Surgical Aspects of Kidney Transplantation: Review Article

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Abstract:

Renal transplantation represents actually the most effective therapy in patients with end-stage renal failure as it is cost effective, allows for a normal life style and reduces the risk of mortality from dialysis related complications. Renal transplantation can be classified in deceased- donor or living-donor transplantation, depending on the source of the donor organ. The short-term results of transplants with kidneys from donors over 65 years old are almost similar to those with younger organs, but in these patients it is mandatory to reduce cold ischemia time. In the last years, the demand for kidney transplantation has increased dramatically, which has been associated with an increase in living-donor organ procurement, which presents several advantages. Moreover, new operative techniques have been recently developed in order to improve surgical outcomes and graft survival and to reduce the complications' rate after renal transplantation.

Keywords: Kidney, transplantation, renal.

Introduction:

The basic operative methodology for renal transplantation has changed little from the principles of vascular anastomosis described by Alexis Carrel in 1902 and subsequently revised by René Küss and colleagues in 1951. (1)

Preparation and preservation of the kidney is essential to maximize early and late graft function after transplantation and is achieved through the use of preservation solutions and maintaining the graft in hypothermic conditions. (2)

Traditionally implantation has been extraperitoneal in the right iliac fossa owing to the superficial position of the external iliac vessels and ease of graft assessment by palpation, auscultation and biopsy. Alternatively, the left iliac fossa can be used. (1)

Implantation site

The classical site for a renal transplantation is the right iliac fossa, centred over the external iliac vasculature, as the longer and more horizontal right external iliac vessels facilitate easier vascular anastomoses. However, the advantage of placing the donor kidney in the recipient's contralateral side ensures the renal pelvis and ureter lie anterior and will be easier to access for further surgeries (e.g. ureteric reconstruction). (3)

Other factors to consider when deciding on the site of surgery include previous surgery (e.g. failed renal transplantation), severe atherosclerotic/calcific disease affecting iliac arteries, pelvic exploration and peritoneal dialysis catheters. (4)

The use of both internal iliac arteries in serial renal transplantations in men is avoided to prevent impotence. (5)

Large grafts have been implanted within the abdominal cavity so as to prevent potential "kidney compartment" syndrome (over compression of the renal parenchyma limiting venous outflow) and to permit aortic anastomosis or common iliac artery with venous drainage either to the inferior vena cava or common iliac vein. (1)

Incisions and Operative bed preparation

The three incisions used for renal transplantation are the Gibson incision, the 'hockey stick' incision and the Rutherford Morrison oblique incision. (6)

The Gibson incision is the most common approach and involves a relatively atraumatic curvilinear incision that starts two centimetres medially to the anterior superior iliac spine, running 0.5 centimetres above the inguinal fold, and is continued to the lateral border of the rectus muscle (fig.1). (6)

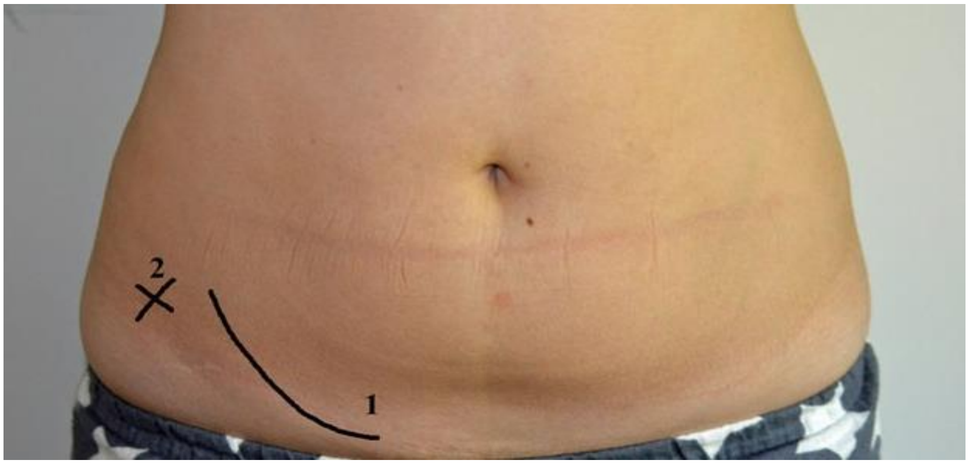

Figure 1: Gibson Incision

The para-rectus 'hockey stick' incision is prolonged medially to the midline above the pubic symphysis and can be extended upward to the subcostal margin. One advantage of this approach is that it yields better access to the common iliac vessels and inferior vena cava (fig.2). (1)

