. Computed tomography-angiography (CTA) revealed active bleeding in all cases, and extravasation in CTA was important for discriminating between venous and arterial hemorrhage. The bleeding focus was frequently the internal pudendal or accessory pudendal artery. However, in only one case, the bleeding focus was a branch of the obturator artery, which may have been injured during pelvic lymph node dissection. Molina *et al* [18] reported a 58-year-old male patient with localized prostate cancer who underwent open RP with preservation of the neurovascular bundles and a left accessory pudendal branch. On the fourth postoperative day, this patient presented severe hematuria and urethral bleeding requiring continuous bladder irrigation and blood transfusion. CTA was performed, which indicated active bleeding at the bulbar artery from the left internal pudendal artery without associated pelvic hematoma. Of course, subsequent TAE was the treatment of choice for all of the aforementioned patients, which avoided requiring open surgical revision and resulted in less morbidity.

Rarely, the cases required any additional surgical intervention. Sukha *et al* [19] presented the case of a 76-year-old male patient who was admitted with bleeding per-urostomy following a radical cystoprostatectomy. CTA revealed a possible small source of bleeding within the ileal-conduit, which was treated conservatively. However, prior to discharge, he developed profuse fresh bleeding from the urostomy. An emergency endoscopy of the conduit and laparotomy revealed a fistula between the right external iliac artery and the proximal end of the ileal-conduit. The right iliac artery was ligated, and an emergency left-to-right femoral-femoral crossover bypass was performed.

Abdominal wall hemorrhage after robotic-assisted radical prostatectomy is a type of postoperative bleeding that also requires a blood transfusion. Tasci *et al* [16] reported that five patients experienced a gradual fall in hematocrit (Hct) levels after surgery, with ecchymosis being detected on the side and posterior walls of the abdomen on the second day. The mean preoperative Hct was 44.3%, and the mean lowest Hct level was 23.1%. All patients were successfully treated without surgical exploration.

Conclusion

With the development of a novel technique to perform RRP, it has evolved from open RP to LRP and, eventually, to RALRP. These developments are associated with several advantages, including a reduction in blood loss in comparison with the corresponding open procedure. Nevertheless, surgical obstacles persist, with the most challenging aspects of achieving perioperative hemostasis in obese patients with a short and broad DVC, a large prostate gland, and a narrow pelvis. Furthermore, severe hemorrhage potentially results in delayed rehabilitation. Therefore, the use of RALRP is advantageous given its ability to reduce the incidence of hemorrhage and to facilitate successful treatment.

Conflicts of interest

The author indicated no potential conflicts of interest.

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