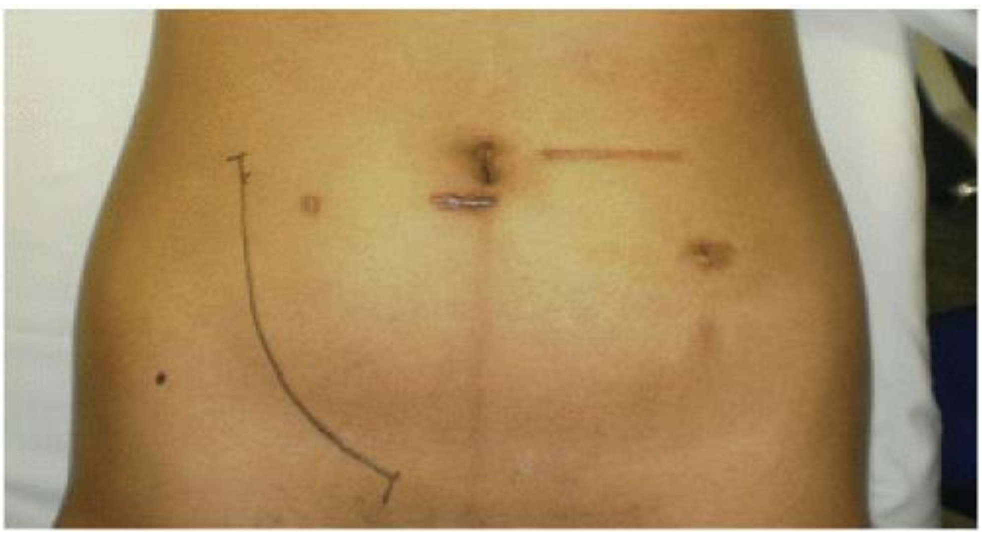

Figure 2: Hockey Stick Incision

Although shorter in length, the oblique incision may require the division of all the lateral abdominal muscles. Nanni and colleagues compared the 'hockey stick' and oblique incisions for post-operative complications and concluded that the latter was better for reduced incidence of hernias and more favorable cosmetically. (7)

Whichever approach is used, it is important that all incisions are accompanied by strict haemostasis to avoid wound or peri-graft haematomas that could eventually lead to infection, dehiscence or kidney compartment syndrome from compression of the graft. (7)

To reach the peritoneum you have to incise the skin and the subcutaneous tissue 0.5–1.0 cm medially from the lateral edge of the rectal muscle. After 5– 6 cm of opening the anterior rectus abdominus sheath, separate the anterior surface of the rectus muscle from the posterior side of the anterior sheath and pull it up and outside with two forceps in order to check whether you have properly opened the anterior rectus abdominal sheath or not. If you are inside, extend the incision downwards and upwards depending on the patient's weight and height, how high or low you want to go and as to whether you are forced to perform a vascular anastomosis (fig.3). (8)

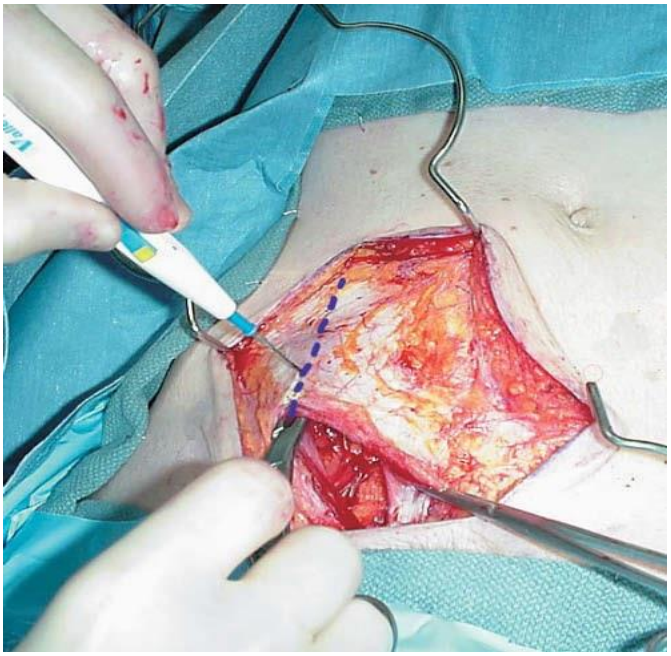

Figure 3: Cutting the anterior sheath of the rectus abdominal muscle

The next step to reach the extraperitoneal space is to coagulate and cut the small vessels and nerves that run on the anterior side of the posterior sheath of the rectus abdominal above the arcuate line (fig.4). Below the arcuate line, the posterior wall of the rectus abdominal directly contacts the parietal peritoneum. Perform a blunt dissection of the peritoneum by using electrocoagulation and different surgical instruments such as your own fingers, forceps and/or a small gauze swab in a holder. Try to very gently detach the parietal peritoneum from the abdominal wall and retro-peritoneum space and sweep it medially (fig.5). The round ligament in women or the spermatic cord in men, the iliac vessels and 50% of the surface of the urinary bladder have to be free. (6)

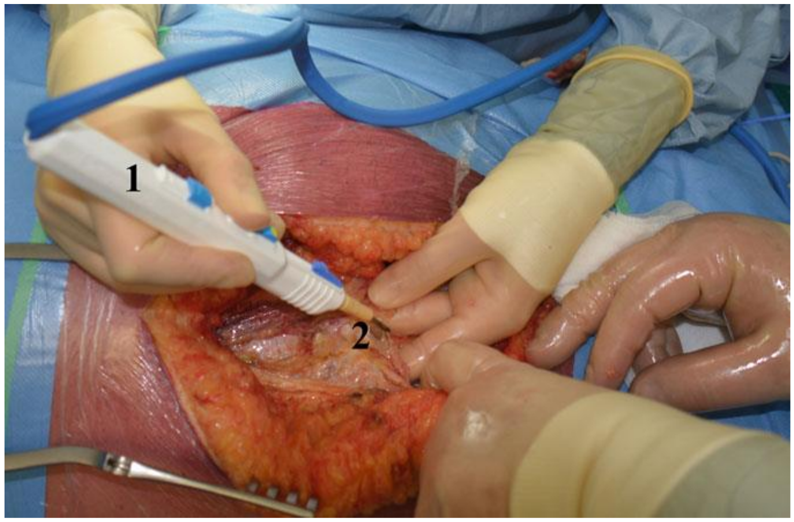

Figure 4: Cutting the posterior sheath of the rectus abdominal muscle
1-Argon coagulation, 2-The posterior sheath of the rectus muscle, located above the arcuate line

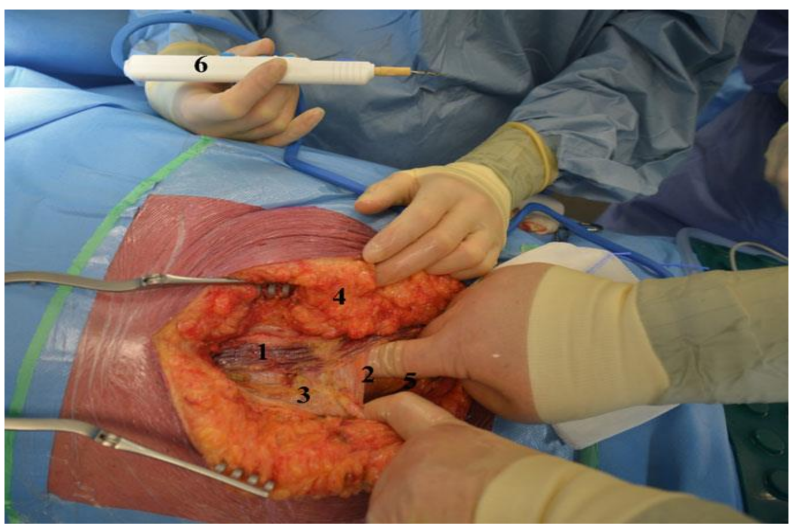

Figure 5: Detachment of the parietal peritoneum
1-Rectus abdominal muscle, 2-Posterior sheath of the rectus abdominal muscle, 3-External oblique abdominal muscle tendon, 4-Subcutaneous tissue, 5-Retroperitoneal space, 6-Argon-beamer coagulation

With each side incision for kidney transplantation, you always will be confronted with an inferior epigastric artery and the vein in the bladder area. The inferior epigastric artery refers to the artery that arises from the external iliac artery and anastomoses with the superior epigastric artery. Along its course, it is accompanied by a similarly named vein, the inferior epigastric vein. The inferior epigastric artery supplies blood to the muscles of the anterior abdominal wall, such as the rectus abdominal muscle and to the deep abdominal wall of the pubic and the lower umbilical regions. If the diameter of the artery exceeds 2.5–3.0 mm, and the artery is not badly altered by atherosclerotic changes and has good blood flow and pulsation, we canuse it if necessaryto reconstruct, for example, If we are going to use the inferior epigastric artery to reconstruct aberrant renal artery supplying inferior pole of the kidney (fig.6). (6)

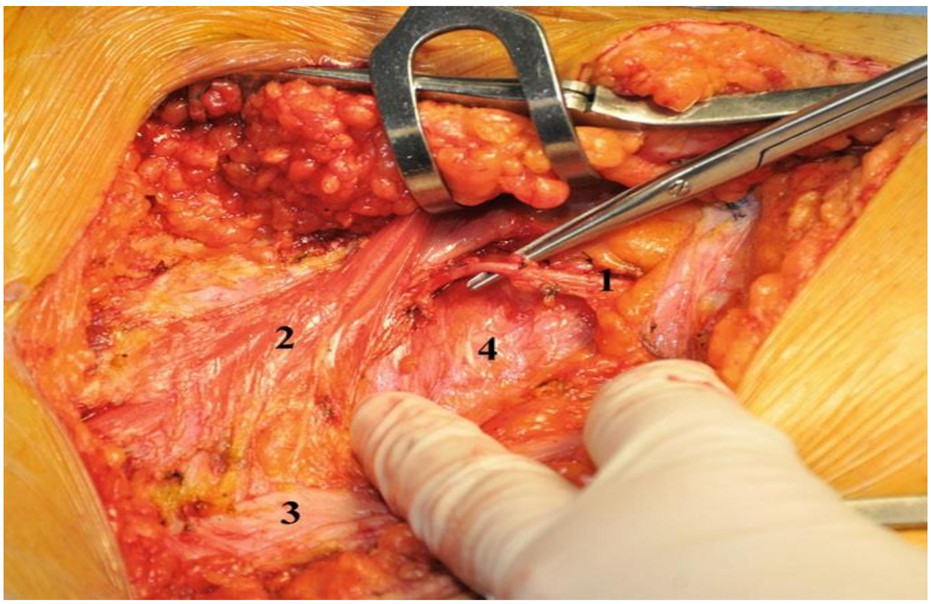

Figure 6: 1-Dissected inferior epigastric artery and vein, 2-Rectus abdominal muscle, 3-Incised anterior sheath of rectus abdominal, 4-Peritoneum.

When exposing the retroperitoneal space, try always in every case to keep the round ligament whole and do not cut it through, especially in young women. During a kidney transplantation the spermatic cord is simply retracted medially by releasing the border of the inguinal canal. (6)

To obtain optimal exposure, a ring retractor was applied. The blades of the retractor are used to pull the abdominal wall outside, the intestines upward and further expose the upper iliac fossa, the contents of the peritoneal sac medially and visualization of the urinary bladder (fig.7). (6)

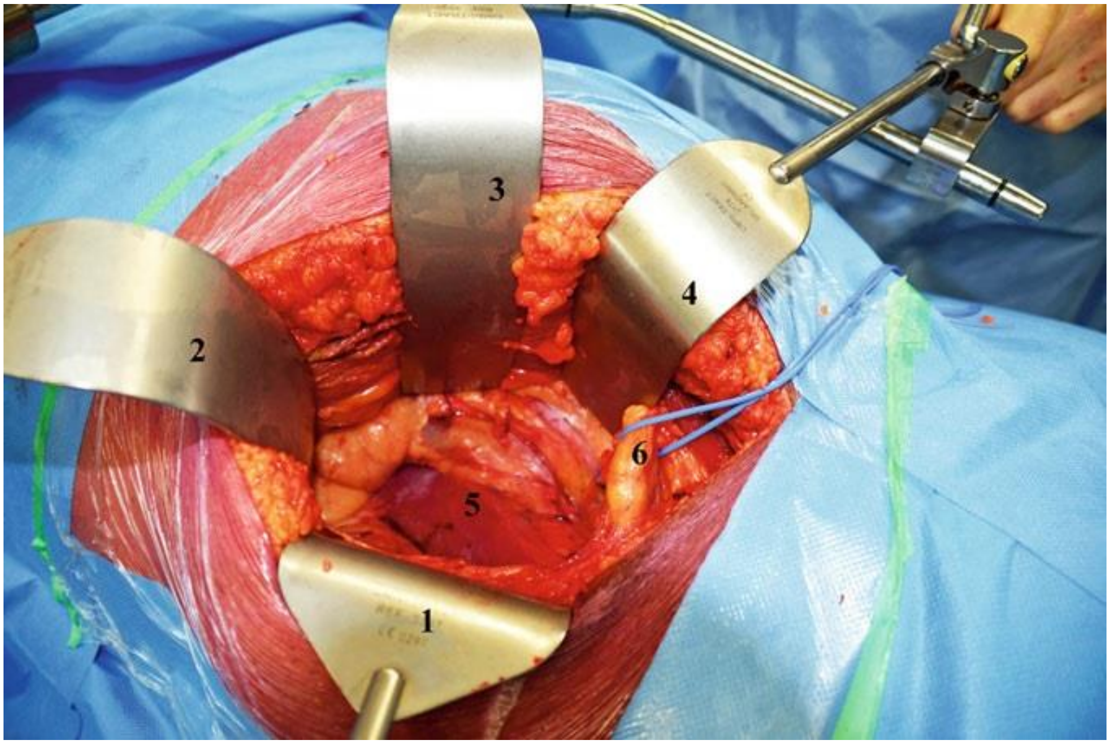

Figure7: Installation of abdominal retractor during kidney transplantation.
1, 2, 3,4-Different blades of the abdominal retractor, 5-Right psoas major muscle, retroperitoneum, 6-Spermatic cord with a vessel loop around.

The gentle preparation of the common, internal and external iliac artery and vein mainly comes down to a gentle separation of them from each other, the surrounding muscles and overlying lymphatic vessels. The lymphatic vessels which were cut during preparation, have to be ligated or coagulated to avoid postoperative lymph leakage or subsequent lymphocele formation. (6)

The right and left external iliac arteries extend from the mid-pelvis to the inguinal ligament as the distal continuation of the common iliac arteries. The common iliac arteries arise from the aortic bifurcation and bifurcate into the external and internal iliac arteries anterior to the sacroiliac joint. The external iliac arteries begin at the common iliac bifurcation and take an anterior course along the medial border of the psoas major muscles before exiting the pelvic girdle posterior to the inguinal ligament. The exit point of the external iliac arteries is lateral to the insertion point of the inguinal ligament on the pubic tubercle, approximately one-third the distance from the pubic tubercle to the anterior superior iliac spine. Distal to the inguinal ligament, the external iliac artery becomes the common femoral artery. (9)

The external iliac arteries give rise to two arterial branches that perfuse surrounding muscles: the inferior epigastric artery and the deep circumflex iliac artery. The inferior epigastric artery originates from the medial side of the distal external iliac artery. It travels superiorly along the posterior surface of the inferior rectus abdominis muscle. The deep circumflex iliac artery originates from the lateral side of the distal external iliac artery and travels laterally along the superior border of the iliac crest. The common femoral artery is the distal continuation of the external iliac artery as it passes posteriorly and inferiorly to the inguinal ligament. (9)

The Internal Iliac artery begins at the common iliac bifurcation, which is anterior to the sacroiliac joint, at the level of the intervertebral disc between the L5 and S1 vertebrae. The artery is 4 cm long and traverses inferoposteriorly to the superior margin of the greater sciatic foramen. Here it bifurcates into two main trunks, Anterior trunk which continues on the same trajectory as the main artery towards the ischial spine and Posterior trunk which passes towards the greater sciatic foramen (fig.8). (10)

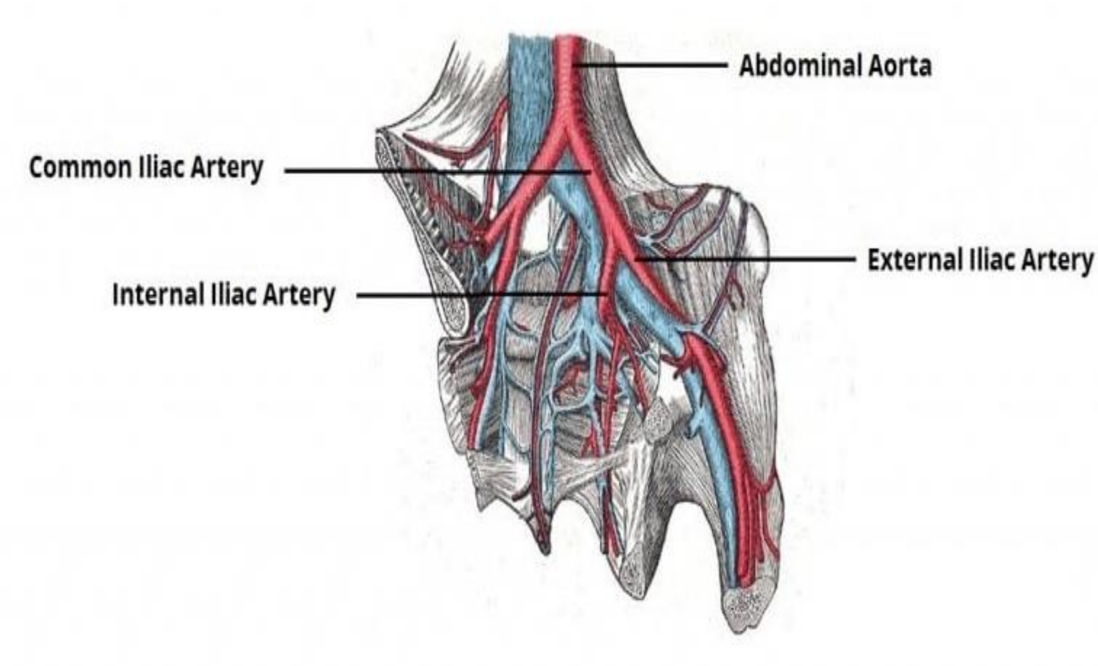

Figure 8: Anatomy of Iliac Arteries

The Internal Iliac Artery is located posterior to the ovaries and the uterine tubes in females, as well as the ureter in both sexes. The internal iliac artery is anterior to the sacroiliac joint, internal iliac vein and lumbosacral trunk. The parietal peritoneum and tributaries of the internal iliac vein are located medial to the artery, whilst the external iliac vein and obturator nerve are found on the lateral side of the artery. (10)

The external iliac vein is a continuation of the femoral vein. It begins when the femoral vein crosses underneath the inguinal ligament. It ascends along the medial aspect of the external iliac artery, before joining with the internal iliac vein to form the common iliac vein. During its short course, the external iliac vein receives the inferior epigastric and deep circumflex iliac veins (fig.9). (11)

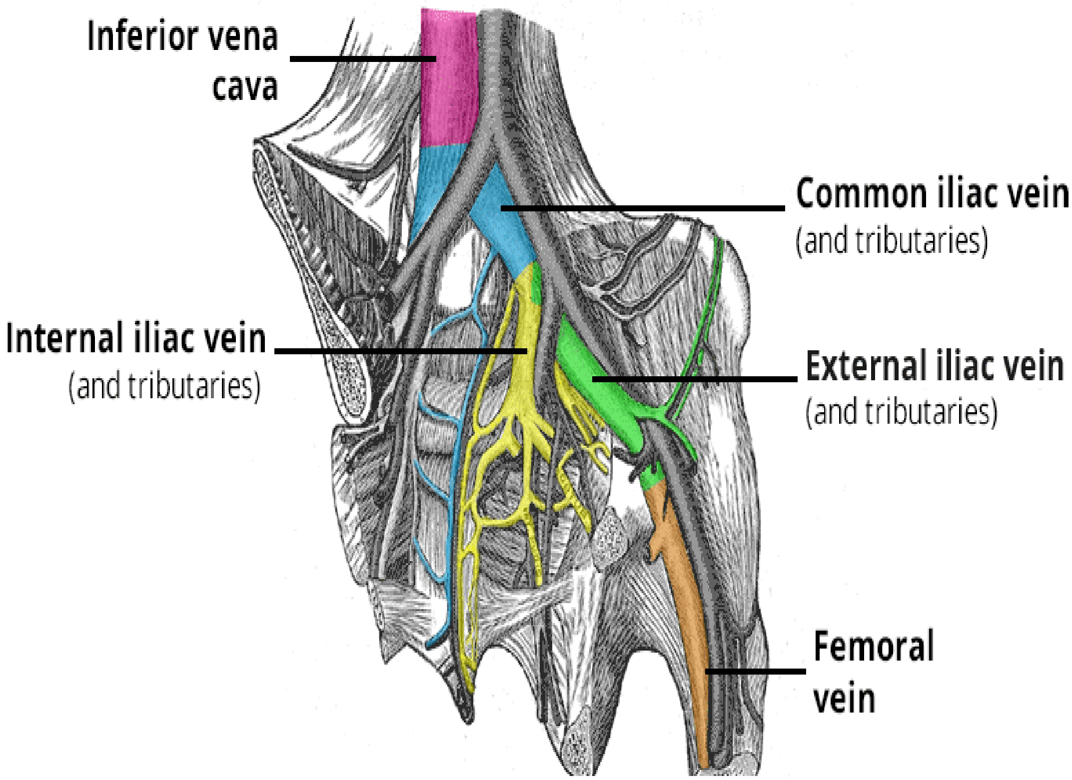

Figure 9: Anatomy of Iliac veins

The common iliac vein is formed by the union of the external and internal iliac veins. The left and right common iliac veins have differing pathways. The right common iliac vein moves in a straight course to form the IVC, while the left common iliac vein must initially join the right common iliac vein at the confluence with the IVC. Therefore, the left common iliac vein's pathway is not as linear. The left common iliac vein is also longer than the right vein. (11)

The external and internal iliac arteries are dissected free and mobilized for an adequate length to allow for subsequent clamp placement and anastomosis. The external iliac vein usually lying just medial to the artery is subsequently isolated (fig.10). (8)

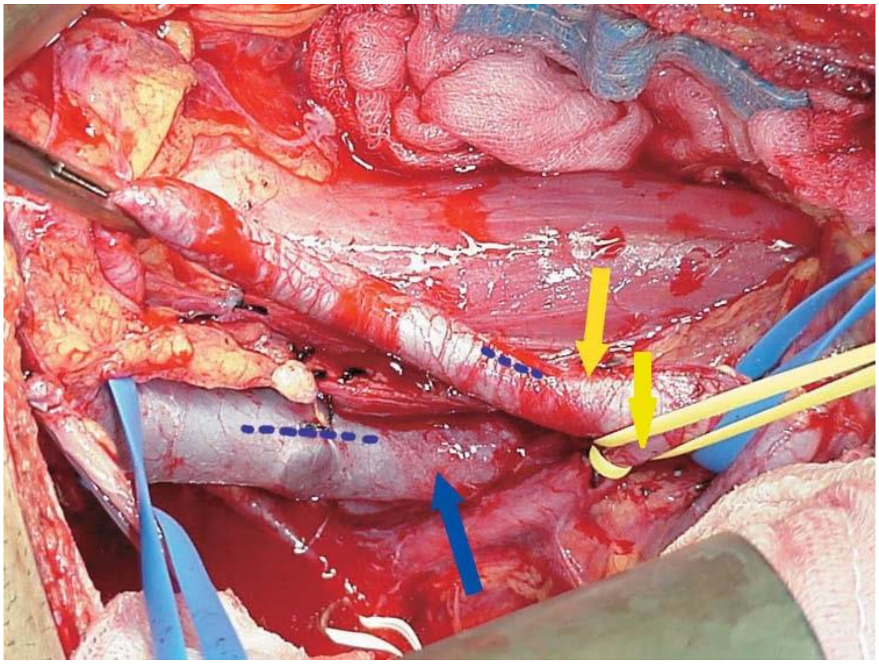

Figure 10: Mobilized External iliac v. (blue arrow), External & Internal iliac arteries (yellow arrow)

Following iliac vessel mobilization, the process of vascular anastomosis may begin after choosing suitable points of vascular inflow and outflow along the iliac vessels. The location of the vascular anastomosis may be determined by: the stage of the iliac vessel's atherosclerosis, earlier vascular operations, the length of the renal vessels, or the ureter. The site of each anastomosis and the position of the graft should be specified accurately according to the size and length of the vessels and also the length of the ureter and position of the recipient bladder. The kidney graft is placed in the wound and the renal vessels stretched to the recipient vessels to determine the best sites for the arterial and venous anastomoses. After confirming the exact length and position of the anastomosis site to prevent donor vessel kinking or rotation, vascular clamps are applied to the recipient vessels as satinsky to the vein and bulldog to the artery. (1)

It is important the anastomosis steps are completed carefully but in a timely manner as the kidney lies outside the body for this process, thus theoretically presenting an opportunity for graft insult. (1)

Venous Anastomoses

Classically, graft vein to the recipient iliac vein is anastomosed in an end-to-side fashion using a continuous monofilament suture (5-0 or 6-0 Prolene). The venous valve site in the external iliac vein should be avoided, if possible, as the wall of the vein is very thin proximal to the venous valves (sinuses of Valsalva) and may be ruptured during the anastomosis and if inevitable valvotomy is done. (1)

The length of the donor vein can be increased by refashioning the inferior vena cava cuff which may be of particular importance in a short right renal vein. Any reconstructions of the donor vein should take place prior to implantation of the kidney and excessive elongation should be avoided to protect against renal vein kinking and thrombosis; this is particular true for the left renal vein which is invariably shortened. (1)

Depending on the predetermined best place for the renal vein anastomosis, grasp the already gently prepared iliac vein with forceps and carry it slightly upwards and then with the help of a Satinsky vascular clamp close the vein partially along its long axis. Assure that during clamping with the Statinsky only the vein is being clamped and not the vein together with all surrounding tissues. Closing the lumen of the vein with the surrounding tissue will result in inadequate closure of the vein and when the vein is cut for anastomosis, the area will bleed, making the anastomosis difficult to perform or forcing the operator to correct the position of the vascular clamp closing the vein. Clamping the IVC and/or one of the iliac veins which is not well dissected from the surrounding tissues will be responsible for bleeding after venotomy, because the vein with too much tissue around it will not be properly closed. After clamping, use scissors to cut an ellipse of the vein. After opening the vein and suction of blood, rinse the vein lumen from inside out with a 0.9% NaCl (Natrium Chloride) with heparin. Then the wall of the vein is further cut lengthwise with vascular scissors, the vein is cut to the width of the renal vein diameter. (6)

Initial sutures are placed either end of the venotomy with an anchor suture sometimes placed at the mid-point of the medial wall to prevent the anterior or posterior wall being caught up in the suture line. Then anastomosis is done in continuous manner either posterior or anterior, the angle must be taken in flush after irrigation with heparinized saline to distend the lumen and make it easy to take last suture in safe manner. Then we apply a bulldog to the renal vein to close its lumen and freeing the satinsky to test the anastomotic line. (12)

Inaccessible or unsuitable iliac veins in the recipient can be managed by using the infrarenal and infra-hepatic inferior vena cava. In rare cases where both the iliac veins and the inferior vena cava have thrombosed, satisfactory results have been achieved with anastomosis of the renal vein to the portal venous drainage system, inferior and superior mesenteric veins and even large venous collaterals such as the left ovarian vein. (12)

Arterial Anastomoses

Using a monofilament suture (5-0, 6-0 or 7-0), the most common vessel for end-to-side anastomosis is the external iliac artery (EIA), which is generally placed at a point more proximally than the vein, and for end-to-end anastomosis the internal iliac artery (IIA). (13)

The external iliac artery is incised longitudinally and the lumen is irrigated with heparinized saline. An opening of a suitably-sized caliber created with an artery puncher is created in the common or external iliac artery facilitates the anastomosis. In IIA the anastomosis is done in end to end manner, stay sutures of both angles by the 6/0 proline without ligation to avoid torsion or kink firstly and if ok we start posteriorly in continuous manner and anteriorly in interrupted manner. (1)

Taking full-thickness sutures of the arterial wall, particularly in patients with arteriosclerosis, must be meticulous to complete the anastomosis. Firstly, assembly done again after venous anastomosis to cut any excess of the artery and allow making the anastomosis c-shaped like. The needle should move from inside to outside of the more diseased artery (usually the recipient artery) to tag the intima to the media of the artery and prevent creating an intimal flap, and potential thrombosis. Mostly do the posterior in continuous manner and the anterior in interrupted manner to prevent stricture. Then apply bulldog to test its patency and detect any bleeding, if any oozing but a gauze and wait then open the vein and artery seeking the anesthesiologist to increase the perfusion specially if the graft were soft and detect urine flow, then remove the gauze if bleeding stopped and if not we can used interrupted superficial suturing but don’t harry to it if minimal oozing. (1)

Multiple renal arteries in a living related donor represent more of a challenge. It is considered acceptable to ligate smaller arteries (less than one millimeter) of the upper and middle pole depending on the supply to the renal cortex, this can be judged during dissection by closing it with bulge and visualized the affected segment. Ligation is usually considered acceptable if the dependent area is judged to be less than 10%. (13)

Arteries bigger than one millimeter should be anastomosed to the EIA or even the inferior epigastric artery following reperfusion of the graft, especially in the lower pole to avoid ischaemia of the ureter. Smaller vessels (one to five millimeters) are generally can be anastomosed using an interrupted monofilament (Prolene) suture that ensures an even distribution of tension around the vessel and preventing theoretical stricturing that can be caused with a continuous suture. Variant anatomy with two or more renal arteries may be anastomosed together side-to-side preserving the lumen of each vessel, or anastomosed separately to either the recipient EIA, IIA or one renal branch to each. (13)

Reperfusion

At the point of completion of the vascular anastomosis, vessel clamps can be removed to aid in reperfusion. The kidney is inspected for fullness of perfusion and then felt globally to ensure the organ is adequately filled. A soft kidney may be indicative of under filling or even arterial inflow problems, whereas an overly tense kidney could be a sign of venous outflow compromise. It is recommended that constant communication is held with the anesthetist during the reperfusion period so that changes in cardiovascular status is known and managed appropriately. (1)

Potential challenges can occur with a non- perfused kidney and a pulsatile hilum- indicative of thrombosis or occlusion. At this point preparation should be made to reclamp the iliac vessels, cold perfuse the organ with preservation solution and refashion the anastomoses. Preparation for blood loss should be made and it may be useful to consider cell salvage of blood. Intraoperative ultrasound can also be used to check flow within the artery and vein if doubt exists on the perfusion of the kidney. (13)

Ureteric Implantation

Urinary tract reconstruction begins following successful reperfusion of the donor kidney with the type of reconstruction dependent on the position of the graft, condition of the recipient's bladder and the length, condition of donor ureter. (8)

The most commonly employed technique is the ureteroneocystostomy (UNC) and is often categorised into transvesical or extravesical procedures. It is prefered to keep the ureter as short as is feasible for a comfortable anastomosis to prevent distal ureteric ischaemia. Maintenance of the lower polar triangle of ureteric mesentery is essential given that blood supply to the upper ureter is originated from the lower polar arterial branches. (8)

The Leadbetter-Politano approach (transvesical UNC) utilises one anterior cystostomy to access the interior of the bladder and a posterior cystostomy to recreate a new ureteric orifice in the normal anatomical position with the ureter subsequently tunnelled in the submucosa to prevent reflux. Murray et al exploited this method during their first successful human renal transplant in 1954. The Lich-Gregoir technique (extravesical UNC) was first published in 1961 where the aim was to avoid a second cystostomy but maintain comparable antireflux mechanisms. (1)

Implantation of the ureter begins with exposing the area of the urinary bladder by using the appropriate blades of abdominal retractor. After exposing the area of the bladder the surgeon or scrub nurse will inject warm Ringer's solution or physiologic natrium chloride solution into the urinary bladder of the recipient. Then, after filling the bladder and localizing it, we proceed to the preparation of its wall from the surrounding fat. After the fat has been removed from the external surface of the urinary bladder wall, use diathermy to cut the muscularis propria (the detrusor of the urinary bladder), muscle and submucosa over a distance of 2.5–3.0 cm, so that the mucosa remains intact. During creating the tunnel avoid mucosal injury and keep good hemostasis, then open and cut the mucosa with scissors over a distance of 1.5–2.0 cm (fig.11). (6)

Start the vesicoureteral anastomosis by placing bladder sutures. For this purpose, use 5/0 or 4/0 absorbable monofilament sutures. Two sutures are placed on the bladder wall. Each suture is armed with two needles. Find the physiological position of the ureter. If it is twisted, unscrew it using nelaton 6fr catheter, then pull it and adjust its length from the kidney to the anastomosis with the bladder. Before starting anastomosis, remember to properly prepare the end of the ureter, which includes removing excess tissue while maintaining its good blood supply. Use sharp scissors to shorten the ureter to the desired length or, if it is long enough, cut it a few millimeters, refreshing its end. After cutting the ureter if it is needed, perform a perfect hemostasis of the bleeding tissues around the ureter. The end of the ureter is cut 1.5–2.0 cm along its long axis and adjusted to the hole previously made in the bladder. Start the uretero-bladder anastomosis with the posterior suture, which has initially punctured into the bladder wall. Choose the suture coming from the lumen of the urinary bladder, and then grab the needle of the same suture in a needle holder. At the same time, the assistant lifts the ureter upwards with forceps, and the operator inserts the forceps very gently into the lumen of the ureter and punctures it from the inside to the outside with the needle through the wall of the ureter at a distance of 2–3 mm from the posterior corner of the ureter. Now we select the suture inside the bladder in the distal corner and puncture it from the inside to the outside in the distal corner of the ureter. (6)

At this point, the transplant surgeon introduces a delicate guidewire through the side opening into the catheter, the purpose of which is to facilitate insertion of the catheter into the pelvis of the transplanted kidney. The next step is to withdraw the guidewire from the JJ catheter placed through the ureter in the renal pelvis and to insert it into one of the lower side openings of the distal part of the JJ catheter and then to insert it into the urinary bladder. Hold the JJ catheter with two forceps and pull the guidewire out of the distal end of the JJ catheter and from the urinary bladder. Lift the previously applied sutures on the ureter and bladder slightly upwards and check if the edges of the bladder and ureter fit and adhere to each other without any tension. Check the position of the inserted JJ catheter. (6)

After checking the position of the JJ catheter at the site of anastomosis, the proximal suture is tied with attention during the tying to avoid alien tissues (fat tissue or the peritoneum) between the mucosa of the ureter and the urinary bladder. The distal suture is not tied, but gently stretched under small tension in such a way that the edges of the ureter and bladder walls adhere perfectly to each other. Start to perform the anastomosis first from the posterior corner (proximal suture) and insert the needle from the outside into the ureter lumen and then from the inside of the bladder to the outside. In most cases anastomosis is done with a running suture from the right and left side of the ureter with an absorbable monofilament 5/0 or 4/0. The ureter and the urinary bladder mucosa are mostly sutured 2–3 mm from their edges and the distance between the sutures is about 2–3 mm. Finally, when the anastomosis is finished the sutures are tied and cut. (6)

Figure 11: Modified Lich-Gregoir technique

The last stage of the vesicoureteral anastomosis is to bring the edges of the bladder closer together above the anastomosis. We place two separate superficial transverse sutures in the bladder wall covering the anastomosis. The stitches are tied loosely over the uretero-bladder anastomosis in order not to cause ureteral ischemia, so that the tissues above the anastomosis are slightly close to each other. Uretero-bladder anastomosis can be completed with an anastomotic leak test by administering warm physiologic natrium saline chloride or Ringer's solution into the bladder. Administer the sterile fluids very slowly under eye observation, palpate the bladder and constantly check the degree of the bladder filling, while checking the tightness of the uretero-bladder anastomosis. Advantages compared to its counterpart procedure involve less bladder dissection, a shorter ureteral length and, overall, a quicker operative time associated with reduced morbidity. (6)

Most surgeons use a ureteral stent to reduce the risk of obstruction in the post-operative period if the ureter or bladder tissue appears marginal. The benefits of stenting the ureter are especially associated with facilitating the healing process of the performed anastomosis, which is often the source of postoperative complications. Stenting protects the ureter also from urinary leak specially if complicated procedure or prior bladder surgery or bladder pathology like bilharziasis. Moreover, ureteral obstruction as a result of postoperative swelling of the mucosa or external compression can be prevented. However, even though the benefits of an inserted stent during implantation are indisputable, possible complications should not be underestimated and should be taken into consideration. The most common and important complications associated with stents are urinary tract infections (UTIs). Stented patients have higher rates of UTIs even after their removal. Besides UTIs, stent migration, encrustation, pain and bladder discomfort may also occur.

Stents may also be forgotten in situ, which may lead to further complications. In general, stent-related complications are especially seen in patients when the stent is left for a longer period in situ. However, there is no consensus about the optimal time of stent removal, in most centers stents are removed between two and six weeks after the transplantation. (1)

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